Package ‘CorrMixed’

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Type  Package
Title  Estimate Correlations Between Repeatedly Measured Endpoints
      (E.g., Reliability) Based on Linear Mixed-Effects Models
Version  1.1
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Description  In clinical practice and research settings in medicine and the behavioral sciences, it is of-
              ten of interest to quantify the correlation of a continuous endpoint that was repeatedly mea-
              sured (e.g., test-retest correlations, ICC, etc.). This package allows for estimating these correla-
              tions based on mixed-effects models. Part of this software has been developed using funding pro-
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Example.Data  

An example dataset

Description

Example.Data is a hypothetical dataset constructed to demonstrate some of the functions in the package. Data are provided for a hypothetical experiment in which a stimulus is provided under different experimental conditions. The outcome is a normally distributed variable. The entire experiment is repeated multiple times (cycle) in each patient.

Usage

data(Example.Data)

Format

A data.frame with 360 observations on 5 variables.

Id  The Subject identifier.
Cycle  The same experiment is repeated multiple times in a patient. Cycle indicates the order of these repeated experiments.
Condition  The experimental condition under which the outcome was measured.
Time  The time point at which the outcome was measured.
Outcome  A continuous outcome.

Explore.WS.Corr  

Explore within-subject correlations (reliabilities)

Description

This function allows for exploring the within-subject (test-retest) correlation ($R$) structure in the data, taking relevant covariates into account. Estimated correlations as a function of time lag (= absolute difference between measurement moments $t_1$ and $t_2$) are provided as well as their confidence intervals (based on a non-parametric bootstrap).

Usage

Explore.WS.Corr(OLS.Model=" ", Dataset, Id, Time, Alpha=0.05, Smoother.Span=.2, Number.Bootstrap=100, Seed=1)
**Explore.WS.Corr**

**Arguments**

- **OLS.Model**: A formula passed to `lm` (to obtain the OLS residuals, i.e., to take covariates into account in the computation of $R$). OLS.Model should thus be a formula that specifies the outcome of interest followed by a ~ sign and the covariates to be taken into account, e.g., `OLS.Model="Outcome~1+as.factor(Time) + as.factor(Treatment)"`.

- **Dataset**: A data.frame that should consist of multiple lines per subject (‘long’ format).

- **Id**: The subject indicator.

- **Time**: The time indicator. Should be coded as 1, 2, etc.

- **Alpha**: The $\alpha$-level to be used in the non-parametric bootstrap-based Confidence Interval for $R$. Default $\text{Alpha}=0.05$


- **Number.Bootstrap**: The number of non-parametric bootstrap samples to be used to estimate the Confidence Interval for $R$. Default $\text{Number.Bootstrap}=100$

- **Seed**: The seed to be used in the bootstrap. Default $\text{Seed}=1$.

**Value**

- **Est.Corr**: The estimated correlations $R$ as a function of time lag. A smoothing (loess) technique is used to estimate $R$ as a function of time lag (based on the output in All.Corrs).

- **All.Corrs**: A matrix that contains the estimated correlations $R$ for all individual time lags.

- **Bootstrapped.Corrs**: A matrix that contains the estimated correlations $R$ as a function of time lag in the bootstrapped samples.

- **Alpha**: The $\alpha$ level used in the estimation of the confidence interval.

- **CI.Upper**: The upper bounds of the confidence intervals.

- **CI.Lower**: The lower bounds of the confidence intervals.

**Author(s)**

Wim Van der Elst, Geert Molenberghs, Ralf-Dieter Hilgers, & Nicole Heussen

**References**


**See Also**

`plot.Explore.WS.Corr`
Examples

# Open data
data(Example.Data)

# Explore correlation structure
Expl_Corr <- Explore.WS.Corr(OLS.Model="Outcome~as.factor(Time)+
   as.factor(Cycle) + as.factor(Condition)", Dataset=Example.Data,
   Id="Id", Time="Time", Alpha=.05, Number.Bootstrap=50, Seed=123)

# explore results
summary(Expl_Corr)

# plot with correlations for all time lags, and
# add smoothed (loess) correlation function
plot(Expl_Corr, Indiv.Corrs=TRUE)
# plot bootstrapped smoothed (loess) correlation function
plot(Expl_Corr)

Fract.Poly

Fit fractional polynomials

Description

Fits regression models with $m$ terms of the form $X^p$, where the exponents $p$ are selected from a small predefined set $S$ of both integer and non-integer values.

Usage

Fract.Poly(Covariate, Outcome, S=c(-2,-1,-0.5,0,0.5,1,2,3), Max.M=5, Dataset)

Arguments

Covariate The covariate to be considered in the models.
Outcome The outcome to be considered in the models.
S The set $S$ from which each power $p^m$ is selected. Default $S=\{-2,-1,-0.5,0,0.5,1,2,3\}$.
Max. M The maximum order $M$ to be considered for the fractional polynomial. This value can be 5 at most. When $M = 5$, then fractional polynomials of order 1 to 5 are considered. Default Max. M=5.
Dataset A data.frame that should consist of multiple lines per subject ('long' format).

Value

Results.M1 The results (powers and AIC values) of the fractional polynomials of order 1.
Results.M2 The results (powers and AIC values) of the fractional polynomials of order 2.
Results.M3 The results (powers and AIC values) of the fractional polynomials of order 3.
Results.M4 The results (powers and AIC values) of the fractional polynomials of order 4.
Results.M5 The results (powers and AIC values) of the fractional polynomials of order 5.


**Author(s)**

Wim Van der Elst, Geert Molenberghs, Ralf-Dieter Hilgers, & Nicole Heussen

**References**


**Examples**

```r
# Open data
data(Example.Data)

# Fit fractional polynomials, mox. order = 3
FP <- Fract.Poly(Covariate = Time, Outcome = Outcome,
                  Dataset = Example.Data, Max.M=3)

# Explore results
summary(FP)
# best fitting model (based on AIC) for m=3,
# powers: p_{1}=3, p_{2}=3, and p_{3}=2

# Fit model and compare with observed means

# plot of mean
Spaghetti.Plot(Dataset = Example.Data, Outcome = Outcome,
               Time = Time, Id=Id, Add.Profiles = FALSE, Lwd.Me=1,
               ylab="Mean Outcome")

# Coding of predictors (note that when p_{1}=p_{2},
# beta_{1}*X^{p_{1}} + beta_{2}*X^{p_{1}} * log(X)
# and when p_{1}=0, X^{0}= log(X) )
term1 <- Example.Data$Time^3
term2 <- (Example.Data$Time^3) * log(Example.Data$Time)
term3 <- Example.Data$Time^2

# fit model
Model <- lm(Outcome~term1+term2+term3, data=Example.Data)
Model$coeff # regression weights (beta's)

# make prediction for time 1 to 47
term1 <- (1:47)^3
term2 <- ((1:47)^3) * log(1:47)
term3 <- (1:47)^2

# compute predicted values

# Add predicted values to plot
lines(x = 1:47, y=pred, lty=2)
legend("topright", c("Observed", "Predicted"), lty=c(1, 2))
```
Heatmap

Plot a heatmap of the correlation structure

Description

This function plots a heatmap of the correlation structure (reliability) in the data. It is a wrapper function for the `cor.plot` function of the `psych` package.

Usage

`Heatmap(Dataset, Id, Outcome, Time, ...)`

Arguments

- `Dataset`: A `data.frame` that should consist of multiple lines per subject ('long' format).
- `Id`: The subject indicator.
- `Outcome`: The outcome indicator.
- `Time`: The time indicator.
- `...`: Other arguments to be passed to `cor.plot`.

Author(s)

Wim Van der Elst, Geert Molenberghs, Ralf-Dieter Hilgers, & Nicole Heussen

References


See Also

`plot.Explore.WS.Corr`

Examples

```r
# Open data
data(Example.Data)

# Make heatmap
Heatmap(Dataset=Example.Data, Id = "Id", Outcome="Outcome", Time = "Time")

# Make heatmap in black and white
Heatmap(Dataset=Example.Data, Id = "Id", Outcome="Outcome", Time = "Time", colors=FALSE)
```
Model.Fit

Compare the fit of linear mixed-effects models

Description

This function compares the fit of Model 1 (random intercept) and 2 (random intercept and Gaussian serial correlation), and of Model 2 (random intercept and Gaussian serial correlation) and 3 (random intercept, slope and Gaussian serial correlation)

Usage

Model.Fit(Model.1, Model.2)

Arguments

Model.1
An object of class WS.Corr.Mixed, the first fitted model.

Model.2
Another object of class WS.Corr.Mixed, the second fitted model.

Author(s)

Wim Van der Elst, Geert Molenberghs, Ralf-Dieter Hilgers, & Nicole Heussen

References


See Also

WS.Corr.Mixed

Examples

data(Example.Data)

# Code predictors for time
Example.Data$Time2 <- Example.Data$Time**2
Example.Data$Time3 <- Example.Data$Time**3
Example.Data$Time3_log <- (Example.Data$Time**3) * (log(Example.Data$Time))

# model 1
Model1 <- WS.Corr.Mixed(
  Fixed.Part=Outcome ~ Time2 + Time3 + Time3_log + as.factor(Cycle) + as.factor(Condition),
  Random.Part =~ 1|Id,
  Dataset=Example.Data, Model=1, Id="Id",
  Number.Bootstrap = 0, Seed = 12345)

# model 2
Model2 <- WS.Corr.Mixed(
plot Explore.WS.Corr

Fixed.Part=Outcome ~ Time2 + Time3 + Time3_log + as.factor(Cycle) + as.factor(Condition), Random.Part = ~ 1|Id, Correlation=corGaus(form= ~ Time, nugget = TRUE), Dataset=Example.Data, Model=2, Id="Id", Number.Bootstrap = 0, Seed = 12345)

# model 3
Model3 <- WS.Corr.Mixed(
  Fixed.Part=Outcome ~ Time2 + Time3 + Time3_log + as.factor(Cycle) + as.factor(Condition),
  Random.Part = ~ 1 + Time|Id,
  Correlation=corGaus(form= ~ Time, nugget = TRUE),
  Dataset=Example.Data, Model=3, Id="Id",
  Number.Bootstrap = 0, Seed = 12345)

# compare models 1 and 2
Model.Fit(Model.1=Model1, Model.2=Model2)

# compare models 2 and 3
Model.Fit(Model.1=Model2, Model.2=Model3)

---

plot Explore.WS.Corr  Plot of exploratory within-subject correlations (reliabilities)

Description

Provides an exploratory plot that allows for examining the within-subject correlations $R$ (reliabilities) as a function if time lag.

Usage

## S3 method for class 'Explore.WS.Corr'
plot(x, Est.Corrs=TRUE, Indiv.Corrs=FALSE,
     Add.CI=FALSE, Add.CI.Smoothed=TRUE, Smoother.Span=0.2,
     Add.Boot.Corrs=FALSE, Add.CI.Polygon=FALSE,
     ylim=c(-1, 1), xlab="Time Lag", ylab="Reliability", ...)

Arguments

- **x** A fitted object of class Explore.WS.Corr.
- **Est.Corrs** Logical. Should the smoothed (loess) correlation function as a function of time lag be added? Default TRUE.
- **Indiv.Corrs** Logical. Should the estimated correlations for all individual time lags be added? Default FALSE.
- **Add.CI** Logical. Should a bootstrapped $100(1 - \alpha)\%$ Confidence Interval be added around the smoothed correlation function? Default FALSE.
- **Add.CI.Smoothed** Logical. Should a smoothed bootstrapped $100(1 - \alpha)\%$ Confidence Interval be added around the smoothed correlation function? Default FALSE.

Add.Boot.Corrs: Logical. Should the individual bootstrapped smoothed (loess) correlation functions be added? Default FALSE.

Add.CI.Polygon: Logical. Similar to Add.CI but adds a grey polygon to mark the a bootstrapped 100(1 − α)% Confidence Interval (instead of dashed lines). Default FALSE.

ylim: The minimum and maximum values of the Y-axis. Default ylim=c(-1,1).

xlab: The label of the X-axis. Default xlab="Time Lag".

ylab: The label of the Y-axis. Default ylab="Reliability".

... Other arguments to be passed to the plot function.

Author(s)
Wim Van der Elst, Geert Molenberghs, Ralf-Dieter Hilgers, & Nicole Heussen

References

See Also
Explore.WS.Corr, Heatmap

Examples
```r
# Open data
data(Example.Data)

# Explore correlation structure
Expl_Corr <- Explore.WS.Corr(OLS.Model="Outcome~as.factor(Time)+
as.factor(Cycle) + as.factor(Condition)", Dataset=Example.Data,
Id="Id", Time="Time", Alpha=.05, Number.Bootstrap=50, Seed=123)

# explore results
summary(Expl_Corr)

# plot with correlations for all time lags, and
# add smoothed (loess) correlation function

# plot bootstrapped smoothed (loess) correlation function
plot(Expl_Corr, Add.Boot.Corrs=TRUE)
```
plot.WS.Corr.Mixed  

Plot the within-subject correlations (reliabilities) obtained by using the mixed-effects modeling approach

Description

Plots the within-subject correlations (reliabilities) and $100(1 - \alpha)\%$ Confidence Intervals based on the fitted mixed-effect models.

Usage

```r
## S3 method for class 'WS.Corr.Mixed'
plot(x, xlab, ylab, ylim, main, All.Individual=FALSE, ...)
```

Arguments

- `x`: A fitted object of class `WS.Corr.Mixed`
- `xlab`: The label of the X-axis.
- `ylab`: The label of the Y-axis.
- `ylim`: The min, max values of the Y-axis.
- `main`: The main title of the plot.
- `All.Individual`: Logical. Should correlation functions be provided that show the correlations between all individual measurement moments $R(t_i, t_k)$? Argument is only used if Model 2 was fitted. Default `All.Individual=FALSE`.
- `...`: Other arguments to be passed to the plot function.

Author(s)

Wim Van der Elst, Geert Molenberghs, Ralf-Dieter Hilgers, & Nicole Heussen

References


See Also


Examples

```r
# open data
data(Example.Data)

# Make covariates used in mixed model
Example.Data$Time2 <- Example.Data$Time**2
```
Example.Data$Time3 <- Example.Data$Time**3
Example.Data$Time3_log <- (Example.Data$Time**3) * (log(Example.Data$Time))

# model 1: random intercept model
Model1 <- WS.Corr.Mixed(
  Fixed.Part=Outcome ~ Time2 + Time3 + Time3_log + as.factor(Cycle)
  + as.factor(Condition), Random.Part = ~ 1|Id,
  Dataset=Example.Data, Model=1, Id="Id", Number.Bootstrap = 50,
  Seed = 12345)

  # plot the results
  plot(Model1)

## Not run: time-consuming code parts
# model 2: random intercept + Gaussian serial corr
Model2 <- WS.Corr.Mixed(
  Fixed.Part=Outcome ~ Time2 + Time3 + Time3_log + as.factor(Cycle)
  + as.factor(Condition), Random.Part = ~ 1|Id,
  Correlation=corGaus(form= ~ Time, nugget = TRUE),
  Dataset=Example.Data, Model=2, Id="Id", Seed = 12345)

  # plot the results
  # estimated corr as a function of time lag (default plot)
  plot(Model2)

  # estimated corr for all pairs of time points
  plot(Model2, All.Individual = T)

# model 3
Model3 <- WS.Corr.Mixed(
  Fixed.Part=Outcome ~ Time2 + Time3 + Time3_log + as.factor(Cycle)
  + as.factor(Condition), Random.Part = ~ 1 + Time|Id,
  Correlation=corGaus(form= ~ Time, nugget = TRUE),
  Dataset=Example.Data, Model=3, Id="Id", Seed = 12345)

  # plot the results
  # estimated corr for all pairs of time points
  plot(Model3)

  # estimated corrs as a function of time lag

## End(Not run)

---

**Spaghetti.Plot**

**Make a Spaghetti plot**

**Description**

Makes a spaghetti plot, i.e., a plot that depicts the outcome as a function of time for each individual subject.
Usage

Spaghetti.Plot(Dataset, Outcome, Time, Id, Add.Profiles=TRUE, Add.Mean=TRUE, Add.Median=FALSE, Col=8, Lwd.Me=3, xlim, ylim, ...)

Arguments

Dataset A data.frame that should consist of multiple lines per subject (‘long’ format).
Outcome The name of the outcome variable.
Time The name of the time indicator.
Id The subject indicator.
Add.Profiles Logical. Should the individual profiles be added? Default Add.Profiles=TRUE.
Add.Mean Logical. Should a line that depicts the mean as a function of time be added? Default Add.Mean=TRUE.
Add.Median Logical. Should a line that depicts the median as a function of time be added? Default Add.Median=FALSE.
Col The color of the individual profiles. Default Col=8 (grey).
Lwd.Me The line width of the lines with mean and/or median. Default Lwd.Me=3.
xlim The (min, max) values for the x-axis.
ylim The (min, max) values for the y-axis.
... Other arguments to be passed to the plot() function.

Author(s)

Wim Van der Elst, Geert Molenberghs, Ralf-Dieter Hilgers, & Nicole Heussen

References


Examples

# Open data
data(Example.Data)

# Plot individual profiles + mean
Spaghetti.Plot(Dataset = Example.Data, Outcome = Outcome, Id=Id, Time = Time)

# Plot individual profiles + median
Spaghetti.Plot(Dataset = Example.Data, Outcome = Outcome, Id=Id, Time = Time, Add.Mean=FALSE, Add.Median=TRUE)
**WS.Corr.Mixed**

Estimate within-subject correlations (reliabilities) based on a mixed-effects model.

### Description

This function allows for the estimation of the within-subject correlations using a general and flexible modeling approach that allows at the same time to capture hierarchies in the data, the presence of covariates, and the derivation of correlation estimates. Non-parametric bootstrap-based confidence intervals can be requested.

### Usage

```r
WS.Corr.Mixed(Dataset, Fixed.Part=" ", Random.Part=" ", Correlation=" ", Id, Time=Time, Model=1, Number.Bootstrap=100, Alpha=.05, Seed=1)
```

### Arguments

<table>
<thead>
<tr>
<th>Argument</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dataset</td>
<td>A data.frame that should consist of multiple lines per subject ('long' format).</td>
</tr>
<tr>
<td>Fixed.Part</td>
<td>The outcome and fixed-effect part of the mixed-effects model to be fitted. The model should be specified in agreement with the <code>lme</code> function requirements of the <code>nlme</code> package. See examples below.</td>
</tr>
<tr>
<td>Random.Part</td>
<td>The random-effect part of the mixed-effects model to be fitted (specified in line with the <code>lme</code> function requirements). See examples below.</td>
</tr>
<tr>
<td>Correlation</td>
<td>An optional object describing the within-group correlation structure (specified in line with the <code>lme</code> function requirements). See examples below.</td>
</tr>
<tr>
<td>Id</td>
<td>The subject indicator.</td>
</tr>
<tr>
<td>Time</td>
<td>The time indicator. Default <code>Time=Time</code>.</td>
</tr>
<tr>
<td>Model</td>
<td>The type of model that should be fitted. Model=1: random intercept model, Model=2: random intercept and Gaussian serial correlation, Model=3: random intercept, slope, and Gaussian serial correlation, and Model=4: random intercept + slope. Default Model=1.</td>
</tr>
<tr>
<td>Number.Bootstrap</td>
<td>The number of bootstrap samples to be used to estimate the Confidence Intervals around $R$. Default <code>Number.Bootstrap=100</code>. As an alternative to obtain confidence intervals, the Delta method can be used (see WS.Corr.Mixed.SAS).</td>
</tr>
<tr>
<td>Alpha</td>
<td>The $\alpha$-level to be used in the bootstrap-based Confidence Interval for $R$. Default $Alpha = 0.05$</td>
</tr>
<tr>
<td>Seed</td>
<td>The seed to be used in the bootstrap. Default $Seed = 1$.</td>
</tr>
</tbody>
</table>
Details

Warning 1
To avoid problems with the \texttt{lme} function, do not specify powers directly in the function call. For example, rather than specifying \texttt{Fixed.Part=ZSV \sim Time + Time**2} in the function call, first add \texttt{Time**2} to the dataset (\texttt{Dataset$TimeSq <- Dataset$Time ** 2}) and then use the new variable name in the call: \texttt{Fixed.Part=ZSV \sim Time + TimeSq}

Warning 2 To avoid problems with the \texttt{lme} function, specify the Random.Part and Correlation arguments like e.g., \texttt{Random.Part = ~ 1| Subject} and \texttt{Correlation=corGaus(form= \sim Time, nugget = TRUE)}
not like e.g., \texttt{Random.Part = ~ 1| Subject} and \texttt{Correlation=corGaus(form= \sim Time| Subject, nugget = TRUE)}
(i.e., do not use Time| Subject)

Value

- **Model**: The type of model that was fitted (model 1, 2, or 3.)
- **D**: The $D$ matrix of the fitted model.
- **Tau2**: The $\tau^2$ component of the fitted model. This component is only obtained when serial correlation is requested (Model 2 or 3), $\varepsilon_2 \sim N(0, \tau^2 H_i)$.
- **Rho**: The $\rho$ component of the fitted model which determines the matrix $H_i$, $\rho(|t_{ij} - t_{ik}|)$. This component is only obtained when serial correlation is considered (Model 2 or 3).
- **Sigma2**: The residual variance.
- **AIC**: The AIC value of the fitted model.
- **LogLik**: The log likelihood value of the fitted model.
- **R**: The estimated reliabilities.
- **CI.Upper**: The upper bounds of the bootstrapped confidence intervals.
- **CI.Lower**: The lower bounds of the bootstrapped confidence intervals.
- **Alpha**: The $\alpha$ level used in the estimation of the confidence interval.
- **Coef.Fixed**: The estimated fixed-effect parameters.
- **Std.Error.Fixed**: The standard errors of the fixed-effect parameters.
- **Time**: The time values in the dataset.
- **Fitted.Model**: A fitted model of class \texttt{lme}.

Author(s)

Wim Van der Elst, Geert Molenberghs, Ralf-Dieter Hilgers, & Nicole Heussen

References

See Also


Examples

```r
# open data
data(Example.Data)

# Make covariates used in mixed model
Example.Data$Time2 <- Example.Data$Time**2
Example.Data$Time3 <- Example.Data$Time**3
Example.Data$Time3_log <- (Example.Data$Time**3) * (log(Example.Data$Time))

# model 1: random intercept model
Model1 <- WS.Corr.Mixed(
  Fixed.Part=Outcome ~ Time2 + Time3 + Time3_log + as.factor(Cycle)
  + as.factor(Condition), Random.Part = ~ 1|Id,
  Dataset=Example.Data, Model=1, Id="Id", Number.Bootstrap = 50,
  Seed = 12345)

  # summary of the results
summary(Model1)
  # plot the results
plot(Model1)

## Not run: time-consuming code parts
# model 2: random intercept + Gaussian serial corr
Model2 <- WS.Corr.Mixed(
  Fixed.Part=Outcome ~ Time2 + Time3 + Time3_log + as.factor(Cycle)
  + as.factor(Condition), Random.Part = ~ 1|Id,
  Correlation=corGaus(form= ~ Time, nugget = TRUE),
  Dataset=Example.Data, Model=2, Id="Id", Seed = 12345)

  # summary of the results
summary(Model2)
  # plot the results
  # estimated corrs as a function of time lag (default plot)
plot(Model2)
  # estimated corrs for all pairs of time points
plot(Model2, All.Individual = T)

# model 3
Model3 <- WS.Corr.Mixed(
  Fixed.Part=Outcome ~ Time2 + Time3 + Time3_log + as.factor(Cycle)
  + as.factor(Condition), Random.Part = ~ 1 + Time|Id,
  Correlation=corGaus(form= ~ Time, nugget = TRUE),
  Dataset=Example.Data, Model=3, Id="Id", Seed = 12345)

  # summary of the results
summary(Model3)
```
WS.Corr.Mixed.SAS

Estimate within-subject (test-retest) correlations based on a mixed-effects model using the SAS proc MIXED output.

Description

This function allows for the estimation of the within-subject correlations using a general and flexible modeling approach that allows at the same time to capture hierarchies in the data, the presence of covariates, and the derivation of correlation estimates. The output of proc MIXED (SAS) is used as the input for this function. Confidence intervals for the correlations based on the Delta method are provided.

Usage

WS.Corr.Mixed.SAS(Model, D, Sigma2, Asycov, Rho, Tau2, Alpha=0.05, Time)

Arguments

Model
The type of model that should be fitted. Model=1: random intercept model, Model=2: random intercept and serial correlation, and Model=3: random intercept, slope, and serial correlation. Default Model=1.

D
The D matrix of the fitted model.

Sigma2
The residual variance.

Asycov
The asymptotic correlation matrix of covariance parameter estimates.

Rho
The ρ component of the fitted model which determines the matrix $H_i$, $ρ(|t_{ij} - t_{ik}|)$. This component is only needed when serial correlation is involved, i.e., when Model 2 or 3 used.

Tau2
The $τ^2$ component of the fitted model. This component is only needed when serial correlation is involved (i.e., when Model 2 or 3 used), $ε_2 \sim N(0, τ^2H_i)$.

Alpha
The α-level to be used in the computation of the Confidence Intervals around the within-subject correlation. The Confidence Intervals are based on the Delta method. Default Alpha=0.05.

Time
The time points available in the dataset on which the analysis was conducted.
Value

- **Model**: The type of model that was fitted.
- **R**: The estimated within-subject correlations.
- **Alpha**: The $\alpha$-level used to compute the Confidence Intervals around $R$.
- **CI.Upper**: The upper bounds of the confidence intervals (Delta-method based).
- **CI.Lower**: The lower bounds of the confidence intervals (Delta-method based).
- **Time**: The time values in the dataset.

Author(s)

Wim Van der Elst, Geert Molenberghs, Ralf-Dieter Hilgers, & Nicole Heussen

References


See Also

- **WS.Corr.Mixed**

Examples

```r
# Open data
data(Example.Data)

# Estimate R and Delta method-based CI
# based on SAS output of fitted Model 2

# First specify asycov matrix
Asy_mat <- matrix(c(129170, -10248, -12.0814, -74.8605,
                     -10248, 25894, 21.0976, -50.1059,
                     -12.0814, 21.0976, 0.07791, 1.2120,
                     -74.8605, -50.1059, 1.212, 370.65), nrow = 4)

                                D=500.98, Tau2=892.97, Rho=3.6302, Sigma2=190.09,
                                Asycov = Asy_mat, Time=c(1:45))
summary(Model2_SAS)
plot(Model2_SAS)
```
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