Package 'BayesMed'

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Type Package

Title Default Bayesian hypothesis tests for correlation, partial correlation, and mediation

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Description Default Bayesian hypothesis tests for correlation, partial correlation, and mediation

License GPL-2

NeedsCompilation no

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R topics documented:

BayesMed *A default Bayesian hypothesis test for mediation, correlation, and partial correlation.*

Description

This package can be used to perform a default Bayesian hypothesis test for mediation, correlation, and partial correlation, either analytically or through the Savage-Dickey method (Dickey & Lientz, 1970). All tests make use of a Jeffreys-Zellner-Siow prior set-up (Liang et al., 2008). This package is based on the paper by Nuijten, Wetzels, Matzke, Dolan, and Wagenmakers (under review).

Details

Package:	BayesMed
Type:	Package
Version:	0.1.0
Date:	2012-07-31
License:	GPL-2

The main functions `jzs_med` and `jzs_medSD` can be used to establish and test mediation in a data set. With `jzs_cor` and `jzs_corSD` you can establish and test correlation, and with jzs_partcor and jzs_partcorSD partial correlation.

Note

This function requires the program "JAGS" (Just Another Gibbs Sampler) to be in the PATH variable. This program can be obtained from http://mcmc-jags.sourceforge.net.

Author(s)

Michele B. Nuijten <m.b.nuijten@uvt.nl>, Ruud Wetzels, Dora Matzke, Conor V. Dolan, and Eric-Jan Wagenmakers. Many thanks to Sacha Epskamp.

References

Dickey, J. M., & Lientz, B. P. (1970). The weighted likelihood ratio, sharp hypotheses about chances, the order of a Markov chain. The Annals of Mathematical Statistics, 214-226.

Liang, F., Paulo, R., Molina, G., Clyde, M. A., & Berger, J. O. (2008). Mixtures of g priors for Bayesian variable selection. Journal of the American Statistical Association, 103(481), 410-423.

Nuijten, M. B., Wetzels, R., Matzke, D., Dolan, C. V., & Wagenmakers, E.-J. (2014). A default Bayesian hypothesis test for mediation. Manuscript submitted for publication.

Wetzels, R. & Wagenmakers, E.-J. (2012). A default Bayesian hypothesis test for correlations and partial correlations. Psychonomic Bulletin & Review.

Examples

```
## Not run:
# simulate mediational data
X <- rnorm(50,0,1)
M <- .5*X + rnorm(50,0,1)
Y <- .3*X + .6*M + rnorm(50,0,1)

############

# run jzs_med to perform the Bayesian hypothesis test for mediation
# jzs_med is an analytical test and is faster than jzs_medSD

result <- jzs_med(independent=X,dependent=Y,mediator=M)
result

### NOTE ###
#Sometimes this error will pop up:
#
#Error in solve.default(nItheta) :
#  system is computationally singular: reciprocal condition number = *some small number*
#Error in mydt2(0, mT, sT, dfT) : unused arguments (mT, sT, dfT)
#In addition: Warning message:
#In jzs_medSD(X, Y, M) :
#  fit.st did not converge. Alternative optimization method was used.
#
#If this happens, just run jzs_medSD() again.
#This usually solves the convergence problem. If it does not,
#try a different SD method. For instance: jzs_medSD(X,Y,M,SDmethod="dnorm").
#
##############

# plot results
plot(result$main_result)

############

# run jzs_medSD to perform the Savage-Dickey (SD) Bayesian hypothesis test for mediation
# advantages of the SD method are:
      # the possibility to test parameters one-sided
      # the possibility to estimate the posterior distributions of the parameters


result_SD <- jzs_medSD(independent=X,dependent=Y,mediator=M)
result_SD

# plot(results)
plot(result_SD$main_result)

# plot posterior samples
# including credible interval, mean, and median of the indirect effect alpha*beta
plot(result_SD$ab_samples)
```

```
# inspect separate posterior distributions of alpha, beta, and tau_prime
plot(result_SD$alpha_samples)
plot(result_SD$beta_samples)
plot(result_SD$tau_prime_samples)

# print a traceplot of the chains
# where the first chain (theta[1]) is for tau' and the second chain (theta[2]) for beta
plot(result$jagssamplesA)
plot(result$jagssamplesTB)

## End(Not run)
```

`Firefighters` *Data from a study of health promotion of firefighters*

Description

«««< HEAD Data from a study of health promotion of firefighters (Elliot et al., 2007). These data are also used as an example in the Bayesian mediation paper of Yuan and MacKinnon (2009) and Nuijten et al. (2014).

Usage

```
data(Firefighters)
```

Format

A data frame with 354 observations on the following 3 variables.

`y` Dependent variable: reported eating of fruits and vegetables

`m` Mediating variable: change from baseline to followup in knowledge of the benefits of eating fruits and vegetables

`x` Independent variable: randomized exposure to an intervention

Details

The data are centered.

Source

Elliot, D. L., Goldberg, L., Kuehl, K. S., Moe, E. L., Breger, R. K. R., Pickering, M. A. (2007). The PHLAME (Promoting Healthy Lifestyles: Alternative Models' Effects) Firefighter Study: Outcomes of Two Models of Behavior Change. JOEM, 49, 204-213.

References

Elliot, D. L., Goldberg, L., Kuehl, K. S., Moe, E. L., Breger, R. K. R., Pickering, M. A. (2007). The PHLAME (Promoting Healthy Lifestyles: Alternative Models' Effects) Firefighter Study: Outcomes of Two Models of Behavior Change. JOEM, 49, 204-213.

Nuijten, M.B., Wetzels, R., Matzke, D., Dolan, C. V., & Wagenmakers, E.-J. (2014). A default Bayesian hypothesis test for mediation. Manuscript submitted for publication.

Yuan, Y., & MacKinnon, D. (2009). Bayesian mediation analysis. Psychological Methods, 14 , 301-322.

Examples

```
## Not run:
data(Firefighters)

# mediation analysis
result <- jzs_med(Firefighters$x,Firefighters$y,Firefighters$m)
result

# underlying mediational model with path weights and posterior probabilities
plot(result$main_result)

# posterior distribution of indirect effect "ab" incl 95% credible interval
plot(result$ab_samples)

## End(Not run)
```

`jzs_cor` *A default Bayesian hypothesis test for correlation (Wetzels, R., & Wagenmakers).*

Description

This function can be used to perform a default Bayesian hypothesis test for correlation, using a Jeffreys-Zellner-Siow prior set-up (Liang et al., 2008).

Usage

```
jzs_cor(V1, V2,
        alternative = c("two.sided", "less", "greater"),
        n.iter=10000,n.burnin=500,standardize=TRUE)
```

Arguments

`V1`	a numeric vector.
`V2`	a numeric vector of the same length as V1.
`alternative`	specify the alternative hypothesis for the correlation coefficient: `two.sided`, `greater` than zero, or `less` than zero.

n.iter	number of total iterations per chain (see the package R2jags). Defaults to 10000.
n.burnin	length of burn in, i.e. number of iterations to discard at the beginning(see the package R2jags). Defaults to 500.
standardize	logical. Should the variables be standardized? Defaults to TRUE.

Details

See Wetzels & Wagenmakers (2012).

Value

The function returns a list with the following items:

Correlation	The correlation coefficient for the relation between V1 and V2. The correlation coefficient is calculated by standardizing the mean of the posterior samples: mean(samples)*(sd(V1)/sd(V2)).
BayesFactor	The Bayes factor for the correlation coefficient. A value greater than one indicates evidence in favor of correlation, a value smaller than one indicates evidence against correlation.
PosteriorProbability	The posterior probability for the existence of a correlation between V1 and V2.
alpha	The posterior samples for the correlation coefficient alpha.
jagssamples	The JAGS output for the MCMC estimation of the path. This object can be used to construct a traceplot.

Author(s)

Michele B. Nuijten <m.b.nuijten@uvt.nl>, Ruud Wetzels, Dora Matzke, Conor V. Dolan, and Eric-Jan Wagenmakers.

References

Liang, F., Paulo, R., Molina, G., Clyde, M. A., & Berger, J. O. (2008). Mixtures of g priors for Bayesian variable selection. Journal of the American Statistical Association, 103(481), 410-423.

Nuijten, M.B., Wetzels, R., Matzke, D., Dolan, C. V., & Wagenmakers, E.-J. (2014). A default Bayesian hypothesis test for mediation. Manuscript submitted for publication.

Wetzels, R., & Wagenmakers, E.-J. (2012). A Default Bayesian Hypothesis Test for Correlations and Partial Correlations. Psychonomic Bulletin & Review, 19, 1057-1064.

See Also

jzs_partcor, jzs_med

Examples

```
## Not run:
# generate correlational data
X <- rnorm(100)
Y <- .4*X + rnorm(100,0,1)

# run jzs_cor
result <- jzs_cor(X,Y)

# inspect posterior distribution
plot(result$alpha_samples)

# print a traceplot of the chains
plot(result$jagssamples)


## End(Not run)
```

`jzs_corSD` *A default Bayesian hypothesis test for correlation using the Savage-Dickey method.*

Description

This function can be used to perform a default Bayesian hypothesis test for correlation, using the Savage-Dickey method (Dickey & Lientz, 1970). The test uses a Jeffreys-Zellner-Siow prior set-up (Liang et al., 2008).

Usage

```
jzs_corSD(V1, V2,
          SDmethod = c("fit.st", "dnorm", "splinefun", "logspline"),
          alternative = c("two.sided", "less", "greater"),
          n.iter=10000,n.burnin=500, standardize=TRUE)
```

Arguments

`V1`	a numeric vector.
`V2`	a numeric vector of the same length as V1.
`SDmethod`	specify the precise method with which the density of the posterior distribution will be estimated in order to compute the Savage-Dickey ratio.
`alternative`	specify the alternative hypothesis for the correlation coefficient: `two.sided`, `greater` than zero, or `less` than zero.
`n.iter`	number of total iterations per chain (see the package `R2jags`). Defaults to 10000.
`n.burnin`	length of burn in, i.e. number of iterations to discard at the beginning(see the package `R2jags`). Defaults to 500.
`standardize`	logical. Should the variables be standardized? Defaults to TRUE.

Value

A list containing the following components:

`Correlation`	The correlation coefficient for the relation between V1 and V2. The correlation coefficient is calculated by standardizing the mean of the posterior samples: mean(samples)*(sd(V1)/sd(V2)).
`BayesFactor`	The Bayes factor for the correlation coefficient. A value greater than one indicates evidence in favor of correlation, a value smaller than one indicates evidence against correlation.
`PosteriorProbability`	The posterior probability for the existence of a correlation between V1 and V2.
`alpha`	The posterior samples for the correlation coefficient alpha.
`jagssamples`	The JAGS output for the MCMC estimation of the path. This object can be used to construct a traceplot.

Warning

In some cases the SDmethod `fit.st` will fail to converge. If so, another optimization method is used, using different starting values. If the other optimization method does not converge either or gives you a negative Bayes factor (which is meaningless), you could try one of the other SDmethod options or see `jzs_cor`.

Author(s)

Michele B. Nuijten <m.b.nuijten@uvt.nl>, Ruud Wetzels, Dora Matzke, Conor V. Dolan, and Eric-Jan Wagenmakers.

References

Dickey, J. M., & Lientz, B. P. (1970). The weighted likelihood ratio, sharp hypotheses about chances, the order of a Markov chain. The Annals of Mathematical Statistics, 214-226.

Liang, F., Paulo, R., Molina, G., Clyde, M. A., & Berger, J. O. (2008). Mixtures of g priors for Bayesian variable selection. Journal of the American Statistical Association, 103(481), 410-423.

Nuijten, M.B., Wetzels, R., Matzke, D., Dolan, C. V., & Wagenmakers, E.-J. (2014). A default Bayesian hypothesis test for mediation. Manuscript submitted for publication.

Wetzels, R., & Wagenmakers, E.-J. (2012). A Default Bayesian Hypothesis Test for Correlations and Partial Correlations. Psychonomic Bulletin & Review, 19, 1057-1064.

See Also

`jzs_cor`, `jzs_partcorSD`

Examples

```
## Not run:
# generate correlational data
X <- rnorm(100)
Y <- .4*X + rnorm(100,0,1)
```

```
# run jzs_cor
result <- jzs_corSD(X,Y)

# inspect posterior distribution
plot(result$alpha_samples)

# print a traceplot of the chains
plot(result$jagssamples)


## End(Not run)
```

---

jzs_med *Perform a default Bayesian hypothesis test for mediation.*

Description

This function can be used to perform a default Bayesian hypothesis test for mediation, using a Jeffreys-Zellner-Siow prior set-up (Liang et al., 2008). The test is based on the default Bayesian hypothesis tests for correlation and partial correlation (Wetzels & Wagenmakers, 2012).

Usage

```
jzs_med(independent, dependent, mediator,
        alternativeA=c("two.sided","less","greater"),
        alternativeB=c("two.sided","less","greater"),
        alternativeT=c("two.sided","less","greater"),
        n.iter=10000,n.burnin=500,standardize=TRUE)
```

Arguments

independent	a vector containing values for the independent variable.
dependent	a vector containing values for the dependent variable.
mediator	a vector containing values for the mediating variable.
alternativeA	specify the alternative hypothesis for path alpha: two.sided, greater than zero, or less than zero.
alternativeB	specify the alternative hypothesis for path beta: two.sided, greater than zero, or less than zero.
alternativeT	specify the alternative hypothesis for path tau_accent: two.sided, greater than zero, or less than zero.
n.iter	number of total iterations per chain (see the package R2jags). Defaults to 10000.
n.burnin	length of burn in, i.e. number of iterations to discard at the beginning(see the package R2jags). Defaults to 500.
standardize	logical. Should the variables be standardized? Defaults to TRUE.

Details

The test consists of four steps. Firstly, it computes the posterior probability for the existence of the path between the independent and the mediating variable (path alpha) by means of a default Bayesian hypothesis test for correlation (Wetzels & Wagenmakers, 2012).

Secondly, it computes the posterior probability for the existence of the path between the mediating and the dependent variable, controlled for the influence of the independent variable (path beta) by means of a default Bayesian hypothesis test for partial correlation (Wetzels & Wagenmakers, 2012).

Thirdly, the evidence for mediation is computed by multiplying the posterior probabilities for the paths alpha and beta.

Fourthly, the evidence for full mediation is computed by multiplying the evidence for mediation with one minus the posterior probability for the existence of path tau', the path between the independent and dependent variable, controlled for the mediator.

Value

jzs_md returns a list containing visible (printed) and invisible components. The visible components are a data frame with the main results and the 95% credible interval of the mediated effect (see next section). The invisible components contain additional information on the parameters, and can be used for plot functions etc.

Visible Output

The visible output, the output that is printed to the screen, is a list containing a data frame and a credible interval.

The mean of the posterior samples of alpha.

Estimate_alpha Estimate_beta The mean of the posterior samples of beta.

Estimate_tau_prime The mean of the posterior samples of tau_prime.

Estimate_Mediation (alpha*beta) The mean of the posterior samples of the indirect effect alpha*beta.

BF_alpha The Bayes factor for the existence of path alpha. A value greater than one indicates evidence that alpha exists, a value smaller than one indicates evidence that alpha does not exist.

BF_beta The Bayes factor for the existence of path beta. A value greater than one indicates evidence that beta exists, a value smaller than one indicates evidence that beta does not exist.

BF_tau_prime The Bayes factor for the existence of path tau_prime. A value greater than one indicates evidence that tau_prime exists, a value smaller than one indicates evidence that tau_prime does not exist.

BF_Mediation (alpha*beta) The Bayes factor for mediation compared to no mediation. A value greater than one indicates evidence in favor of mediation, a value smaller than one indicates evidence against mediation.

PostProb_alpha The posterior probability that the path alpha (the relation between the independent and the mediating variable) is not zero.

PostProb_beta The posterior probability that the path beta (the relation between the mediating and the dependent variable after controlling for the independent variable) is not zero.

PostProb_tau_prime The posterior probability that the path tau_prime (the relation between the independent and the dependent variable after controlling for the mediator) is not zero.

PostProb_Mediation (alpha*beta) The posterior probability that the relation between the independent and the dependent variable is mediated by the specified mediator.

CI_ab The 95% credible interval of the indirect effect "ab".

Author(s)

Michele B. Nuijten <m.b.nuijten@uvt.nl>, Ruud Wetzels, Dora Matzke, Conor V. Dolan, and Eric-Jan Wagenmakers.

References

Liang, F., Paulo, R., Molina, G., Clyde, M. A., & Berger, J. O. (2008). Mixtures of g priors for Bayesian variable selection. Journal of the American Statistical Association, 103(481), 410-423.

Nuijten, M.B., Wetzels, R., Matzke, D., Dolan, C. V., & Wagenmakers, E.-J. (2014). A default Bayesian hypothesis test for mediation. Manuscript submitted for publication.

Wetzels, R., & Wagenmakers, E.-J. (2012). A Default Bayesian Hypothesis Test for Correlations and Partial Correlations. Psychonomic Bulletin & Review, 19, 1057-1064.

See Also

jzs_cor, jzs_partcor, jzs_medSD

Examples

```
## Not run:
# simulate mediational data
a <- .5
b <- .6
t_prime <- .3

X <- rnorm(50,0,1)
M <- a*X + rnorm(50,0,1)
Y <- t_prime*X + b*M + rnorm(50,0,1)

# run jzs_med

result <- jzs_med(independent=X,dependent=Y,mediator=M)
result

#------------------------------------

# load Firefighter data
data(Firefighters)

X <- Firefighters$x
M <- Firefighters$m
Y <- Firefighters$y
```

```
# run jzs_med
result <- jzs_med(independent=X,dependent=Y,mediator=M)

# plot the result in a mediation diagram
plot(result$main_result)

# inspect posterior distribution of the coefficients
plot(result$alpha_samples)
plot(result$beta_samples)
plot(result$tau_prime_samples)

# print a traceplot of the chains
plot(result$jagssamplesA)
plot(result$jagssamplesTB)
# where the first chain (theta[1]) is for tau' and the second chain (theta[2]) for beta

# calculate and plot a 95% credible interval for the
# posterior mean of the indirect effect
result$CI_ab
plot(result$ab_samples)



## End(Not run)
```

`jzs_medSD` *Perform a default Bayesian hypothesis test for mediation using the Savage-Dickey method.*

Description

This function can be used to perform a default Bayesian hypothesis test for mediation, using the Savage-Dickey method (Dickey & Lientz, 1970). The test uses a Jeffreys-Zellner-Siow prior set-up (Liang et al., 2008).

Usage

```
jzs_medSD(independent, dependent, mediator,
          SDmethod=c("fit.st","dnorm","splinefun","logspline"),
          alternativeA=c("two.sided","less","greater"),
          alternativeB=c("two.sided","less","greater"),
          alternativeT=c("two.sided","less","greater"),
          n.iter=10000,n.burnin=500,
          standardize=TRUE)
```

Arguments

`independent`	a vector containing values for the independent variable.
`dependent`	a vector containing values for the dependent variable.

mediator	a vector containing values for the mediating variable.
SDmethod	specify the precise method with which the density of the posterior distribution will be estimated in order to compute the Savage-Dickey ratio.
alternativeA	specify the alternative hypothesis for path alpha: two.sided, greater than zero, or less than zero.
alternativeB	specify the alternative hypothesis for path beta: two.sided, greater than zero, or less than zero.
alternativeT	specify the alternative hypothesis for path tau_accent: two.sided, greater than zero, or less than zero.
n.iter	number of total iterations per chain (see the package R2jags). Defaults to 10000.
n.burnin	length of burn in, i.e. number of iterations to discard at the beginning(see the package R2jags). Defaults to 500.
standardize	logical. Should the variables be standardized? Defaults to TRUE.

Details

The test consists of four steps. Firstly, it computes the posterior probability for the existence of the path between the independent and the mediating variable (path alpha) through the Savage-Dickey density ratio method.

Secondly, it computes the posterior probability for the existence of the path between the mediating and the dependent variable, controlled for the influence of the independent variable (path beta), again with the Savage-Dickey density ratio method.

Thirdly, the evidence for mediation is computed by multiplying the posterior probabilities for the paths alpha and beta.

Fourthly, the evidence for full mediation is computed by multiplying the evidence for mediation with one minus the posterior probability for the existence of path tau', the path between the independent and dependent variable, controlled for the mediator.

Value

jzs_mdSD returns a list containing visible (printed) and invisible components. The visible components are a data frame with the main results and the 95% credible interval of the mediated effect (see next section). The invisible components contain additional information on the parameters, and can be used for plot functions etc.

Visible Output

The visible output, the output that is printed to the screen, is a list containing a data frame and a credible interval.

The mean of the posterior samples of alpha.

Estimate_alpha **Estimate_beta** The mean of the posterior samples of beta.

Estimate_tau_prime The mean of the posterior samples of tau_prime.

Estimate_Mediation (alpha*beta) The mean of the posterior samples of the indirect effect alpha*beta.

BF_alpha The Bayes factor for the existence of path alpha. A value greater than one indicates evidence that alpha exists, a value smaller than one indicates evidence that alpha does not exist.

BF_beta The Bayes factor for the existence of path beta. A value greater than one indicates evidence that beta exists, a value smaller than one indicates evidence that beta does not exist.

BF_tau_prime The Bayes factor for the existence of path tau_prime. A value greater than one indicates evidence that tau_prime exists, a value smaller than one indicates evidence that tau_prime does not exist.

BF_Mediation (alpha*beta) The Bayes factor for mediation compared to no mediation. A value greater than one indicates evidence in favor of mediation, a value smaller than one indicates evidence against mediation.

PostProb_alpha The posterior probability that the path alpha (the relation between the independent and the mediating variable) is not zero.

PostProb_beta The posterior probability that the path beta (the relation between the mediating and the dependent variable after controlling for the independent variable) is not zero.

PostProb_tau_prime The posterior probability that the path tau_prime (the relation between the independent and the dependent variable after controlling for the mediator) is not zero.

PostProb_Mediation (alpha*beta) The posterior probability that the relation between the independent and the dependent variable is mediated by the specified mediator.

CI_ab The 95% credible interval of the indirect effect "ab".

Invisible Output

jzs_medSD also returns output that is not printed to the screen. This invisible output contains the following elements:

The posterior samples of alpha.

alpha_samples beta_samples The posterior samples of beta.

tau_prime_samples The posterior samples of tau_accent.

ab_samples The posterior distribution of alpha multiplied by the posterior distribution of beta. This is equivalent to the posterior distribution of the indirect effect "ab".

jagssamplesA The JAGS output for the MCMC estimation of path alpha. This object can be used to construct a traceplot.

jagssamplesTB The JAGS output for the MCMC estimation of path tau' and beta. This object can be used to construct a traceplot.

Warning

In some cases the SDmethod `fit.st` will fail to converge. If so, jzs_medSD automatically switches to another optimization method (optim stats) with different starting values (mean and sd of the posterior sample). If the other optimization method does not converge either, you could either try to run the same code again (sometimes it will converge a second time), or you could try one of the other SDmethod options or try the analytical mediation test instead (see `jzs_med`).

Note

This function requires the program "JAGS" (Just Another Gibbs Sampler). This program can be obtained from http://mcmc-jags.sourceforge.net.

Author(s)

Michele B. Nuijten <m.b.nuijten@uvt.nl>, Ruud Wetzels, Dora Matzke, Conor V. Dolan, and Eric-Jan Wagenmakers.

References

Dickey, J. M., & Lientz, B. P. (1970). The weighted likelihood ratio, sharp hypotheses about chances, the order of a Markov chain. The Annals of Mathematical Statistics, 214-226.

Liang, F., Paulo, R., Molina, G., Clyde, M. A., & Berger, J. O. (2008). Mixtures of g priors for Bayesian variable selection. Journal of the American Statistical Association, 103(481), 410-423.

Nuijten, M.B., Wetzels, R., Matzke, D., Dolan, C. V., & Wagenmakers, E.-J. (2014). A default Bayesian hypothesis test for mediation. Manuscript submitted for publication.

Wetzels, R., & Wagenmakers, E.-J. (2012). A Default Bayesian Hypothesis Test for Correlations and Partial Correlations. Psychonomic Bulletin & Review, 19, 1057-1064.

See Also

jzs_med

Examples

```
## Not run:

# simulated mediational data
a <- .5
b <- .6
t_prime <- .3

X <- rnorm(50,0,1)
M <- a*X + rnorm(50,0,1)
Y <- t_prime*X + b*M + rnorm(50,0,1)

# run jzs_medSD
result <- jzs_medSD(independent=X,dependent=Y,mediator=M)

# print result
result

### NOTE ###
#Sometimes this error will pop up:
#
#Error in solve.default(nItheta) :
#  system is computationally singular: reciprocal condition number = *some small number*
#Error in mydt2(0, mT, sT, dfT) : unused arguments (mT, sT, dfT)
#In addition: Warning message:
```

```
#In jzs_medSD(X, Y, M) :
#  fit.st did not converge. Alternative optimization method was used.
#
#If this happens, just run jzs_medSD() again.
#This usually solves the convergence problem. If it does not,
#try a different SD method. For instance: jzs_medSD(X,Y,M,SDmethod="dnorm").
#
#############

#-----------------------------------------

# load Firefighter data
data(Firefighters)

X <- Firefighters$x
M <- Firefighters$m
Y <- Firefighters$y

# run jzs_medSD
result <- jzs_medSD(independent=X,dependent=Y,mediator=M)

# plot the result in a mediation diagram
plot(result$main_result)

# inspect posterior distribution of the coefficients
plot(result$alpha_samples)
plot(result$beta_samples)
plot(result$tau_prime_samples)

# print a traceplot of the chains
plot(result$jagssamplesA)
plot(result$jagssamplesTB)
# where the first chain (theta[1]) is for tau' and the second chain (theta[2]) for beta

# calculate and plot a 95% credible interval for the
# posterior mean of the indirect effect
result$CI_ab
plot(result$ab_samples)



## End(Not run)
```

`jzs_partcor` *A default Bayesian hypothesis test for partial correlation (Wetzels, R., & Wagenmakers).*

Description

This function can be used to perform a default Bayesian hypothesis test for partial correlation, using a Jeffreys-Zellner-Siow prior set-up (Liang et al., 2008).

Usage

```
jzs_partcor(V1, V2, control, alternative = c("two.sided", "less", "greater"),
          n.iter=10000,n.burnin=500,standardize=TRUE)
```

Arguments

V1	a numeric vector.
V2	a numeric vector of the same length as V1.
control	a numeric vector of the same length as V1 and V2. This variable is partialled out of the correlation between V1 and V2.
alternative	specify the alternative hypothesis for the correlation coefficient: two.sided, greater than zero, or less than zero.
n.iter	number of total iterations per chain (see the package R2jags). Defaults to 10000.
n.burnin	length of burn in, i.e. number of iterations to discard at the beginning(see the package R2jags). Defaults to 500.
standardize	logical. Should the variables be standardized? Defaults to TRUE.

Details

See Wetzels & Wagenmakers, 2012.

Value

The function returns a list with the following items:

PartCoef	Mean of the posterior samples of the unstandardized partial correlation (the regression coefficient beta in the equation V2 = intercept + alpha*control + beta*V1).
BayesFactor	The Bayes factor for the existence of a partial correlation between V1 and V2, controlled for the control variable. A value greater than one indicates evidence in favor of partial correlation, a value smaller than one indicates evidence against partial correlation.
PosteriorProbability	The posterior probability for the existence of a partial correlation between V1 and V2, controlled for the control variable.
beta	The posterior samples for the regression coefficient beta. This is the unstandardized partial correlation.
jagssamples	The JAGS output for the MCMC estimation of the path. This object can be used to construct a traceplot.

Author(s)

Michele B. Nuijten <m.b.nuijten@uvt.nl>, Ruud Wetzels, Dora Matzke, Conor V. Dolan, and Eric-Jan Wagenmakers.

References

Liang, F., Paulo, R., Molina, G., Clyde, M. A., & Berger, J. O. (2008). Mixtures of g priors for Bayesian variable selection. Journal of the American Statistical Association, 103(481), 410-423.

Nuijten, M.B., Wetzels, R., Matzke, D., Dolan, C. V., & Wagenmakers, E.-J. (2014). A default Bayesian hypothesis test for mediation. Manuscript submitted for publication.

Wetzels, R., & Wagenmakers, E.-J. (2012). A Default Bayesian Hypothesis Test for Correlations and Partial Correlations. Psychonomic Bulletin & Review, 19, 1057-1064.

Examples

```
## Not run:
# simulate partially correlated data
X <- rnorm(50,0,1)
C <- .5*X + rnorm(50,0,1)
Y <- .3*X + .6*C + rnorm(50,0,1)

# run jzs_partcor
res <- jzs_partcor(X,Y,C)

# plot posterior samples
plot(res$beta_samples)

# plot traceplot
plot(res$jagssamples)
# where the first chain (theta[1]) is for tau' and the second chain (theta[2]) for beta


## End(Not run)
```

`jzs_partcorSD` *A default Bayesian hypothesis test for partial correlation using the Savage-Dickey method.*

Description

This function can be used to perform a default Bayesian hypothesis test for partial correlation, using the Savage-Dickey method (Dickey & Lientz, 1970). The test uses a Jeffreys-Zellner-Siow prior set-up (Liang et al., 2008).

Usage

```
jzs_partcorSD(V1, V2, control,
              SDmethod = c("fit.st", "dnorm", "splinefun", "logspline"),
              alternative = c("two.sided", "less", "greater"),
              n.iter=10000,n.burnin=500,standardize=TRUE)
```

Arguments

V1	a numeric vector.
V2	a numeric vector of the same length as V1.
control	a numeric vector of the same length as V1 and V2. This variable is partialled out of the correlation between V1 and V2.
SDmethod	specify the precise method with which the density of the posterior distribution will be estimated in order to compute the Savage-Dickey ratio.
alternative	specify the alternative hypothesis for the correlation coefficient: `two.sided`, `greater` than zero, or `less` than zero.
n.iter	number of total iterations per chain (see the package `R2jags`). Defaults to 10000.
n.burnin	length of burn in, i.e. number of iterations to discard at the beginning(see the package `R2jags`). Defaults to 500.
standardize	logical. Should the variables be standardized? Defaults to TRUE.

Value

PartCoef	Mean of the posterior samples of the unstandardized partial correlation (the regression coefficient beta in the equation V2 = intercept + alpha*control + beta*V1).
BayesFactor	The Bayes factor for the correlation coefficient. A value greater than one indicates evidence in favor of correlation, a value smaller than one indicates evidence against correlation.
PosteriorProbability	The posterior probability for the existence of a correlation between V1 and V2.
beta	The posterior samples for the regression coefficient beta. This is the unstandardized partial correlation.
jagssamples	The JAGS output for the MCMC estimation of the path. This object can be used to construct a traceplot.

Warning

In some cases the SDmethod `fit.st` will fail to converge. If so, another optimization method is used, using different starting values. If the other optimization method does not converge either or gives you a negative Bayes factor (which is meaningless), you could try one of the other SDmethod options or see `jzs_partcor`.

Author(s)

Michele B. Nuijten <m.b.nuijten@uvt.nl>, Ruud Wetzels, Dora Matzke, Conor V. Dolan, and Eric-Jan Wagenmakers.

References

Dickey, J. M., & Lientz, B. P. (1970). The weighted likelihood ratio, sharp hypotheses about chances, the order of a Markov chain. The Annals of Mathematical Statistics, 214-226.

Liang, F., Paulo, R., Molina, G., Clyde, M. A., & Berger, J. O. (2008). Mixtures of g priors for Bayesian variable selection. Journal of the American Statistical Association, 103(481), 410-423.

Nuijten, M.B., Wetzels, R., Matzke, D., Dolan, C. V., & Wagenmakers, E.-J. (2014). A default Bayesian hypothesis test for mediation. Manuscript submitted for publication.

Wetzels, R., & Wagenmakers, E.-J. (2012). A Default Bayesian Hypothesis Test for Correlations and Partial Correlations. Psychonomic Bulletin & Review, 19, 1057-1064.

See Also

jzs_partcor, jzs_corSD

Examples

```
# simulate partially correlated data
X <- rnorm(50,0,1)
C <- .5*X + rnorm(50,0,1)
Y <- .3*X + .6*C + rnorm(50,0,1)

# run jzs_partcor
(res <- jzs_partcorSD(X,Y,C))

# plot posterior samples
plot(res$beta_samples)

# plot traceplot
plot(res$jagssamples)
# where the first chain (theta[1]) is for tau' and the second chain (theta[2]) for beta
```

---

plot.CI *Plot the posterior distribution of the indirect effect alpha*beta*

Description

Plot the posterior distribution of the indirect effect alpha*beta including a 95% credible interval around the mean of the posterior (see Nuijten et al. (2014); Yuan & MacKinnon, 2009).

Usage

```
## S3 method for class 'CI'
plot(x,...)
```

Arguments

x	the posterior samples of alpha*beta as obtained from the output of jzs_medSD. This is an object of class CI.
...	additional arguments to be passed on to the plot method, such as graphical parameters (see par).

Author(s)

Michele B. Nuijten <m.b.nuijten@uvt.nl>, Ruud Wetzels, Dora Matzke, Conor V. Dolan, and Eric-Jan Wagenmakers.

References

Nuijten, M.B., Wetzels, R., Matzke, D., Dolan, C. V., & Wagenmakers, E.-J. (2014). A default Bayesian hypothesis test for mediation. Manuscript submitted for publication.

Yuan, Y., & MacKinnon, D. (2009). Bayesian mediation analysis. Psychological Methods, 14, 301-322.

See Also

jzs_medSD

Examples

```
## Not run:
# simulate mediational data
a <- .5
b <- .6
t_prime <- .3

X <- rnorm(50,0,1)
M <- a*X + rnorm(50,0,1)
Y <- t_prime*X + b*M + rnorm(50,0,1)

# run jzs_medSD
res <- jzs_medSD(independent=X,dependent=Y,mediator=M)

# plot posterior distribution of a*b
plot(res$ab_samples)

# print the exact lower and upper boundary of the interval
res$CI_ab

## End(Not run)
```

plot.JZSMed *Display the results of* jzs_med *in a figure.*

Description

This function displays the estimates and posterior probabilities of path alpha, beta, and tau' in a mediation schema and thus renders a clear view of the structure in the data.

Usage

```
## S3 method for class 'JZSMed'
plot(x,...)
```

Arguments

x	the output of the jzs_med function.
...	additional arguments to be passed on to the plot method, such as graphical parameters (see par).

Author(s)

Michele B. Nuijten <m.b.nuijten@uvt.nl>, Ruud Wetzels, Dora Matzke, Conor V. Dolan, and Eric-Jan Wagenmakers.

See Also

jzs_med

Examples

```
## Not run:
# simulate mediational data
a <- .5
b <- .6
t_prime <- .3

X <- rnorm(50,0,1)
M <- a*X + rnorm(50,0,1)
Y <- t_prime*X + b*M + rnorm(50,0,1)

# save jzs_medSD output
res <- jzs_medSD(independent=X,dependent=Y,mediator=M)

# plot results
plot(res$main_result)

## End(Not run)
```

plot.rjags *Plot the chains of the JAGS samples*

Description

Displays a plot of iterations vs. sampled values for each variable in the chain, with a separate plot per variable (see `traceplot` of the package `R2jags`; Su & Yajima, 2012).

Usage

```
## S3 method for class 'rjags'
plot(x,...)
```

Arguments

`x`	an `rjags` object.
`...`	additional arguments to be passed on to the traceplot method, such as graphical parameters (see `traceplot`).

Author(s)

Michele B. Nuijten <m.b.nuijten@uvt.nl>, Ruud Wetzels, Dora Matzke, Conor V. Dolan, and Eric-Jan Wagenmakers.

References

Nuijten, M.B., Wetzels, R., Matzke, D., Dolan, C. V., & Wagenmakers, E.-J. (2014). A default Bayesian hypothesis test for mediation. Manuscript submitted for publication.

Su, Y.-S., & Yajima, M. (2012). R2jags: A package for running jags from Rb[Computer software manual]. Available from http://CRAN.R-project.org/package=R2jags (R package version 0.03-08)

Examples

```
## Not run:
# simulate correlational data
X <- rnorm(50,0,1)
Y <- .3*X + rnorm(50,0,1)

# save jzs_corSD output
res <- jzs_corSD(X,Y)

# plot results
plot(res$jagssamples)

############

# simulate mediational data
a <- .5
```

```
b <- .6
t_prime <- .3

X <- rnorm(50,0,1)
M <- a*X + rnorm(50,0,1)
Y <- t_prime*X + b*M + rnorm(50,0,1)

# run jzs_medSD
res2 <- jzs_medSD(independent=X,dependent=Y,mediator=M,SDmethod='dnorm')

# plot resulting chains for alpha, beta, and tau_prime
plot(res2$jagssamplesA)
plot(res2$jagssamplesTB)

## End(Not run)
```

`print.jzs_med` *Print jzs_med output.*

Description

Print the output of a jzs_med object.

Usage

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

Arguments

`x`	a JZSMedSD object.
`...`	further arguments passed to or from other methods.

Value

The function returns a list with the following items:

`EvidenceMediation`
: The posterior probability that the relation between the independent and the dependent variable is mediated by the specified mediator.

`EvidenceFullMediation`
: The posterior probability that the relation between the independent and the dependent variable is fully mediated by the specified mediator and the direct effect of the independent variable on the dependent variable disappears after introducing the mediator.

`BF_Mediation`
: The Bayes factor for mediation compared to no mediation. A value greater than one indicates evidence in favor of mediation, a value smaller than one indicates evidence against mediation.

`BF_FullMediation`
: The Bayes factor for full mediation compared to no mediation. A value greater than one indicates evidence in favor of full mediation, a value smaller than one indicates evidence against full mediation.

`BF_alpha`
: The Bayes factor for the existence of path alpha. A value greater than one indicates evidence that alpha exists, a value smaller than one indicates evidence that alpha does not exist.

`BF_beta`
: The Bayes factor for the existence of path beta. A value greater than one indicates evidence that beta exists, a value smaller than one indicates evidence that beta does not exist.

`BF_tau_accent`
: The Bayes factor for the existence of path tau_accent. A value greater than one indicates evidence that tau_accent exists, a value smaller than one indicates evidence that tau_accent does not exist.

Author(s)

Michele B. Nuijten <m.b.nuijten@uvt.nl>, Ruud Wetzels, Dora Matzke, Conor V. Dolan, and Eric-Jan Wagenmakers.

Examples

```
## Not run:
# simulate mediational data
a <- .5
b <- .6
t_prime <- .3

X <- rnorm(50,0,1)
M <- a*X + rnorm(50,0,1)
Y <- t_prime*X + b*M + rnorm(50,0,1)

# run jzs_medSD
result <- jzs_medSD(independent=X,dependent=Y,mediator=M,SDmethod='dnorm')

# print result
result

## End(Not run)
```

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