# Package ‘epsiwal’

June 10, 2026

**Version** 0.2.0

**Date** 2026-06-08

**License** LGPL-3

**Title** Exact Post Selection Inference with Applications to the Lasso

**BugReports** https://github.com/shabbychef/epsiwal/issues

**Description** Implements the conditional estimation procedure of Lee, Sun, Sun and Taylor (2016) <doi:10.1214/15-AOS1371>. This procedure allows hypothesis testing on the mean of a normal random vector subject to linear constraints. Also supports computation of the MLE of the mean subject to the same constraints.

**Depends** R (>= 3.0.2)

**Suggests** testthat

**URL** https://github.com/shabbychef/epsiwal

**Collate** 'ci_connorm.r' 'epsiwal.r' 'mle_connorm.r' 'pconnorm.r' 'ptruncnorm.r' 'utils.r'

**RoxygenNote** 7.3.3

**NeedsCompilation** no

**Author** Steven E. Pav [aut, cre] (ORCID: <https://orcid.org/0000-0002-4197-6195>)

**Maintainer** Steven E. Pav <shabbychef@gmail.com>

**Repository** CRAN

**Date/Publication** 2026-06-10 05:21:20 UTC

## Contents

---

`ci_connorm` *ci_connorm* .

---

## Description

Confidence intervals on normal mean, subject to linear constraints.

## Usage

```
ci_connorm(
  y,
  A,
  b,
  eta,
  Sigma = NULL,
  p = c(level/2, 1 - (level/2)),
  level = 0.05,
  Sigma_eta = Sigma %*% eta
)
```

## Arguments

| | |
|---|---|
| `y` | an $n$ vector, assumed multivariate normal with mean $\mu$ and covariance $\Sigma$. |
| `A` | an $k \times n$ matrix of constraints. |
| `b` | a $k$ vector of inequality limits. |
| `eta` | an $n$ vector of the test contrast, $\eta$. |
| `Sigma` | an $n \times n$ matrix of the population covariance, $\Sigma$. Not needed if `Sigma_eta` is given. |
| `p` | a vector of probabilities for which we return equivalent $\eta^\top \mu$. |
| `level` | if `p` is not given, we set it by default to `c(level/2,1-level/2)`. |
| `Sigma_eta` | an $n$ vector of $\Sigma\eta$. |

## Details

Inverts the constrained normal inference procedure described by Lee *et al.*

Let $y$ be multivariate normal with unknown mean $\mu$ and known covariance $\Sigma$. Conditional on $Ay \leq b$ for conformable matrix $A$ and vector $b$, and given constrast vector $eta$ and level $p$, we compute $\eta^\top \mu$ such that the cumulative distribution of $\eta^\top y$ equals $p$.

### Value

The values of $\eta^\top \mu$ which have the corresponding CDF.

### Note

An error will be thrown if we do not observe $Ay \le b$.

### Author(s)

Steven E. Pav <shabbychef@gmail.com>

### References

Lee, J. D., Sun, D. L., Sun, Y. and Taylor, J. E. "Exact post-selection inference, with application to the Lasso." Ann. Statist. 44, no. 3 (2016): 907-927. doi:10.1214/15-AOS1371. https://arxiv.org/abs/1311.6238

### See Also

the CDF function, pconnorm, the MLE function, mle_connorm, the special case code for conditioning on the max, ci_connorm_max

### Examples

```
set.seed(1234)
n <- 10
y <- rnorm(n)
A <- matrix(rnorm(n*(n-3)),ncol=n)
b <- A%*%y + runif(nrow(A))
Sigma <- diag(runif(n))
mu <- rnorm(n)
eta <- rnorm(n)

pval <- pconnorm(y=y,A=A,b=b,eta=eta,mu=mu,Sigma=Sigma)
cival <- ci_connorm(y=y,A=A,b=b,eta=eta,Sigma=Sigma,p=pval)
stopifnot(abs(cival - sum(eta*mu)) < 1e-4)
```

---

`ci_connorm_max` *ci_connorm_max .*

---

### Description

Confidence intervals on normal mean, conditioning on the max.

## Usage

```
ci_connorm_max(
  yk,
  yk1,
  sigma = 1,
  rho = 0,
  p = c(level/2, 1 - (level/2)),
  level = 0.05
)
```

## Arguments

| | |
|---|---|
| yk | the observed maximum value, $y_k$. |
| yk1 | a vector of the other observed values, $y_{k1}$, or just the scalar second largest value. |
| sigma | the common standard deviation. |
| rho | the common correlation. |
| p | a vector of probabilities for which we return equivalent $\eta^\top \mu$. |
| level | if p is not given, we set it by default to c(level/2,1-level/2). |

## Details

Computes the confidence interval of unknown mean of a normal vector conditional on the one element being the maximum.

Let $y$ be multivariate normal with unknown mean $\mu$ and known covariance $\Sigma$. We assume that $\Sigma$ is compound symmetric with common variance $\sigma^2$ and common correlation $\rho$.

Conditional on $y_k \geq y_i$ for all $i$, we compute the confidence interval of $\mu_k$.

## Value

The values of $\mu_k$ which have the corresponding CDF.

## Author(s)

Steven E. Pav <shabbychef@gmail.com>

## References

Lee, J. D., Sun, D. L., Sun, Y. and Taylor, J. E. "Exact post-selection inference, with application to the Lasso." Ann. Statist. 44, no. 3 (2016): 907-927. doi:10.1214/15-AOS1371. https://arxiv.org/abs/1311.6238

## See Also

the CDF function, pconnorm, the MLE function, mle_connorm_max, the more general version, ci_connorm.

epsiwal *Exact Post Selection Inference with Applications to the Lasso.*

## Description

Exact Post Selection Inference with Applications to the Lasso.

## Details

This simple package supports the simple procedure outlined in Lee *et al.* where one observes a normal random variable, then performs inference conditional on some linear inequalities.

Suppose $y$ is multivariate normal with mean $\mu$ and covariance $\Sigma$. Conditional on $Ay \le b$, one can perform inference on $\eta^\top \mu$ by transforming $y$ to a truncated normal. Similarly one can invert this procedure and find confidence intervals on $\eta^\top \mu$.

## Legal Mumbo Jumbo



## Note

This package is maintained as a hobby.

## Author(s)

Steven E. Pav <shabbychef@gmail.com>

**Maintainer**: Steven E. Pav <shabbychef@gmail.com> (ORCID)

## References

Lee, J. D., Sun, D. L., Sun, Y. and Taylor, J. E. "Exact post-selection inference, with application to the Lasso." Ann. Statist. 44, no. 3 (2016): 907-927. doi:10.1214/15-AOS1371. https://arxiv.org/abs/1311.6238

Pav, S. E. "Conditional inference on the asset with maximum Sharpe ratio." Arxiv e-print (2019). https://arxiv.org/abs/1906.00573

Pav, S. E. "Post selection estimation of Sharpe ratios." Arxiv e-print (2026). https://arxiv.org/abs/2606.01650

## See Also

Useful links:

- https://github.com/shabbychef/epsiwal
- Report bugs at https://github.com/shabbychef/epsiwal/issues

| epsiwal-NEWS | *News for package 'epsiwal':* |
|---|---|

## Description

News for package 'epsiwal'

## epsiwal Initial Version 0.2.0 (2026-06-08)

- fix numerical stability issues in ptruncnorm and downstream utilities (CIs).
- add MLE estimator of Reid, Taylor, Tibshirani.
- add helper functions for the case of conditioning on the max of a vector.

## epsiwal Initial Version 0.1.0 (2019-06-28)

- first CRAN release.

| mle_connorm | *mle_connorm .* |
|---|---|

## Description

Maximum likelihood estimate of normal mean, subject to linear constraints.

## Usage

```
mle_connorm(y, A, b, eta, Sigma = NULL, Sigma_eta = Sigma %*% eta, ...)
```

## Arguments

| | |
|---|---|
| `y` | an $n$ vector, assumed multivariate normal with mean $\mu$ and covariance $\Sigma$. |
| `A` | an $k \times n$ matrix of constraints. |
| `b` | a $k$ vector of inequality limits. |
| `eta` | an $n$ vector of the test contrast, $\eta$. |
| `Sigma` | an $n \times n$ matrix of the population covariance, $\Sigma$. Not needed if `Sigma_eta` is given. |
| `Sigma_eta` | an $n$ vector of $\Sigma\eta$. |
| `...` | dots are passed to `uniroot`. |

### Details

Computes the maximum likelihood estimate of unknown mean of a normal vector conditional on linear constraints.

Let $y$ be multivariate normal with unknown mean $\mu$ and known covariance $\Sigma$. Conditional on $Ay \leq b$ for conformable matrix $A$ and vector $b$, and given constrast vector $eta$, we compute the maximum likelihood estimate of $\eta^\top \mu$.

### Value

The maximum likelihood estimate of $\eta^\top \mu$.

### Author(s)

Steven E. Pav <shabbychef@gmail.com>

### References

Reid, S., Taylor, J. and Tibshirani, R. "Post-selection point and interval estimation of signal sizes in Gaussian samples." Can. J. Statistics. 45, no. 2 (2017): 128-148. doi:10.1002/cjs.11320. https://arxiv.org/abs/1405.3340

### See Also

the confidence interval function, ci_connorm, the CDF function, pconnorm, the special case code for conditioning on the max, mle_connorm_max

### Examples

```
set.seed(1234)
n <- 10
y <- rnorm(n)
A <- matrix(rnorm(n*(n-3)),ncol=n)
b <- A%*%y + runif(nrow(A))
Sigma <- diag(runif(n))
mu <- rnorm(n)
eta <- rnorm(n)

mval <- mle_connorm(y=y,A=A,b=b,eta=eta,Sigma=Sigma)
# try again, but control tolerance:
mval <- mle_connorm(y=y,A=A,b=b,eta=eta,Sigma=Sigma,tol=1e-8)
```

mle_connorm_max *mle_connorm_max* .

## Description

Maximum likelihood estimate of normal mean, conditioning on the max.

## Usage

```
mle_connorm_max(yk, yk1, sigma = 1, rho = 0, ...)
```

## Arguments

| | |
|---|---|
| yk | the observed maximum value, $y_k$. |
| yk1 | a vector of the other observed values, $y_{k1}$, or just the scalar second largest value. |
| sigma | the common standard deviation. |
| rho | the common correlation. |
| ... | dots are passed to `uniroot`. |

## Details

Computes the maximum likelihood estimate of unknown mean of a normal vector conditional on the one element being the maximum.

Let $y$ be multivariate normal with unknown mean $\mu$ and known covariance $\Sigma$. We assume that $\Sigma$ is compound symmetric with common variance $\sigma^2$ and common correlation $\rho$.

Conditional on $y_k \geq y_i$ for all $i$, we compute the maximum likelihood estimate of $\mu_k$.

## Value

The maximum likelihood estimate of $\mu_k$.

## Author(s)

Steven E. Pav <shabbychef@gmail.com>

## References

Reid, S., Taylor, J. and Tibshirani, R. "Post-selection point and interval estimation of signal sizes in Gaussian samples." Can. J. Statistics. 45, no. 2 (2017): 128-148. doi:10.1002/cjs.11320. https://arxiv.org/abs/1405.3340

## See Also

the confidence interval function, `ci_connorm_max`, the CDF function, `pconnorm`, the more general version, `mle_connorm`.

pconnorm *pconnorm .*

## Description

CDF of the conditional normal variate.

## Usage

```
pconnorm(
  y,
  A,
  b,
  eta,
  mu = NULL,
  Sigma = NULL,
  Sigma_eta = Sigma %*% eta,
  eta_mu = as.numeric(t(eta) %*% mu),
  lower.tail = TRUE,
  log.p = FALSE
)
```

## Arguments

| | |
|---|---|
| `y` | an $n$ vector, assumed multivariate normal with mean $\mu$ and covariance $\Sigma$. |
| `A` | an $k \times n$ matrix of constraints. |
| `b` | a $k$ vector of inequality limits. |
| `eta` | an $n$ vector of the test contrast, $\eta$. |
| `mu` | an $n$ vector of the population mean, $\mu$. Not needed if `eta_mu` is given. |
| `Sigma` | an $n \times n$ matrix of the population covariance, $\Sigma$. Not needed if `Sigma_eta` is given. |
| `Sigma_eta` | an $n$ vector of $\Sigma\eta$. |
| `eta_mu` | the scalar $\eta^\top\mu$. |
| `lower.tail` | logical; if TRUE (default), probabilities are P[X <= x] otherwise, P[X > x]. |
| `log.p` | logical; if TRUE, probabilities p are returned as log(p). |

## Details

Computes the CDF of the truncated normal conditional on linear constraints, as described in section 5 of Lee *et al.*

Let $y$ be multivariate normal with mean $\mu$ and covariance $\Sigma$. Conditional on $Ay \le b$ for conformable matrix $A$ and vector $b$ we compute the CDF of a truncated normal maximally aligned with $\eta$. Inference depends on the population parameters only via $\eta^\top\mu$ and $\Sigma\eta$, and only these need to be given.

The test statistic is aligned with $y$, meaning that an output p-value near one casts doubt on the null hypothesis that $\eta^\top\mu$ is less than the posited value.

### Value

The CDF.

### Note

An error will be thrown if we do not observe $Ay \leq b$.

### Author(s)

Steven E. Pav <shabbychef@gmail.com>

### References

Lee, J. D., Sun, D. L., Sun, Y. and Taylor, J. E. "Exact post-selection inference, with application to the Lasso." Ann. Statist. 44, no. 3 (2016): 907-927. doi:10.1214/15-AOS1371. https://arxiv.org/abs/1311.6238

### See Also

the confidence interval function, `ci_connorm`, the MLE function, `mle_connorm`.

---

## pconnorm_max *pconnorm_max .*

---

### Description

CDF of the conditional normal variate, conditioning on the max.

### Usage

```
pconnorm_max(
  yk,
  yk1,
  mu_k,
  sigma = 1,
  rho = 0,
  lower.tail = TRUE,
  log.p = FALSE
)
```

### Arguments

| | |
|---|---|
| `yk` | the observed maximum value, $y_k$. |
| `yk1` | a vector of the other observed values, $y_{k1}$, or just the scalar second largest value. |
| `mu_k` | the scalar mean of the maximal element $\mu_k$. |
| `sigma` | the common standard deviation. |

| | |
|---|---|
| `rho` | the common correlation. |
| `lower.tail` | logical; if TRUE (default), probabilities are P[X <= x] otherwise, P[X > x]. |
| `log.p` | logical; if TRUE, probabilities p are returned as log(p). |

## Details

Computes the CDF of the conditional maximum of a normal vector using the truncated normal from the polyhedral lemma. Let $y$ be multivariate normal where the maximal observed element is known to have mean $\mu_k$, and the vector has known covariance $\Sigma$. We assume that $\Sigma$ is compound symmetric with common variance $\sigma^2$ and common correlation $\rho$.

Conditional on $y_k \geq y_i$ for all $i$, we compute the CDF of $y_k$

## Value

The CDF.

## Author(s)

Steven E. Pav <shabbychef@gmail.com>

## References

Lee, J. D., Sun, D. L., Sun, Y. and Taylor, J. E. "Exact post-selection inference, with application to the Lasso." Ann. Statist. 44, no. 3 (2016): 907-927. doi:10.1214/15-AOS1371. https://arxiv.org/abs/1311.6238

## See Also

the general CDF function, `pconnorm`, the MLE function, `mle_connorm_max`, the confidence interval function, `ci_connorm_max`.

---

`ptruncnorm` *ptruncnorm .*

---

## Description

Cumulative distribution of the truncated normal function.

## Usage

```
ptruncnorm(
  q,
  mean = 0,
  sd = 1,
  a = -Inf,
  b = Inf,
  lower.tail = TRUE,
  log.p = FALSE
)
```

## Arguments

| | |
|---|---|
| `q` | vector of quantiles, |
| `mean` | vector of means. |
| `sd` | vector of standard deviations. |
| `a` | vector of the left truncation value(s). |
| `b` | vector of the right truncation value(s). |
| `lower.tail` | logical; if TRUE (default), probabilities are P[X <= x] otherwise, P[X > x]. |
| `log.p` | logical; if TRUE, probabilities p are returned as log(p). |

## Value

The distribution function of the truncated normal.

Invalid arguments will result in return value `NaN` with a warning.

## Note

Input are recycled as possible.

## Author(s)

Steven E. Pav <shabbychef@gmail.com>

## References

Hattaway, James T. "Parameter estimation and hypothesis testing for the truncated normal distribution with applications to introductory statistics grades." BYU Masters Thesis (2010). https://scholarsarchive.byu.edu/cgi/viewcontent.cgi?referer=&httpsredir=1&article=3052&context=etd

## Examples

```
y <- ptruncnorm(seq(-5,5,length.out=101), a=-1, b=2)
```

# Index