

# Package: ppRep (via r-universe)

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**Author** Samuel Pawel [aut, cre]  
(<https://orcid.org/0000-0003-2779-320X>)

**Maintainer** Samuel Pawel <samuel.pawel@uzh.ch>

**Title** Analysis of Replication Studies using Power Priors

**Description** Provides functionality for Bayesian analysis of replication studies using power prior approaches (Pawel et al., 2023) <[doi:10.1007/s11749-023-00888-5](https://doi.org/10.1007/s11749-023-00888-5)>.

**License** GPL-3

**Encoding** UTF-8

**Imports** hypergeo

**Suggests** roxygen2, tinytest, cubature

**NeedsCompilation** no

**RoxygenNote** 7.2.3

**URL** <https://github.com/SamCH93/ppRep>

**BugReports** <https://github.com/SamCH93/ppRep/issues>

**Repository** <https://samch93.r-universe.dev>

**RemoteUrl** <https://github.com/samch93/pprep>

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|           |   |
|-----------|---|
| bfPPalpha | <i>Bayes factor for testing power parameter</i> |
|-----------|---|

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### Description

This function computes the Bayes factor contrasting  $H_1: \alpha = 1$  to  $H_0: \alpha < 1$  for the replication data assuming a normal likelihood. The power parameter  $\alpha$  indicates how much the normal likelihood of the original data is raised to and then incorporated in the prior for the effect size  $\theta$  (e.g., for  $\alpha = 0$  the original data are completely discounted). Under  $H_0$ , the power parameter can either be fixed to 0, or it can have a beta distribution  $\alpha|H_0 \sim \text{Beta}(1, y)$ . For the fixed power parameter case, the specification of a unit-information prior  $\theta \sim N(0, uv)$  for the effect size  $\theta$  is required as the prior is otherwise not proper.

### Usage

```
bfPPalpha(tr, sr, to, so, y = 2, uv = NA, ...)
```

### Arguments

|     |   |
|-----|---|
| tr  | Effect estimate of the replication study.   |
| sr  | Standard error of the replication effect estimate.  |
| to  | Effect estimate of the original study.  |
| so  | Standard error of the original effect estimate.   |
| y   | Number of failures parameter for beta prior of power parameter under $H_0$ . Has to be larger than 1 so that density is monotonically decreasing. Defaults to 2 (a linearly decreasing prior with zero density at 1). Is only taken into account when $uv = NA$ . |
| uv  | Variance of the unit-information prior for the effect size that is used for testing the simple hypothesis $H_0: \alpha = 0$ . Defaults to NA.   |
| ... | Additional arguments passed to <code>stats::integrate</code> .  |

### Value

Bayes factor (BF > 1 indicates evidence for  $H_0$ , whereas BF < 1 indicates evidence for  $H_1$ )

### Author(s)

Samuel Pawel

### See Also

[bfPPtheta](#)

**Examples**

```
## use unit variance of 2
bfPPalpha(tr = 0.09, sr = 0.0518, to = 0.205, so = 0.0506, uv = 2)

## use beta prior alpha|H1 ~ Be(1, y = 2)
bfPPalpha(tr = 0.09, sr = 0.0518, to = 0.205, so = 0.0506, y = 2)
```

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|           |   |
|-----------|---|
| bfPPtheta | <i>Bayes factor for testing effect size</i> |
|-----------|---|

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**Description**

This function computes the Bayes factor contrasting  $H_0: \theta = 0$  to  $H_1: \theta \sim f(\theta|to, so, \alpha)$  for the replication data assuming a normal likelihood. The prior of the effect size  $\theta$  under  $H_1$  is the posterior of the effect size obtained from combining a normal likelihood of the original data raised to the power of  $\alpha$  with a flat initial prior with a. Under  $H_1$ , the power parameter can either be fixed to some value between 0 and 1, or it can have a beta distribution  $\alpha|H_1 \sim \text{Beta}(x, y)$ .

**Usage**

```
bfPPtheta(tr, sr, to, so, x = 1, y = 1, alpha = NA, ...)
```

**Arguments**

|       |  |
|-------|--|
| tr    | Effect estimate of the replication study.  |
| sr    | Standard error of the replication effect estimate.   |
| to    | Effect estimate of the original study.   |
| so    | Standard error of the original effect estimate.  |
| x     | Number of successes parameter for beta prior of power parameter under $H_1$ . Defaults to 1. Is only taken into account when <code>alpha = NA</code> . |
| y     | Number of failures parameter for beta prior of power parameter under $H_1$ . Defaults to 1. Is only taken into account when <code>alpha = NA</code> .  |
| alpha | Power parameter under $H_1$ . Can be set to a number between 0 and 1. Defaults to NA.  |
| ...   | Additional arguments passed to <code>stats::integrate</code> .   |

**Value**

Bayes factor (BF > 1 indicates evidence for  $H_0$ , whereas BF < 1 indicates evidence for  $H_1$ )

**Author(s)**

Samuel Pawel

**See Also**[bfPPalpha](#)**Examples**

```
## uniform prior on power parameter
bfPPtheta(tr = 0.09, sr = 0.0518, to = 0.205, so = 0.0506)

## power parameter fixed to alpha = 1
bfPPtheta(tr = 0.090, sr = 0.0518, to = 0.205, so = 0.0506, alpha = 1)
```

margLik

*Marginal likelihood of replication effect estimate***Description**

This function computes the marginal likelihood of the replication effect estimate `tr` under the power prior model

$$f(\text{tr}|\text{to}, \text{so}, \text{sr}, x, y) = \int_0^1 \int_{-\infty}^{\infty} \text{N}(\text{tr}; \theta, \text{sr}^2) \times \text{N}(\theta; \mu, \phi) \times \text{Beta}(\alpha; x, y) \, d\theta \, d\alpha$$

with  $\phi = 1/(1/v + \alpha/\text{so}^2)$  and  $\mu = \phi\{(\alpha \times \text{to})/\text{so}^2 + m/v\}$  using numerical integration.

**Usage**

```
margLik(tr, to, sr, so, x = 1, y = 1, m = 0, v = Inf, ...)
```

**Arguments**

|                  |  |
|------------------|--|
| <code>tr</code>  | Effect estimate of the replication study.  |
| <code>to</code>  | Effect estimate of the original study.   |
| <code>sr</code>  | Standard error of the replication effect estimate.   |
| <code>so</code>  | Standard error of the original effect estimate.  |
| <code>x</code>   | Number of successes parameter of beta prior for $\alpha$ . Defaults to 1.                  |
| <code>y</code>   | Number of failures parameter of beta prior for $\alpha$ . Defaults to 1.                   |
| <code>m</code>   | Mean parameter of initial normal prior for $\theta$ . Defaults to 0.                       |
| <code>v</code>   | Variance parameter of initial normal prior for $\theta$ . Defaults to Inf (uniform prior). |
| <code>...</code> | Additional arguments passed to <code>stats::integrate</code> .                             |

**Value**

Marginal likelihood

**Author(s)**

Samuel Pawel

plotPP

*Plot joint and marginal posterior distributions***Description**

This convenience function computes and, if desired, visualizes the joint posterior density of effect size  $\theta$  and power parameter  $\alpha$ , as well as the marginal posterior densities of effect size  $\theta$  and power parameter  $\alpha$  individually. See the functions [postPP](#), [postPPalpha](#), and [postPPtheta](#) for more details on their computation.

**Usage**

```
plotPP(
  tr,
  sr,
  to,
  so,
  x = 1,
  y = 1,
  m = 0,
  v = Inf,
  thetaRange = c(tr - 3 * sr, tr + 3 * sr),
  alphaRange = c(0, 1),
  nGrid = 100,
  plot = TRUE,
  CI = FALSE,
  ...
)
```

**Arguments**

|            |  |
|------------|--|
| tr         | Effect estimate of the replication study.  |
| sr         | Standard error of the replication effect estimate.   |
| to         | Effect estimate of the original study.   |
| so         | Standard error of the original effect estimate.  |
| x          | Number of successes parameter of beta prior for $\alpha$ . Defaults to 1.                        |
| y          | Number of failures parameter of beta prior for $\alpha$ . Defaults to 1.                         |
| m          | Mean parameter of initial normal prior for $\theta$ . Defaults to 0.                             |
| v          | Variance parameter of initial normal prior for $\theta$ . Defaults to Inf (uniform prior).       |
| thetaRange | Range of effect sizes. Defaults to three standard errors around the replication effect estimate. |
| alphaRange | Range of power parameters. Defaults to the range between zero and one.                           |
| nGrid      | Number of grid points. Defaults to 100.  |

|      |   |
|------|---|
| plot | Logical indicating whether data should be plotted. If FALSE only the data used for plotting are returned.   |
| CI   | Logical indicating whether 95% highest posterior credible intervals should be plotted. Defaults to FALSE.   |
| ...  | Additional arguments passed to <code>stats::integrate</code> for computation of posterior densities and highest posterior density credible intervals. |

**Value**

Plots joint and marginal posterior densities, invisibly returns a list with the data for the plots.

**Author(s)**

Samuel Pawel

**See Also**

[postPP](#), [postPPalpha](#), [postPPtheta](#)

**Examples**

```
plotPP(tr = 0.2, sr = 0.05, to = 0.15, so = 0.05)
```

---

postPP

*Posterior density of effect size and power parameter*

---

**Description**

This function computes the posterior density of effect size  $\theta$  and power parameter  $\alpha$  assuming a normal likelihood for original and replication effect estimate. A power prior for  $\theta$  is constructed by updating an initial normal prior  $\theta \sim N(m, v)$  with the likelihood of the original data raised to the power of  $\alpha$ . A marginal beta prior  $\alpha \sim \text{Beta}(x, y)$  is assumed.

**Usage**

```
postPP(theta, alpha, tr, sr, to, so, x = 1, y = 1, m = 0, v = Inf, ...)
```

**Arguments**

|       |   |
|-------|---|
| theta | Effect size. Has to be of length one or the same length as alpha.         |
| alpha | Power parameter. Has to be of length one or the same length as theta.     |
| tr    | Effect estimate of the replication study.                                 |
| sr    | Standard error of the replication effect estimate.                        |
| to    | Effect estimate of the original study.                                    |
| so    | Standard error of the original effect estimate.                           |
| x     | Number of successes parameter of beta prior for $\alpha$ . Defaults to 1. |

**y**                    Number of failures parameter of beta prior for  $\alpha$ . Defaults to 1.  
**m**                    Mean parameter of initial normal prior for  $\theta$ . Defaults to 0.  
**v**                    Variance parameter of initial normal prior for  $\theta$ . Defaults to Inf (uniform prior).  
**...**                Additional arguments passed to `stats::integrate`.

**Value**

Posterior density

**Author(s)**

Samuel Pawel

**See Also**

[postPPalpha](#), [postPPtheta](#), [plotPP](#)

**Examples**

```

alpha <- seq(0, 1, length.out = 200)
theta <- seq(0, 0.3, length.out = 200)
parGrid <- expand.grid(alpha = alpha, theta = theta)
postdens <- postPP(theta = parGrid$theta, alpha = parGrid$alpha, tr = 0.1,
                  sr = 0.05, to = 0.2, so = 0.05)
postdensMat <- matrix(data = postdens, ncol = 200, byrow = TRUE)
filled.contour(x = theta, y = alpha, z = postdensMat,
              xlab = bquote("Effect size" ~ theta),
              ylab = bquote("Power parameter" ~ alpha), nlevels = 15,
              color.palette = function(n) hcl.colors(n = n, palette = "viridis"))
  
```

---

postPPalpha

*Marginal posterior distribution of power parameter*

---

**Description**

These functions compute the marginal posterior of the power parameter  $\alpha$ . A power prior for  $\theta$  is constructed by updating an initial normal prior  $\theta \sim N(m, v)$  with the likelihood of the original data raised to the power of  $\alpha$ . A marginal beta prior  $\alpha \sim \text{Beta}(x, y)$  is assumed.

**Usage**

```
postPPalpha(alpha, tr, sr, to, so, x = 1, y = 1, m = 0, v = Inf, ...)
```

```
postPPalphaHPD(level = 0.95, tr, sr, to, so, x = 1, y = 1, m = 0, v = Inf, ...)
```

**Arguments**

|       |  |
|-------|--|
| alpha | Power parameter. Can be a vector.  |
| tr    | Effect estimate of the replication study.  |
| sr    | Standard error of the replication effect estimate.   |
| to    | Effect estimate of the original study.   |
| so    | Standard error of the original effect estimate.  |
| x     | Number of successes parameter of beta prior $\alpha$ . Defaults to 1.                      |
| y     | Number of failures parameter of beta prior $\alpha$ . Defaults to 1.                       |
| m     | Mean parameter of initial normal prior for $\theta$ . Defaults to 0.                       |
| v     | Variance parameter of initial normal prior for $\theta$ . Defaults to Inf (uniform prior). |
| ...   | Additional arguments passed to <code>stats::integrate</code> .                             |
| level | Credibility level of the highest posterior density interval. Defaults to 0.95.             |

**Value**

postPPalpha returns the marginal posterior density of the power parameter.

postPPalphaHPD returns the highest marginal posterior density interval of the power parameter.

**Author(s)**

Samuel Pawel

**See Also**

[postPP](#), [postPPtheta](#), [plotPP](#)

**Examples**

```
alpha <- seq(0, 1, 0.001)
margpostdens <- postPPalpha(alpha = alpha, tr = 0.1, to = 0.2, sr = 0.05, so = 0.05)
plot(alpha, margpostdens, type = "l", xlab = bquote("Power parameter" ~ alpha),
      ylab = "Marginal posterior density", las = 1)
```

---

postPPtheta

*Marginal posterior distribution of effect size*

---

**Description**

These functions compute the marginal posterior of the effect size  $\theta$ . A power prior for  $\theta$  is constructed by updating an initial normal prior  $\theta \sim N(m, v)$  with likelihood of the original data raised to the power of  $\alpha$ . The power parameter  $\alpha$  can either be fixed to some value between 0 and 1 or it can have a beta prior distribution  $\alpha \sim \text{Beta}(x, y)$ .



**Usage**

```

postPPtheta(
  theta,
  tr,
  sr,
  to,
  so,
  x = 1,
  y = 1,
  alpha = NA,
  m = 0,
  v = Inf,
  hypergeo = FALSE,
  ...
)

postPPthetaHPD(
  level,
  tr,
  sr,
  to,
  so,
  x = 1,
  y = 1,
  alpha = NA,
  m = 0,
  v = Inf,
  thetaRange = tr + c(-1, 1) * stats::qnorm(p = (1 + level)/2) * sr * 3,
  quantileRange = c((1 - level) * 0.2, (1 - level) * 0.8),
  ...
)

```

**Arguments**

|       |   |
|-------|---|
| theta | Effect size. Can be a vector.   |
| tr    | Effect estimate of the replication study.   |
| sr    | Standard error of the replication effect estimate.  |
| to    | Effect estimate of the original study.  |
| so    | Standard error of the original effect estimate.   |
| x     | Number of successes parameter for beta prior of power parameter $\alpha$ . Defaults to 1. Is only taken into account when <code>alpha = NA</code> . |
| y     | Number of failures parameter for beta prior of power parameter $\alpha$ . Defaults to 1. Is only taken into account when <code>alpha = NA</code> .  |
| alpha | Power parameter. Can be set to a number between 0 and 1. Defaults to NA (a beta prior on the power parameter).                                      |
| m     | Mean parameter of initial normal prior for $\theta$ . Defaults to 0.  |

|               |  |
|---------------|--|
| v             | Variance parameter of initial normal prior for $\theta$ . Defaults to Inf (uniform prior).   |
| hypergeo      | Logical indicating whether for uniform priors, the marginal posterior should be computed with the hypergeometric function. Defaults to FALSE (using numerical integration instead).  |
| ...           | Additional arguments passed to <code>stats::integrate</code> or <code>hypergeo::genhypergeo</code> (depending on the <code>hypergeo</code> argument).  |
| level         | Credibility level of the highest posterior density interval. Defaults to 0.95.   |
| thetaRange    | The numerical search range for the effect size. Defaults to the <code>level*100%</code> confidence interval range inflated by a factor of three. We recommend changing this argument only if there are numerical problems in calculating the HPD interval.                           |
| quantileRange | The numerical search range for the lower posterior quantile of the HPD interval. Defaults to the range between $(1 - \text{level}) * 0.2$ and $(1 - \text{level}) * 0.8$ . We recommend changing this argument only if there are numerical problems in calculating the HPD interval. |

### Value

`postPPtheta` returns the marginal posterior density of the effect size.

`postPPthetaHPD` returns the highest marginal posterior density interval of the effect size (this may take a while).

### Author(s)

Samuel Pawel

### See Also

[postPP](#), [postPPalpha](#), [plotPP](#)

### Examples

```
theta <- seq(0, 0.6, 0.001)
margpostdens <- postPPtheta(theta = theta, tr = 0.1, to = 0.2, sr = 0.05, so = 0.05)
plot(theta, margpostdens, type = "l", xlab = bquote("Effect size" ~ theta),
      ylab = "Marginal posterior density", las = 1)
```

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