

# Intro\_RPS

## About package

The goal of RPS package is to provide the functionality for the Research Program Strategy (RPS) as explained in the article “**Hypothesis-testing demands trustworthy data-a simulation approach to inferential statistics advocating the research program strategy**” by *Krefeld-Schwalb, Witte & Zenker (2018)*. For more details about the theory, please have a look at the main paper and related technical appendix document;

- **Main paper:** <https://www.frontiersin.org/articles/10.3389/fpsyg.2018.00460/full>
- **Appendix:** <https://osf.io/gaetn/>

## About RPS Description

Every step of our simulation mimics 100 t-values for one-sided t-tests sampled from two normal distributions featuring the same variance but different means. One mean is set to zero ( $x_0$ ), the other mean corresponds to the effect size  $\delta$  of the focal condition ( $x_1$ ), such that  $x_1 \sim Normal(\delta, 1)$  and  $x_0 \sim Normal(0, 1)$ . The following equation is used to define the sample size,  $N_{min}$ , drawn from these distributions that is needed to achieve the power  $(1 - \beta)$  given  $\alpha$ -error, and the effect size  $\delta$ .

$$N = (z(1 - \alpha) + z(1 - \beta))^2 / (\delta / \sqrt{2})^2 \quad (1)$$

We next calculated the t-value based on the difference of the means,  $\mu$ , of these distributions.

$$t = (\mu_{x1} - \mu_{x0}) / \sqrt{2/n} \quad (2)$$

The consecutive steps of the research program strategy (RPS) is summarized below;

1. Preliminary Discovery:  $p \leq \alpha, \alpha \leq .05$ , unknown  $\beta$
2. Substantial Discovery:  $p \leq \alpha, \alpha \leq .05$ , known  $\beta$
3. Preliminary Falsification:  $\frac{L(d > 0|x)}{L(d = 0|x)} > \frac{1 - \beta}{\alpha}$
4. Substantial Falsification:  $\frac{L(d > \delta|x)}{L(d = 0|x)} > \frac{1 - \beta}{\alpha}$
5. Preliminary Verification:  $\frac{L(d = \delta|x)}{L(d = 0|x)} > \frac{1 - \beta}{\alpha}$
6. Substantial Verification:  $\frac{L(d = \delta|x)}{L(d = 0|x)} > \frac{1 - \beta}{\alpha} \cap \frac{L(d|x)}{L(d = \delta|x)} > \frac{pdf(P50|d)}{pdf(P95|d)} > 4$

In order to calculate these proportions we used the **density of the respective t-distributions** and calculated the one-sided  $p$ -values,  $p$ , as well as the likelihood,  $L$ . The Wald-criterion,  $\frac{1-\beta}{\alpha}$ , was applied for interpreting the corresponding likelihood ratios in steps 3 to 5. As a criterion for substantial verification in step 6 we further used the ratio of the probability density function, pdf, at the 50'th and 95'th percentiles,  $P50$  and  $P95$ , respectively.

## Simulation Example

```
## Number of simulated tests
Nsample = 100

## Level of significance
alpha = 0.05

### Different effect sizes
effectSize = 0.2

### Different Power
pow = 0.95
```

Here, in the simulation example, the goal is to estimate the minimum sample size  $N_{min}$  by using the effect size,  $\delta$ , and test power,  $(1 - \beta)$ , which together determine the induction quality of data, between the conditions,  $d = [0.2]$  and  $(1 - \beta) = [0.95]$ .

For the above parameters, the estimated sample size is obtained as;

```
samph1 <- RPS::samplesH1(Nsample = 100, alpha=alpha, effectSize = effectSize, pow = pow)
round(samph1$Nest, 0)
```

```
## [1] 541
```

## Visualization

For the visualizations of the outputs, separate functions are given in **ModelVis.R** file and the wrap-up function (**plot\_RPS.R**) is ready to use by selection of the figures when all the necessary inputs are provided. Distinctly, the **ggplot2** syntax was used for all figures in the package so the obtained graphs are different from the ones you observed in the Shiny app!

The main tool is **plot\_RPS.R**, as a wrap-up function to make a general visualization of the outputs by making selection. To illustrate,

```
samph0 <- RPS::samplesH0(Nsample = 100, alpha = 0.05, effectSize = 0.2,
                        pow = 0.95)

samph1 <- RPS::samplesH1(Nsample = 100, alpha = 0.05, effectSize = 0.2,
                        pow = 0.95)

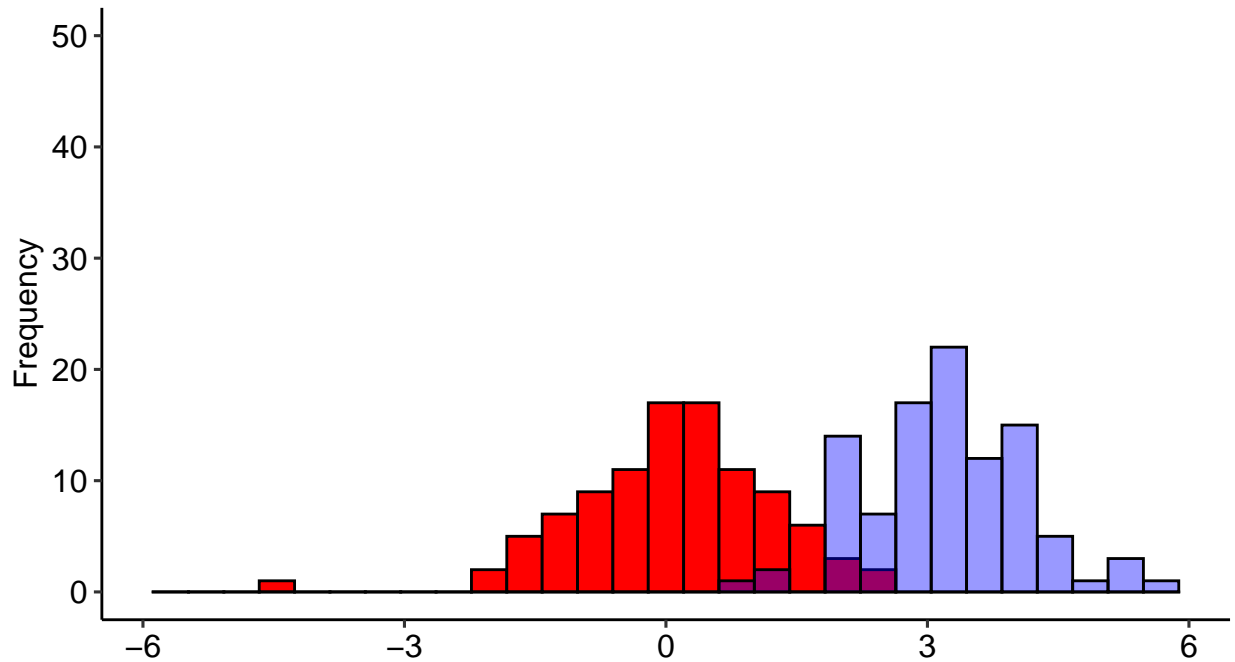
sampEmp <- RPS::samplesEmp(Nsample = 100, N = 30, Temp = 3, alphaEmp = 0.05)

# About plotting, you can consider different selections by select argumen
RPS::plot_RPS(samph0 = samph0, samph1 = samph1, sampEmp = sampleEmp, select = 1)

## 'stat_bin()' using 'bins = 30'. Pick better value with 'binwidth'.
## 'stat_bin()' using 'bins = 30'. Pick better value with 'binwidth'.
```

Distribution of t-values for given **H0** and **H1**.

$d = 0.2, N = 541, ncp = 3.29$



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One can use the **Figure** functions separately,

```
sampH1 <- RPS::samplesH1(Nsample = 100, alpha = 0.05, effectSize = 0.2, pow = 0.95)

# Run this function manually if you want from ModelVis.R script
# figure1(sampH1 = sampH1)
```

## Summarizing Results

For the tabularization of the outputs, separate functions are given in **TableOutputs.R** file and the wrap-up function (**table\_RPS.R**) is ready to use by selection of the different tables when all the necessary inputs are provided. Similar to visualization, ready to publish tables are generated by using **gt package**.

```
# The below results are necessary before creating tables generally
# By using sampleH1
samp30 <- RPS::samples30(Nsample = 100, alpha = 0.05, effectSize = 0.2,
  pow = 0.95, samp = sampH1)

sampEmp0 <- RPS::samplesEmp0(Nsample = 100, N = 30, Temp = 3, alphaEmp = 0.05)

# The creation of the
# Table 1: Proportion of correct positive results (prior to data collection)

RPS::table_RPS(sampH0 = sampH0, sampH1 = sampH1, sampEmp = sampEmp,
  sampEmp0 = sampEmp0, samp30 = samp30, select = 1)
```

Step in RPS	Proportion
4. Substantial Falsification	0.92
5. Preliminary Verification	0.8
6. Substantial Verification	0.72
False Negatives: Substantial Falsification - Substantial Verification	0.2
Substantial Verification if $N' = N + N/2.271$ , $1 - \beta = 0.99$	0.82