Tutorial R package `puniform`

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Links to package on CRAN and GitHub

February 24, 2023

Publication bias

- Publication bias is "the selective publication of studies with a significant outcome"
- $\approx$ 90% of main hypotheses are significant in psychology [1]
- But this is not in line with average statistical power (about 20-50%)
- Consequences:
  - Overestimation
  - False impression

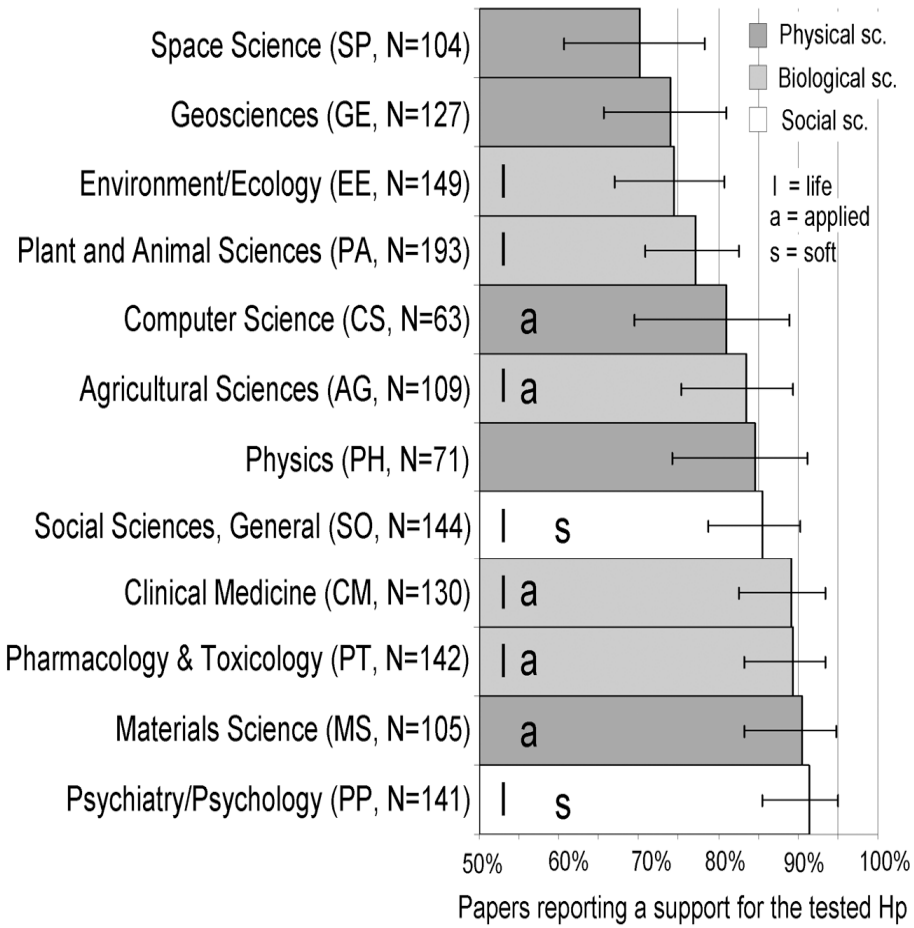


Figure adapted from Fanelli (2010)

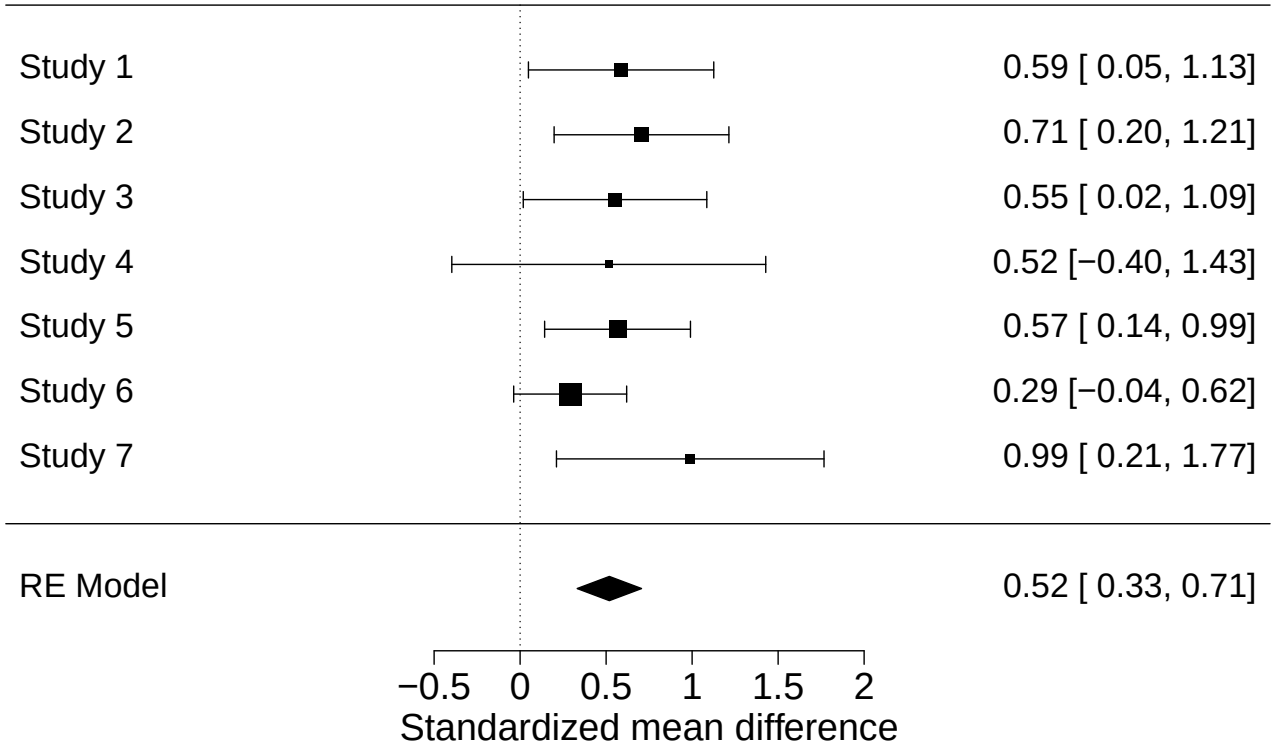
Example

- Example meta-analysis by Cowlishaw et al. (2012) [2]
- Efficacy of cognitive behavior therapy (CBT) for treating pathological and problem gambling
- Participants in the experimental group received CBT and no treatment was given to participants in the control group
- Meta-analysis contains $k = 7$ standardized mean differences
- A positive effect size indicates smaller financial loss for the experimental group

Photo by Benoit Dare on Unsplash

Example: Forest plot

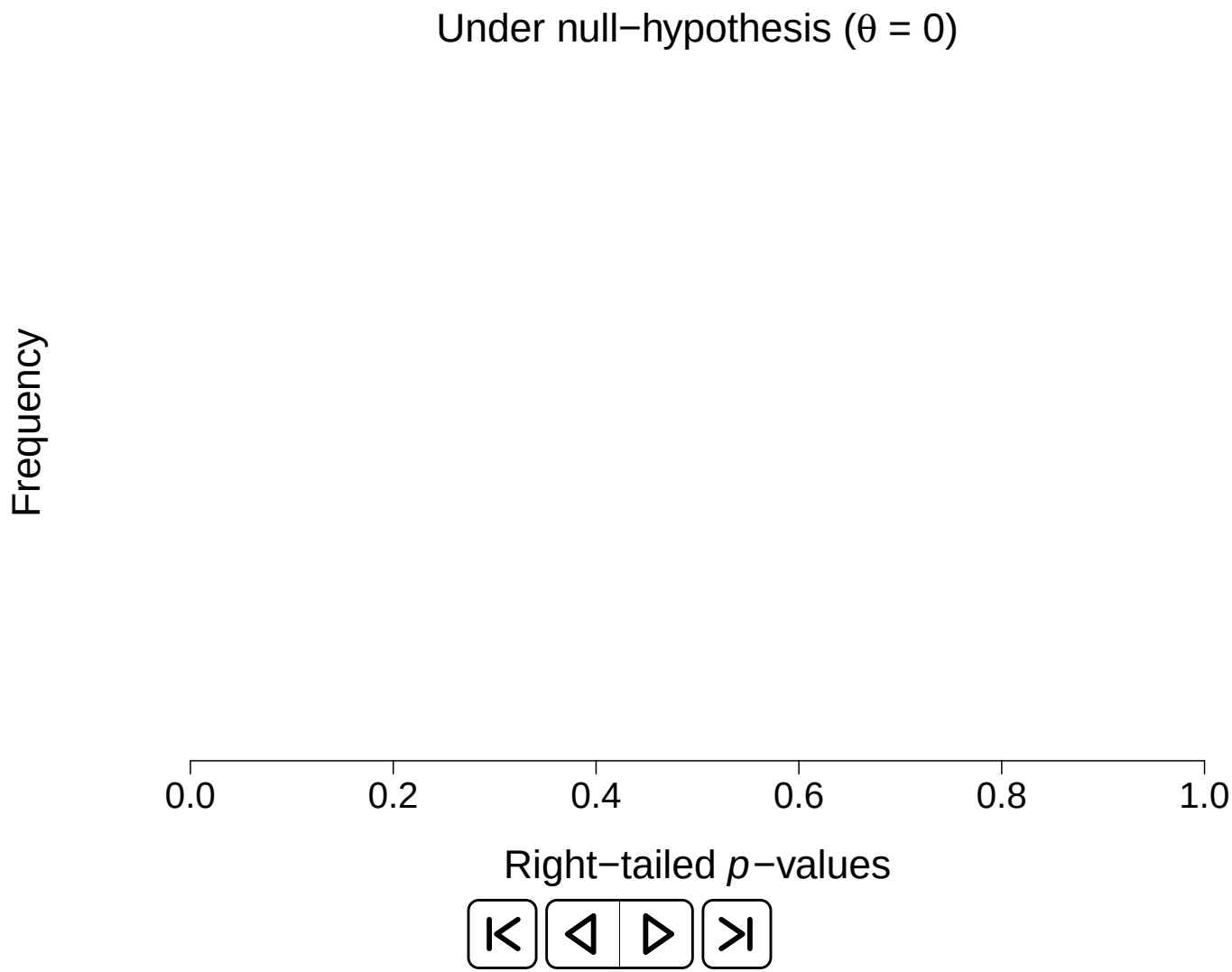
- Fitting random-effects model (REML) using `metafor` [3]



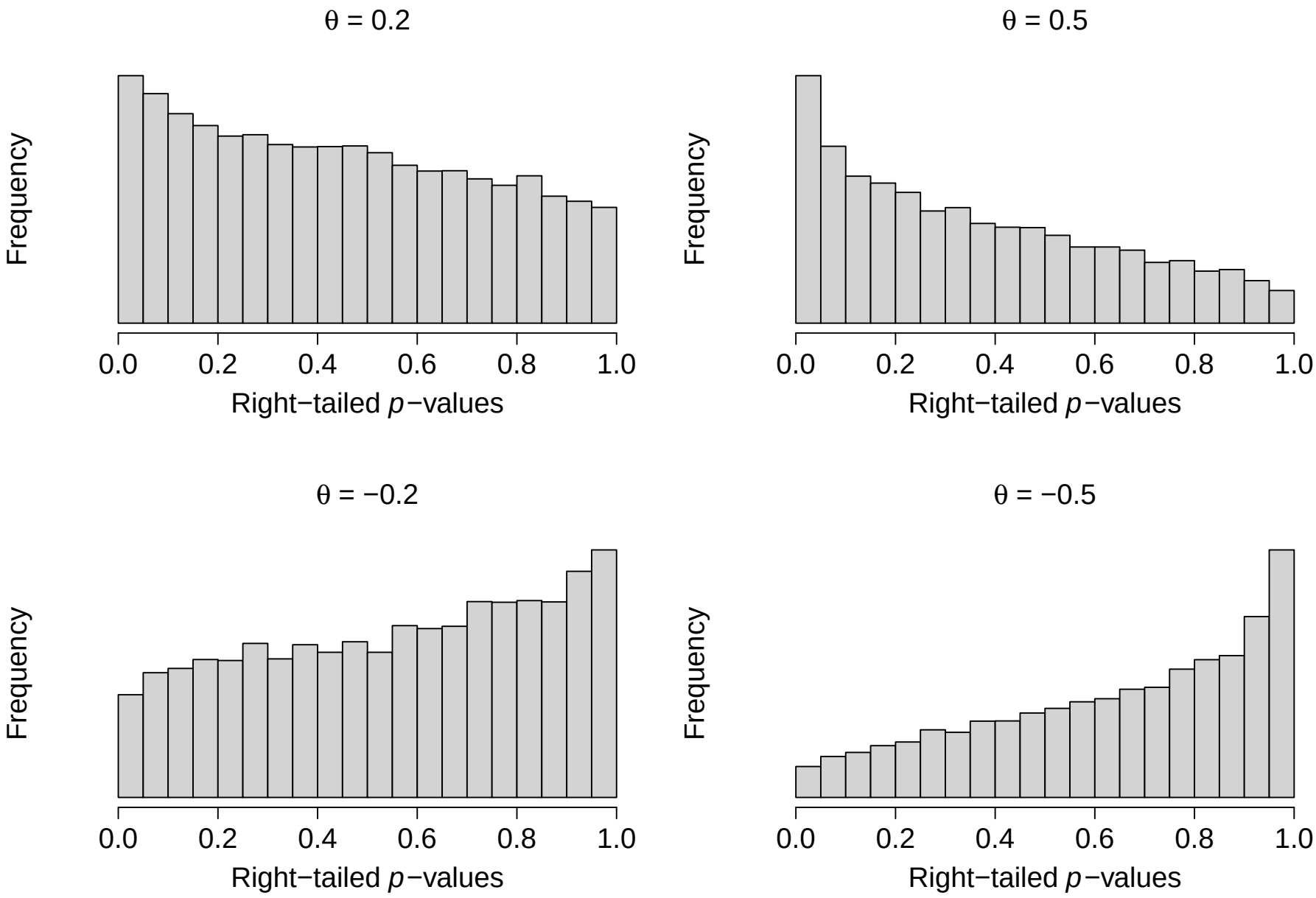

```
## tau^2 (estimated amount of total heterogeneity): 0 (SE = 0.0346)
##
## Test for Heterogeneity:
## Q(df = 6) = 3.8971, p-val = 0.6906
```

P-uniform [4,5]

- **Main idea:** *p*-values are uniformly distributed under the null-hypothesis



P-uniform [4,5]


θ = 0.2
Frequency
0.0
0.2
0.4
0.6
0.8
1.0
Right−tailed p−values
θ = 0.5
Frequency
0.0
0.2
0.4
0.6
0.8
1.0
Right−tailed p−values
θ = −0.2
Frequency
0.0
0.2
0.4
0.6
0.8
1.0
Right−tailed p−values
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1.0
Right−tailed p−values

P-uniform [4,5]

- Applied to gamble example ($\hat{\mu} = 0.519$):

```
install.packages("puniform") # Install "puniform" package
library(puniform) # Load "puniform" package
puniform(yi = dat$yi, vi = dat$vi, side = "right")
```

```
## Method: P
##
## Effect size estimation p-uniform
##
##        est     ci.lb     ci.ub       L.0      pval      ksig
##     0.2178   -0.7867    0.6559    -0.672    0.2508         5
##
## ===
##
## Publication bias test p-uniform
##
##       L.pb      pval
##      1.284    0.0996
```

P-uniform* [6]

- Drawbacks of *p*-uniform:
  - Overestimation in case of heterogeneity in true effect size
  - Not all available information is used (i.e., not efficient method)

- *P*-uniform* is an improvement over *p*-uniform because:
  1. It enables estimating and testing of heterogeneity in true effect size (τ^2)
  2. Takes into account significant and nonsignificant effect sizes

P-uniform* [6]

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- *P*-uniform* is an improvement over *p*-uniform because:
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  2. Takes into account significant and nonsignificant effect sizes

- A function to apply *p*-uniform* is in the `puniform` package:

```
puni_star(yi = dat$yi, vi = dat$vi, side = "right") # Apply p-uniform*
```

P-uniform* [6]

- Applied to gamble example ($\hat{\mu} = 0.519$):

```
##
## Method: ML (k = 7; ksig = 5)
##
## Estimating effect size p-uniform*
##
##        est     ci.lb     ci.ub       L.0      pval
##     0.3938    0.0593    0.7214    5.4141      0.02
##
## ===
##
## Estimating between-study variance p-uniform*
##
##       tau2   tau2.lb   tau2.ub     L.het      pval
##          0         0    0.0639         0         1
```

P-uniform* [6]

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##          0         0    0.0639         0         1
```

- **Conclusions:**
  - The (average) effect size was considerably smaller when estimated with *p*-uniform and *p*-uniform*
  - The null-hypothesis of no effect was rejected with *p*-uniform* but not with *p*-uniform

Web applications and future developments

- Shiny web applications are available for all four methods:
  - *p*-uniform: https://rvanaert.shinyapps.io/p-uniform/
  - *p*-uniform*: https://rvanaert.shinyapps.io/p-uniformstar/

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- Future developments
  - Add more intervals to treat effect sizes in these intervals differently
  - Allow for the inclusion of moderators

Other methods in `puniform`

- Meta-analyzing an original and replication study
  - Hybrid method of meta-analysis [7]: `hybrid()`
  - Snapshot Bayesian hybrid meta-analysis method [8]: `snapshot()`
- Meta-plot [9]: meta_plot()
- Correcting for Outcome Reporting Bias (CORB) method [10]

Thank you for your attention

www.robbievanaert.com

www.metaresearch.nl

Links to the `puniform` package on CRAN and GitHub

References I

[1] Fanelli D. "Positive" results increase down the hierarchy of the sciences. PLOS ONE 2010;5:e10068. https://doi.org/10.1371/journal.pone.0010068.

[2] Cowlishaw S, Merkouris S, Dowling N, Anderson C, Jackson A, Thomas S. Psychological therapies for pathological and problem gambling. Cochrane Database of Systematic Reviews 2012. https://doi.org/10.1002/14651858.CD008937.pub2.

[3] Viechtbauer W. Conducting meta-analyses in R with the metafor package. Journal of Statistical Software 2010;36:1–48. https://doi.org/10.18637/jss.v036.i03.

[4] van Assen MALM, van Aert RCM, Wicherts JM. Meta-analysis using effect size distributions of only statistically significant studies. Psychological Methods 2015;20:293–309. https://doi.org/10.1037/met0000025.

[5] van Aert RCM, Wicherts JM, van Assen MALM. Conducting meta-analyses on p-values: Reservations and recommendations for applying p-uniform and p-curve. Perspectives on Psychological Science 2016;11:713–29. https://doi.org/10.1177/1745691616650874.

[6] van Aert RCM, van Assen MALM. Correcting for publication bias in a meta-analysis with the p-uniform* method. Manuscript submitted for publication. 2023. https://doi.org/10.31222/osf.io/zqjr9.

[7] van Aert RCM, van Assen MALM. Examining reproducibility in psychology: A hybrid method for combining a statistically significant original study and a replication. Behavior Research Methods 2018;50:1515–39. https://doi.org/10.3758/s13428-017-0967-6.

[8] van Aert RCM, van Assen MALM. Bayesian evaluation of effect size after replicating an original study. PLOS ONE 2017;12:e0175302. https://doi.org/10.1371/journal.pone.0175302.

[9] van Assen MALM, van den Akker OR, Augusteijn HEM, Bakker M, Nuijten MB, Olsson-Collentine A, et al. The meta-plot: A graphical tool for interpreting the results of a meta-analysis. Zeitschrift Für Psychologie 2023;231:65–78. https://doi.org/10.1027/2151-2604/a000513.

[10] van Aert RCM, Wicherts JM. Correcting for outcome reporting bias in a meta-analysis: A meta-regression approach. Manuscript submitted for publication. 2021. https://doi.org/10.31222/osf.io/bn8vd.