P-uniform*: A new meta-analytic method to correct for publication bias

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Message

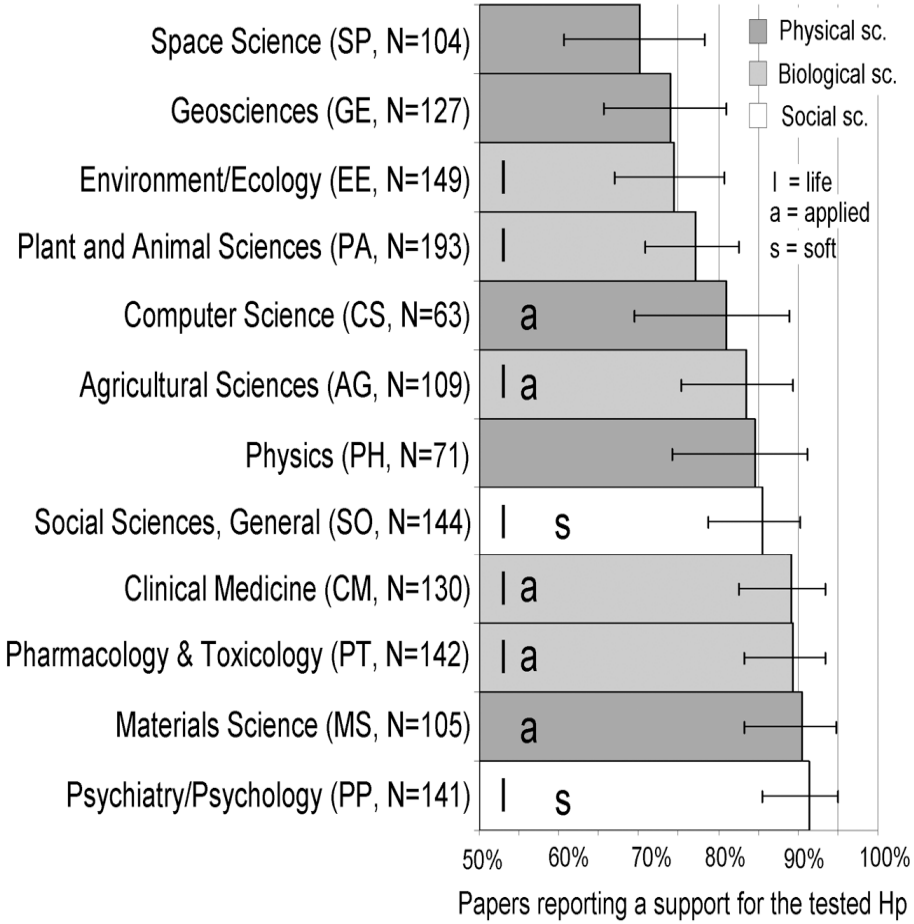
- Publication bias is omnipresent in science
- Publication bias $\rightarrow$ overestimation of effect size in meta-analysis
- The publication bias method *p*-uniform overestimates effect size in case of heterogeneity in true effect size
- The improved and extended method *p*-uniform*:
  1. eliminates overestimation due to heterogeneity
  2. uses information of significant *and* nonsignificant effect sizes
  3. enables estimating and testing of the extent of heterogeneity

Overview

1. Publication bias
2. From *p*-uniform to *p*-uniform*
3. Monte-Carlo simulation study
4. Conclusion and discussion

Publication bias

- Publication bias is "the selective publication of studies with a significant outcome"
- ≈90% of main hypotheses are significant in psychology
- But this is not in line with average statistical power (about 20-50%)



Adapted from Fanelli (2010)

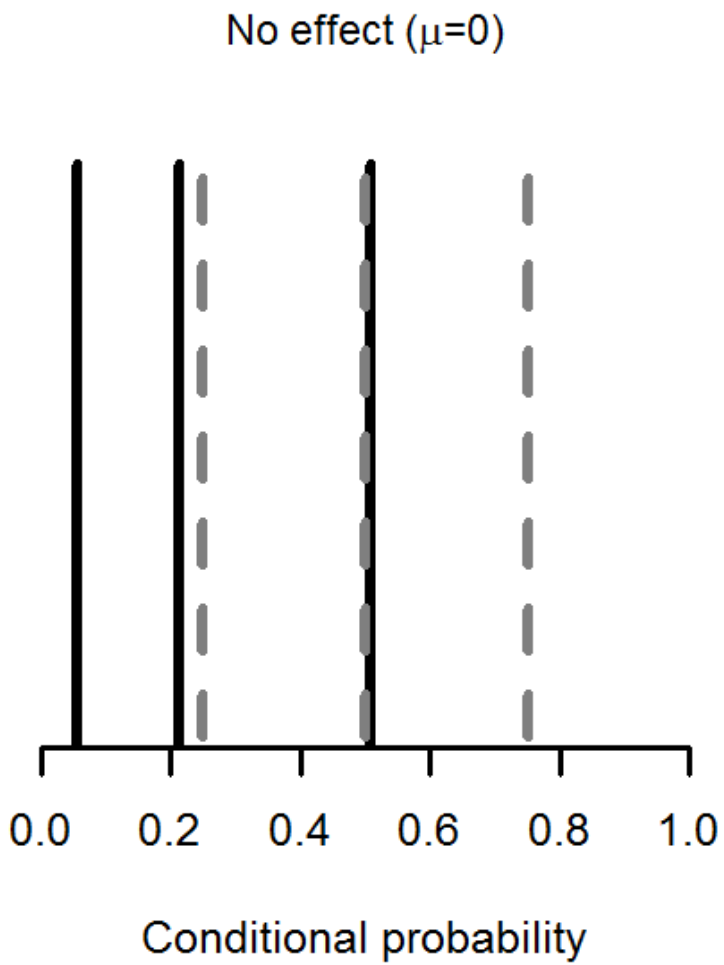
From *p*-uniform to *p*-uniform*: *p*-uniform

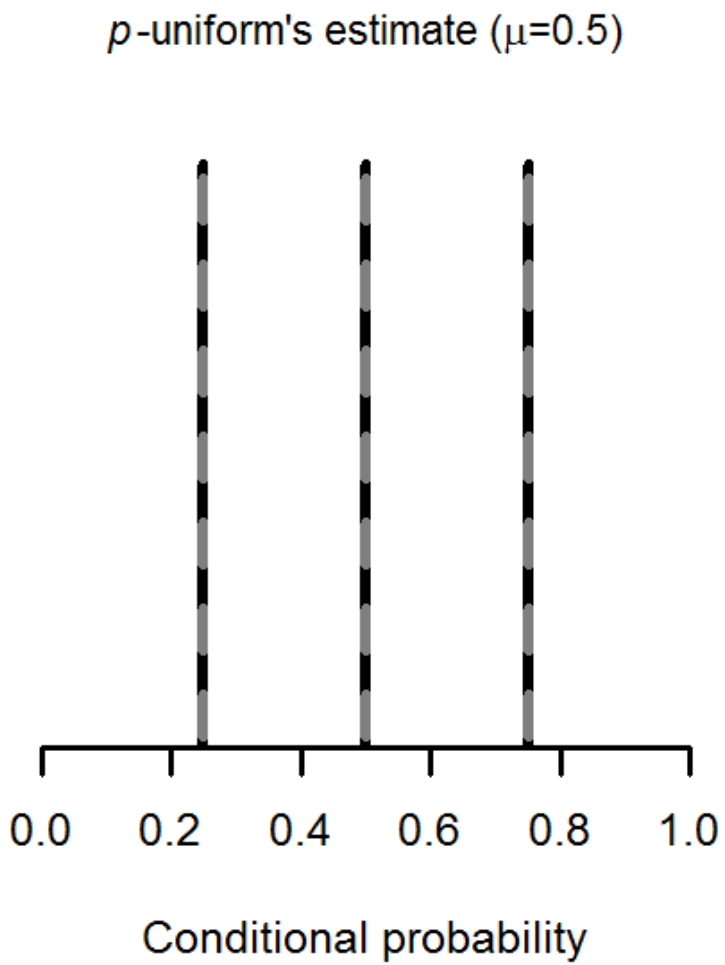
- Only considers significant effect sizes and discards others
- **Statistical principle:** Distribution of *p*-values *at the true effect size* is uniform
- Only significant effect sizes $\rightarrow$ *p*-values/probabilities conditional on significance are needed
- Important assumptions:
  - Homogeneous true effect size
  - All significant effect sizes have an equal probability of getting included in a meta-analysis

From *p*-uniform to *p*-uniform*: *p*-uniform

- Example with three observed effect sizes ($\mu = 0.5$):

$t(48)=3.133$, $p=.0029$; $t(48)=2.646$, $p=.011$; $t(48)=2.302$, $p=.025$





From *p*-uniform to *p*-uniform*: *p*-uniform*

- Drawbacks of *p*-uniform:
  1. overestimation due to heterogeneity
  2. uses only information of significant effect sizes $\rightarrow$ suboptimal
  3. no estimating and testing of the extent of heterogeneity

From *p*-uniform to *p*-uniform*: *p*-uniform*

- Drawbacks of *p*-uniform:
  1. overestimation due to heterogeneity
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  3. no estimating and testing of the extent of heterogeneity

- *P*-uniform* considers the significant **and** nonsignificant effect sizes

- Now effect sizes not only conditional on significance but also on nonsignificance

- Important assumption:
  - Probability of including a significant and nonsignificant effect size in a meta-analysis is assumed to be constant (but may differ from each other)

Simulation study: Method

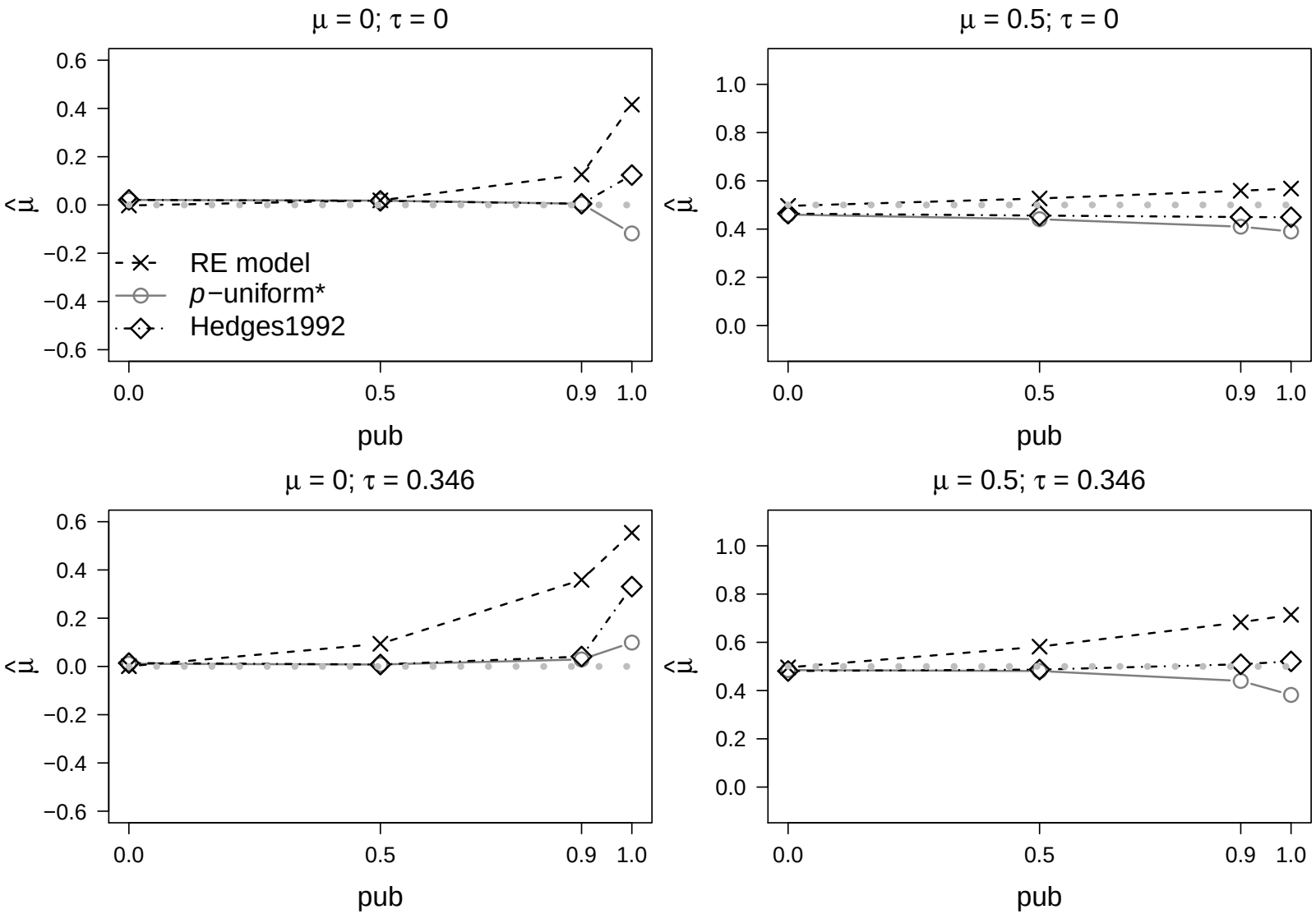
- **Goal:** Evaluate performance of *p*-uniform* and compare to other methods

- Effect size measure is standardized mean difference with 50 as sample size per group

- Conditions:
  - $\mu = 0; 0.2; 0.5$
  - $\tau = 0; 0.163; 0.346 \rightarrow I^2 = 0\%; 40\%; 75\%$
  - Number of studies (k) = 10; 30; 60; 120
  - Extent of publication bias (pub) = 0; 0.5; 0.9; 1

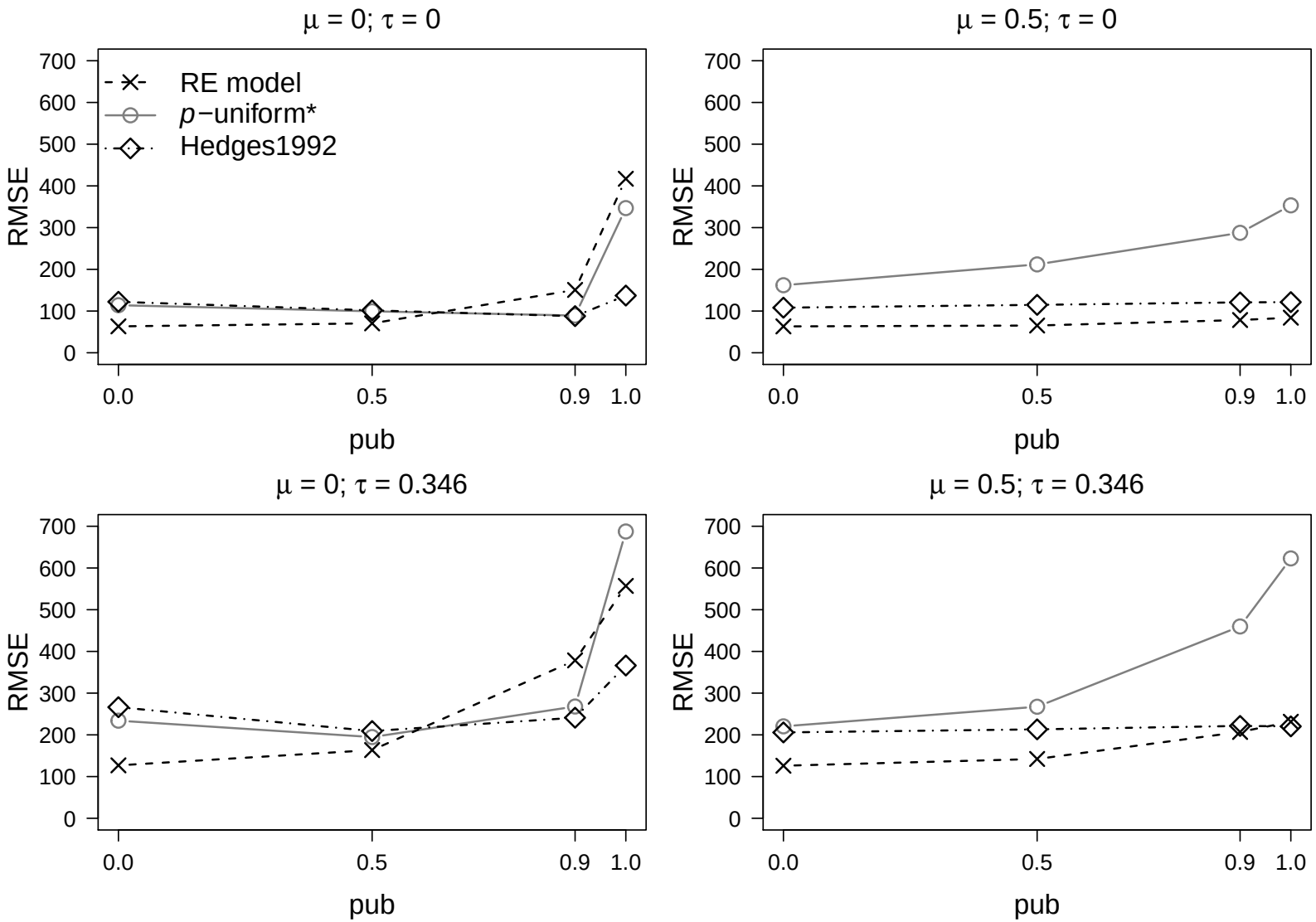
- Included methods:
  - *p*-uniform*
  - random-effects meta-analysis
  - selection model approach by Hedges (1992) $\rightarrow$ cut-off at α=.05

Simulation study: Estimating μ



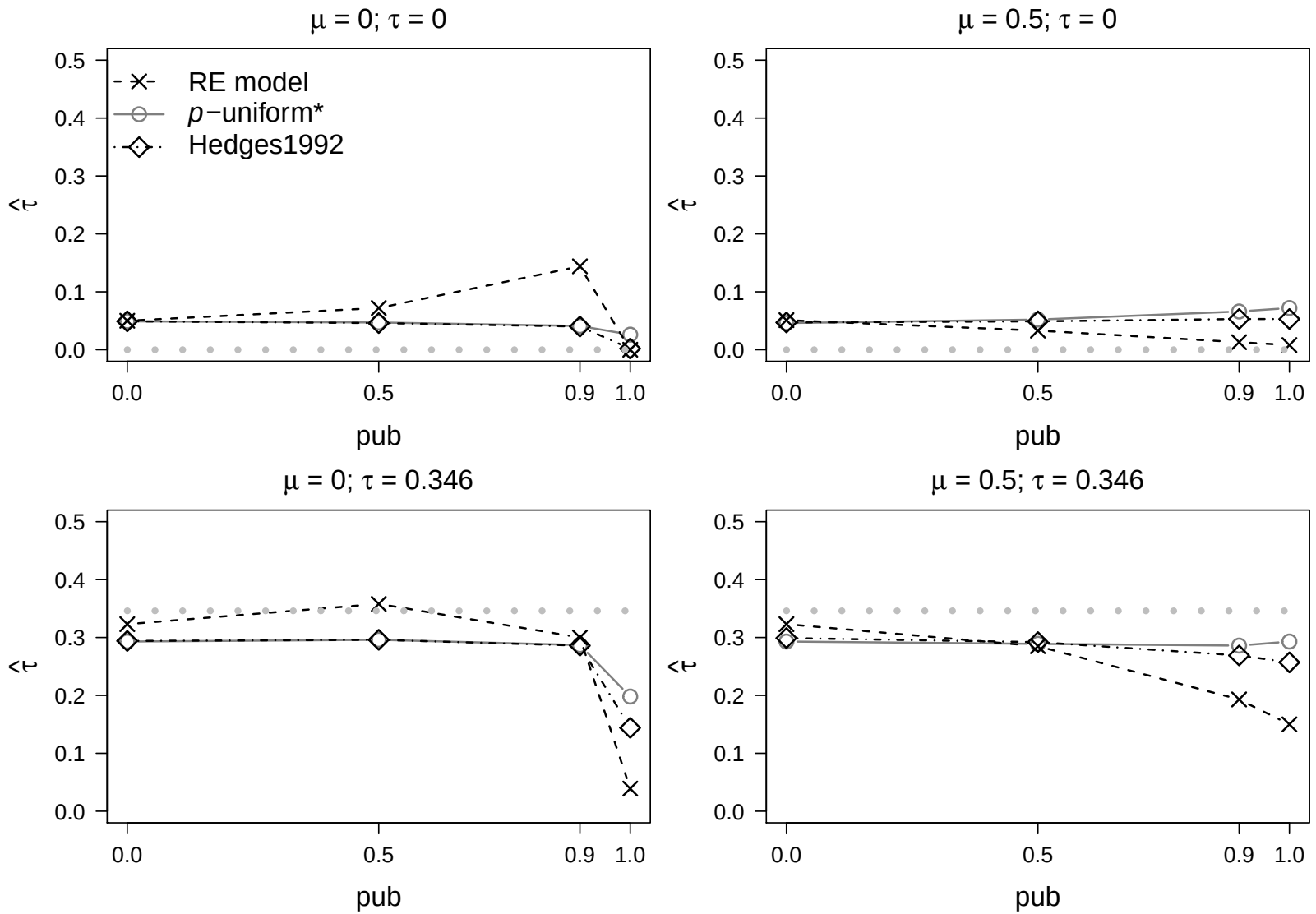
- Random-effects model overestimates μ if *pub* > 0
- Systematic positive bias for Hedges1992 if *pub* $= 1$ and $\mu = 0$

Simulation study: RMSE Estimating μ



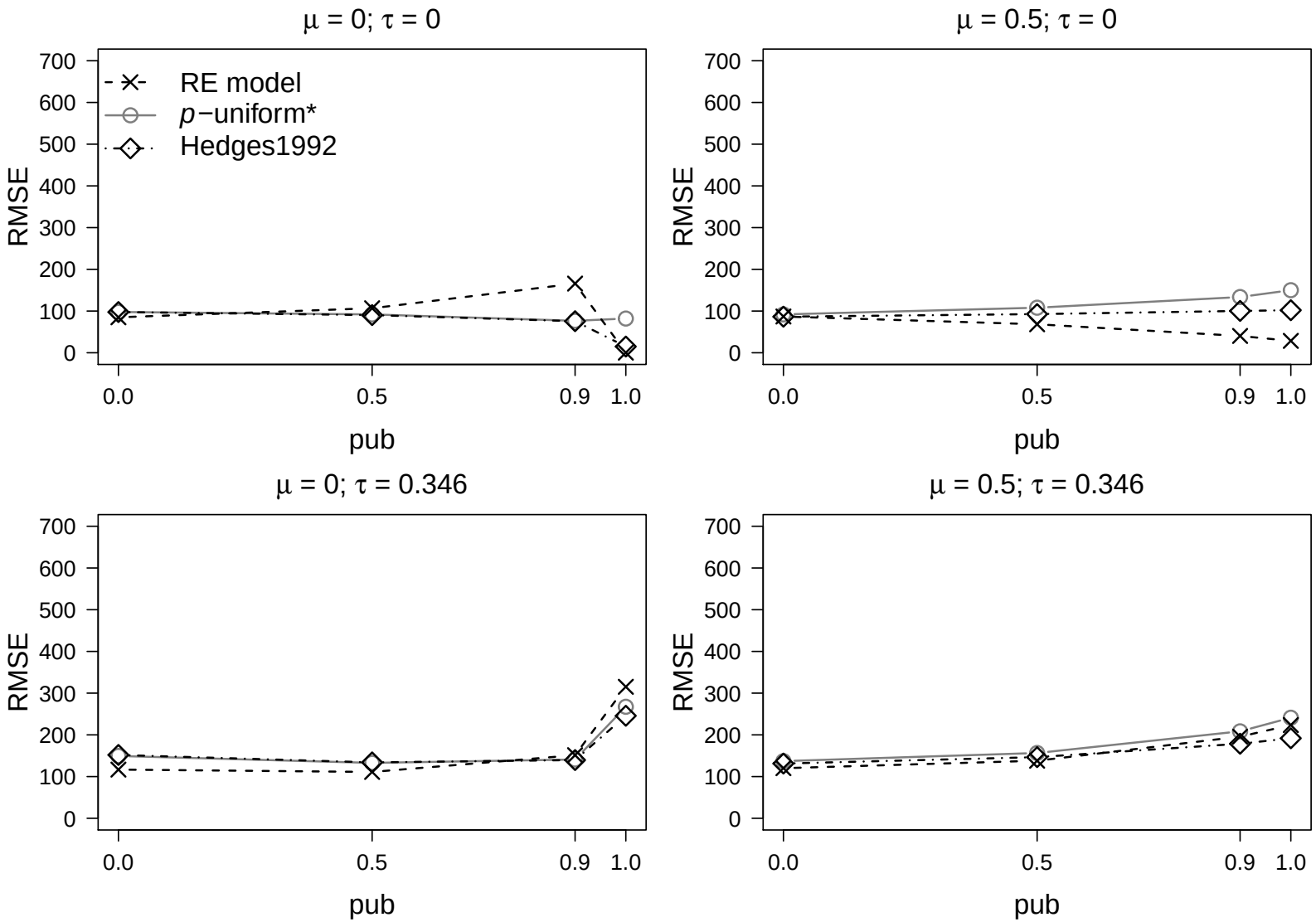
- RMSE of all methods increased as a function of τ and *pub*
- RMSE of *p*-uniform* generally larger than Hedges1992

Simulation study: Estimating τ



- RE model overestimates τ if $\tau = 0$ and underestimates if $\tau > 0$
- *P*-uniform* less negatively biased than Hedges1992 if $\tau > 0$

Simulation study: RMSE Estimating τ



- RMSE of all methods increased as a function of *pub* if $\tau > 0$
- RMSE of *p*-uniform* generally slightly larger than Hedges1992

Conclusion and discussion

- *P*-uniform* is an improvement over *p*-uniform, because
  1. eliminates overestimation due to heterogeneity
  2. is a more efficient estimator than *p*-uniform's estimator
  3. enables estimating and testing of the extent of heterogeneity

- Random-effects meta-analysis had the best statistical properties in the absence of publication bias

- Statistical properties of *p*-uniform* and the selection model approach by Hedges (1992) were comparable

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- Recommendations:
  - report results of *p*-uniform* and selection model approach by Hedges (1992) in any meta-analysis
  - be reluctant when extreme publication bias is expected with only significant effect sizes

Conclusion and discussion

- Future research:
  - Violations of the assumption of equal probabilities of significant and nonsignificant effect sizes for getting published
  - Consequences of *p*-hacking

- Software:
  - Hedges' (1992) selection model approach: R package `weightr` and web application https://vevealab.shinyapps.io/WeightFunctionModel
  - *p*-uniform*: R package `puniform` and web application https://rvanaert.shinyapps.io/p-uniformstar

Web application p-uniform*

Manual on how to use this application

Author: Robbie C.M. van Aert

Enter the characteristics of your meta-analysis below:

Select effect size measure

- ○ One-sample mean
- ◉ Two-independent means
- ○ One correlation

Alpha level in primary studies (default .05)

0.05

Select direction of effect in primary studies

- ◉ Right (positive)
- ○ Left (negative)

Select estimation method for p-uniform

- ◉ ML
- ○ P
- ○ LNP

Data entry

Select how you will enter data (see manual)

- ◉ Via CSV file
- ○ Manually in table

Enter data via CSV file

Browse... rabelo.csv

Upload complete

Analyze

p-uniform* (k = 25; ksig = 23)

Estimating effect size p-uniform*:

estimate	ci.lb	ci.ub	L.0	pval
0.0749	-0.1876	0.3067	0.3395	0.5601

Estimating between-study variance p-uniform*:

estimate	tau2.lb	tau2.ub	L.het	pval
0	0	0.0224	0	1

Publication bias test p-uniform*:

L.pb	pval
21.2298	<.001

Random-effects meta-analysis (tau^2 estimator PM):

Estimating effect size random-effects meta-analysis:

estimate	se	ci.lb	ci.ub	zval	pval
0.5706	0.0523	0.468	0.6731	10.9038	<.001

Estimating between-study variance random-effects meta-analysis:

estimate	se	tau2.lb	tau2.ub	Q	pval
0	0.0198	0	0	4.5523	1

Thank you for your attention

www.robbievanaert.com

www.metaresearch.nl

Preprint paper about *p*-uniform*:
https://osf.io/preprints/bitss/zqjr9/