

R Packages for Research Synthesis and Meta-Analysis

Evidence Synthesis Hackathon

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Quick Introduction

- born and raised in Germany
- moved to United States when I was 16
- 1998-2004: PhD at the University of Illinois, Urbana-Champaign
- dissertation research on statistical methods for meta-analysis
- at the time, the meta-analytic landscape in R looked like this ...

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Meta-Analytic Landscape in R (~1998)

Early Developments

- 1996: earliest references I could find to **RevMan** (not R)
 - 1997: **MetaWin** (version 1) released (also not R)
 - 1998: **Comprehensive Meta-Analysis** released (still no R)
 - 1999: **rmeta** package, but no 'meta-regression' capabilities
 - ~2000: wrote function for fitting random/mixed-effects models
 - ~2005: put function on my personal website
 - ~2005: **meta** package (still no meta-regression)
 - 2006-2009: a few other packages
 - 2009: published **metafor** package
 - 2009-2019: lots of new packages (current count: 102)
- based on CRAN Task View on Meta-Analysis:
<https://cran.r-project.org/view=MetaAnalysis>

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CRAN Task View: Meta-Analysis

CRAN Task View: Meta-Analysis

Maintainer: Michael Dewey
Contact: lists at dewey.myzen.co.uk
Version: 2019-01-26
URL: <https://CRAN.R-project.org/view=MetaAnalysis>

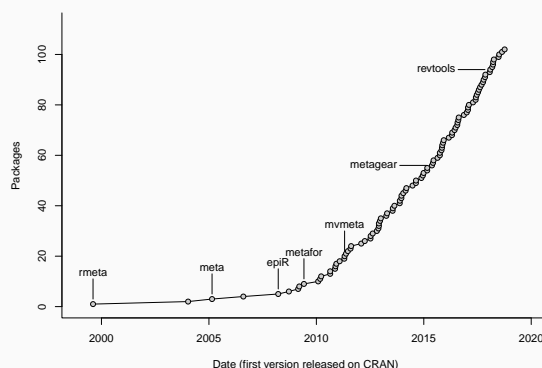
This task view covers packages which include facilities for meta-analysis of summary statistics from primary studies. The task view does not consider the meta-analysis of individual participant data (IPD) which can be handled by any of the standard linear modelling functions but does include some packages which offer special facilities for IPD.

The standard meta-analysis model is a form of weighted least squares and so any of the wide range of R packages providing weighted least squares would in principle be able to fit the model. The advantage of using a specialised package is that (a) it takes care of the small tweaks necessary (b) it provides a range of ancillary functions for displaying and investigating the model. Where the model is referred to below it is this model which is meant.

Where summary statistics are not available a meta-analysis of significance levels is possible. This is not completely disconnected with the problem of adjustment for multiple comparisons but the packages below which offer this, chiefly in the context of genetic data, also offer additional functionality.

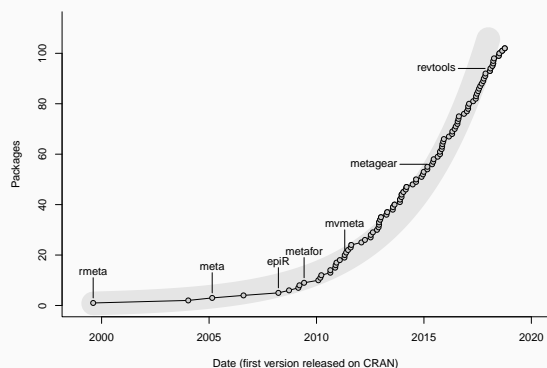
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First Releases of Meta-Analysis Packages



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Exponential Growth (sort of)



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Meta-Analytic Landscape Now

- have lots of good packages for meta-analysis
- and packages that support the entire systematic review workflow
- but very little integration and no standards
- **metaverse** to the rescue?
- tutorials that show how packages fit together?

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My Plans

- keep expanding on the capabilities of **metafor**
 - add 'selection models' to **rma.uni()** (and **rma.mv()**?)
 - allow fitting **rma.uni()** models using fully Bayesian methods
 - allow models with 'random slopes' in **rma.mv()**
 - make **reporter()** work with meta-regression models
 - ...
- a meta-analysis data package (**metadat**) – in progress!

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The reporter() Function

- automatically generates a report based on '**rma.uni**' objects
- describes the statistical methods used
- gives a natural language summary of the results
- includes a forest and a funnel plot
- gives references for all methods used
- output can be html, pdf, or docx

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Quick Demo: The Usual Workflow

```
### calculate log risk ratios and corresponding sampling variances
dat <- escalc(measure="RR", ai=tpos, bi=tneg, ci=cpos, di=cneg,
             slab=paste(author, " ", year, sep=" "), data=dat.bcg)

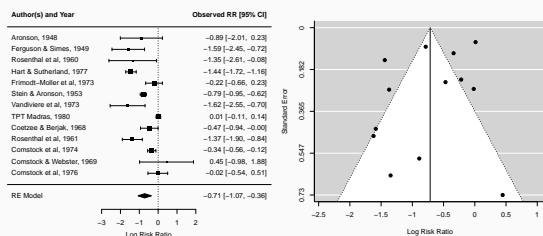
### random-effects model, using log risk ratios and variances as input
res <- rma(yi, vi, data=dat)
res

## Random-Effects Model (k = 13; tau^2 estimator: REML)
##
## tau^2 (estimated amount of total heterogeneity): 0.3132 (SE = 0.1664)
## tau (square root of estimated tau^2 value): 0.5597
## I^2 (total heterogeneity / total variability): 92.22%
## H^2 (total variability / sampling variability): 12.86
##
## Test for Heterogeneity:
## Q(df = 12) = 152.2330, p-val < .0001
##
## Model Results:
##
## estimate se zval pval ci.lb ci.ub
## -0.7145 0.1798 -3.9744 <.0001 -1.0669 -0.3622 ***
##
## ---
## Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

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Quick Demo: The Usual Workflow

```
### then do lots more stuff ...
forest(res)
funnel(res)
influence(res)
ranktest(dat$yi, dat$vi)
regtest(dat$yi, dat$vi)
```



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Quick Demo: Using Reporter

```
reporter(res)
```

Directory for generating the report is: /tmp/RtmpfH6xxC

Copying references.bib and apa.csl to report directory ...

Saving model object to report_res.rdata ...

Creating report_res.rmd file ...

Rendering report_res.rmd file ...

Generated /tmp/RtmpfH6xxC/report_res.html ...

Opening report ...

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Reporter To-Do

- make `reporter()` work with meta-regression models
- other ideas:
 - option to suppress forest/funnel plots?
 - allow transformation of results? (like `transf` argument)
 - add explanatory footnotes?
 - what if number of outliers/influential studies is very large?
 - include correlation table for moderators?
 - extend to `rma.mh`, `rma.peto`, and `rma.glmm` objects?
 - more customization? (group names, outcome name, ...)
 - ...

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