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Doing Meta-Analysis with R – A Hands-On Guide

Mathias Harrer, Pim Cuijpers, Toshi A. Furakawa, David D. Ebert
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Context

Scientific synthesis is a diverse field of contemporary science. Syntheses advance knowledge in many domains and can include data compilation, theory syntheses, methods contrasts, and systematic reviews with meta-analyses through an integrated and big-picture view of evidence (Halpern *et al.* 2020). All these knowledge tools are typically strongly supported by statistical software including the open-source programming language R. Within this environment, there are nearly 100 packages to support meta-analyses each with different functions and specific capabilities (Lortie and Filazzola 2020). Meta-analyses are defined in most domains as the calculation of effect sizes or a weighted relative strength of evidence from a set of studies or trials to then subsequently examine high-level statistical patterns and variance (Gurevitch, Koricheva, Nakagawa, and Stewart 2018). They are increasingly used in many fields of science to examine consilience in hypotheses (Lortie 2014) and have been proposed as the gold or even platinum standard of evidence when there is statistical agreement in the efficacy of an intervention across studies (Stegenga 2011). Consequently, there is a critical need for accessible, pragmatic publications, resources, and texts that enable scientists with varying levels of expertise to engage in scientific syntheses using meta-analysis.

Content

There are many resources to support doing meta-analyses including generalized primers published as papers (Impellizzeri and Bizzini 2012), reviews that describe when and why to apply (Crocetti 2015), extensive support for packages published on the CRAN task view "Meta-Analysis" (Dewey 2022), and texts that describe the process in depth (Koricheva, Gurevitch, and Mengersen 2013). One of the most recent additions to the field is the book reviewed here (Harrer, Cuijpers, Furukawa, and Ebert 2022). This is the first edition comprised of a total of 17 chapters in addition to an appendix that further includes common questions and answers,

effect size formulas, and details of specific deployment in R. The organization of the book is clear, representative of a workflow, and advances from primary, fundamental meta-analysis steps such as handling data, data aggregation, exploring heterogeneity, data visualization, right up to model building and testing assumptions. The chapters are thus organized into four major overarching sections including getting started in R, doing a meta-analysis, advanced models, and helpful tools. Each chapter is then further divided into well-articulated subsections that describe the specifics of a process or model in detail. The capacity for R to support all levels of statistical work are incorporated throughout each chapter, and the salient principles and concepts including those that underpin the fundamentals of meta-analysis and its history are included, appropriately, in every chapter.

The more advanced and also contemporary/cutting-edge methods are also included such as network meta-analysis, Bayesian meta-analysis, and others. The final section of the book, entitled helpful tools, develops some but not all of the more common additional considerations and methods that are at times needed in doing a meta-analysis. This includes power analysis, bias, reproducibility, and conversion between effect sizes to explore sensitivity. Plots, equations, code chunks, model outputs from R, are all included in addition to traditional text descriptions. This is a strongly visual and highly readable textbook. There are also text boxes with a symbol including for instance a lightbulb icon to highlight critical ideas or an exclamation icon for other text boxes to catch the attention of the reader to be mindful of a caveat or consideration. Reporting sections, functions, and a test your knowledge set of text boxes are also provided to ensure that the content is well structured, organized, and consistently identified. This sufficiently breaks up the writing and makes the textbook more functional and thus hands on. Data and examples are always provided, and annotation and labeling of code and data visualization is also provided so as to guide the reader in quickly accessing concepts from the quantitative visual elements provided. Finally, the R and package information provided at the end of textbook lists all versions of tools used, and the bibliography is comprehensive providing an excellent balance between contemporary and fundamental works needed to support further learning on this subject.

Critique

This text is instrumental in effectively completing a meta-analysis. Full stop. It is particularly profitable for the adept use of R to calculate and analyze effect sizes from basic to more advanced models. The chapters are internally well organized, logical, and clearly articulate why, how and what to do. The code needed to complete work is provided in the flow within each chapter for each instance or step associated with a particular method. The chapters are also clearly organized across the book advancing in a progression that supports the thinking and logic of a workflow for a meta-analysis from start-to-finish (Field and Gillett 2010). The examples are specific and accessible, but the work and code provided is resilient, reusable and sufficiently general for all readers. The decisions to follow one step with another are well cited with the appropriate scientific synthesis literature, and a host of packages for R are provided relevant to each challenge step. In the event that there are multiple options, each package is described and how the functions differ in their capacity to address a particular issue or examine and provide a set of summary statistics are clearly contrasted. These contrasts are a powerful heuristic for both the new and advanced meta-analyst. In particular, Chapter 8 on meta-regression is a standout exemplar of deep pedagogy, linkages to synthesis science,

and replicable code. If you have data that includes moderators (or factors in more common statistical nomenclature), this is a chapter that will be revisited repeatedly to ensure one is exploring model fit well, examining interactions, and best addressing multiple moderator effects. This chapter is also a representative indicator of the strength of this text because it includes a subsection that describes the common pitfalls associated with multiple meta-regression. Many other chapters similarly provide the reader with the nuances of a model or analytical approach through subsections that describe outliers, heterogeneity, problems typical to a method, or the rationale between choices. The subsection labels are clear and informative for quick queries, and the purpose of that specific component of text is evident. Some the subtitles are also amusing and compelling and all tell a story that both supports statistical reasoning and pragmatic application of meta-analysis to derived data.

This is a hands-on, clear step-by-step text. It is appropriate to wide ranging audiences from beginners to meta-analysis (but not necessarily R) to more advanced synthesis scientists. This text will support meta-analyses for all researchers, agnostic of their domain, provided they have a clear question and some competency in R. There is also sufficient detail in the math, explanations, and theory to support readers who need to learn how to do a meta-analysis but perhaps elect to use another statistical software application. The worked examples are well coded, annotated, and interpreted to support learning from any tool that generates similar and common statistics from a meta-analysis. The output of many statistical software applications can be a challenge to reconcile with purpose or theory, and this is adroitly handled here throughout the text. This is thus a readable, accessible corpus of statistical approaches that is relatively light on unnecessary jargon and defines key terms. The questions and answers provided for each chapter also ensure consolidation of critical and applied concepts for each chapter. Writing composition is clear, and the enthusiasm for meta-analysis by the authors and its merit are inspiring. This is an ideal resource to support doing meta-analysis, and it is likely not necessary for most readers to access resources outside the text because it develops each principle and step in sufficient detail and depth. The commitment by the reader to the material in the text depends on the purpose of accessing this resource. If the reader simply seeks solutions to a challenge with data in R and understands the correct application of a method conceptually, this text can be a quick source for code snippets. Ideal use of this text however would be to engage to a greater extent with the content provided because it is a compelling and balanced offering that advances and promotes a reasoned and replicable approach to meta-analysis that is exceptionally well grounded in theory and statistics.

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