Tutorial: Meta-Analytic Methods for Cognitive Science

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Meta-analysis is a powerful and underused tool in cognitive science. It allows researchers to leverage entire bodies of literature to make more precise estimates of effect sizes, which are important for theory development, as well as for conducing power-analyses for prospective studies. In this tutorial, we will introduce meta-analysis as an analytical tool, and provide participants with hands-on experience conducting their own meta-analysis. We will also present an online platform we have developed for conducing meta-analyses in the field of language development: MetaLab (http://metalab.stanford.edu).

Keywords: meta-analysis; reproducability

Significance

The empirical social sciences are in crisis: many subfields are plagued by issues of low reliability and validity of their findings (Ioannidis, 2005; Open Science Collaboration, 2013, 2015). One source of this crisis may be poor estimates of effect size as a result of under-powered studies. Meta-analysis is powerful tool for addressing this issue. By aggregating across studies, meta-analysis allows researchers to get more precise estimates of effect size than could be achieved by a single study alone. Critically, better estimates of effect size allow researchers to design new studies robustly, by basing sample size decisions on power analysis, and develop theories better grounded in the empirical data.

However, despite these benefits, meta-analysis has not become a prevalent tool in cognitive science. One reason may be that there are high hurdles and few rewards to conducting a meta-analysis. Conducting a meta-analysis is a laborious process, particularly according to common practice where a few people do the work, and with little ready-to-use support tools and educational materials available. In addition, the general benefits of meta-analyses, for instance the possibility of conducting power analyses, are often neither evident nor accessible to individual researchers, and so the incentives for conducting analyses are low. Moreover, traditional meta-analyses remain static after publication, aging quickly as new results emerge.

The goal of of this tutorial is to lower these hurdles and demonstrate the potential rewards for conducting meta-analyses. We will start with a broad introduction to meta-analyses as an analytical tool. Participants will then get hands-on experience conducting a meta-analysis in an interactive session. By the end of the tutorial, participants will have a better understanding of the practical and theoretical utility of meta-analysis, as well as working knowledge about how to go about conducting their own meta-analysis in a topic of interest.

Part of the focus of the tutorial will be introducing participants to a tool we have been developing for meta-analysis, MetaLab (http://metalab.stanford.edu; Bergmann et al., 2015; Lewis et al., 2015). MetaLab is an online platform that aggregates meta-analyses on topics related to language development (e.g., phoneme discrimination and word segmentation; Tsuji & Cristia, 2014; Bergmann & Cristia, 2015). MetaLab addresses three key challenges in conducting meta-analyses. First, it supplies templates and analysis scripts, streamlining the process of learning about and conducting a meta-analysis. Second, it supports community-augmented meta-analyses (CAMA; Tsuji, Bergmann, & Cristia, 2014), allowing a meta-analysis to be conducted and extended by multiple researchers, both reducing the workload of the individual researcher as well as allowing for dynamic extensions to always include the newest results. Third, for each meta-analysis conducted in the MetaLab framework, we provide free and easy-to-use tools for power analysis and data exploration (Fig. 1).

By introducing researchers to the method of meta-analysis, this tutorial will promote thinking in terms of effect sizes rather than significance, emphasize replicability, and increase the benefits of meta-analysis for the whole research community.

Structure

This one-day [half-day?] tutorial will introduce participants to the method of meta-analysis, providing a hands-on step-to-step guide to use the MetaLab infrastructure for conducting a meta-analysis, working on it collaboratively, and sharing it

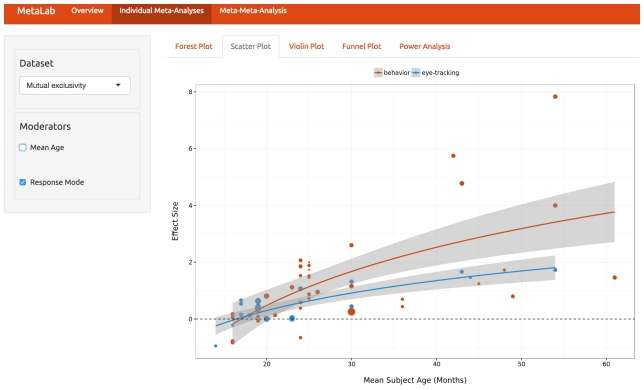

Figure 1: Screenshot of the MetaLab interactive tool. For each meta-analysis in the database, MetaLab provides a set of visualization tools, allowing users to interactively explore the role of moderators on effect sizes. Here, we see an increasing effect sizes for the bias to select a novel referent for a novel word (mutual exclusivity) across development, and as a function of method.

with the research community.

Participants will step-to-step guide to conduct a meta-analysis based on a pre-selected topic. The topics of literature search and study selection, which precede the actual meta-analysis, will be covered briefly, but not included in the hands-on part of the tutorial. Participants will be walked through the steps of a meta-analysis with a theoretical and practical part in each step. Two tutorial organizers will be available for questions and assistance throughout the tutorial.

1. Coding of variables (2h)
   (a) Theory: How to decide on independent and dependent variables to be included; which information is needed
   (b) Hands-on: Set-up of a spreadsheet in standardized format, deciding on variables to be included, coding of one pre-selected article (different article for each participant)
2. Effect size calculation (1h)
   (a) Theory: Introduction to different types of effect sizes, their calculation, and how to transform between them
   (b) Hands-on: Effect size calculation for paper coded
3. Meta-analysis (3h)
   (a) Theory: Introduction to meta-analytic regression, choice of model, choice of moderator variables, correction for publication bias, and interpretation of analysis output
   (b) Hands-on: Putting together the papers coded by each participant and conducting a meta-analysis

Organizer Credentials

All organizers have conducted meta-analyses in their field. We have also worked together to develop the MetaLab platform since 2/2015. AC, CB, and ST have expertise creating CAMAs (Tsuji et al., 2014). ST, ML, CB, and AC have experience leading meta-analysis workshops. MB, MF, ML, and PP have experience with web development, dynamic data entry, and online statistical analyses.

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