Neuroimaging Meta-analyses: Concepts and practice

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Educational Course - Half Day

This is a timely educational topic for two main reasons.

First, the literature is expanding so quickly that it's not feasible for every researcher and clinician to manually review the literature. For example, there are over 2000 fMRI papers published each year according to PubMed. Attendees will be able to demonstrate understanding of the history and importance of neuroimaging meta-analyses so that they can effectively synthesize past results, form hypotheses, and interpret new information.

Second, there is a growing number of methods and tools for meta-analyzing neuroimaging data, each with its own benefits, limitations, and interpretations. Participating researchers and clinicians will be able to understand these distinctions well enough to determine the quality of a meta-analysis and its conclusions, as well as to know which kinds of meta-analyses they could perform with the data and tools available to them.

Objective

- Participants will be able to evaluate and differentiate the landscape of methods and tools used for neuroimaging meta-analyses. They should be able to read a new meta-analysis and critically consider its conclusions in light of the particular method's strengths and limitations, as well as other common sources of statistical error.
- Participants will be able to explain how to use previous meta-analytic results in new studies. For example, they will know how to generate regions of interest when planning a study and how to interpret novel results using large-scale automated meta-analysis tools like NeuroSynth and NeuroQuery.
- Participants who participate in the hands-on tutorial at the end of the course will be able to to perform a basic meta-analysis using an open-source tool in Python.

Target Audience

This course will be useful for researchers and clinicians with any of these three goals:
1) To read and understand a meta-analysis' methods, limitations, and interpretation;
2) To use past meta-analyses to form new hypotheses and interpret results in novel research; and
3) To perform neuroimaging meta-analyses in a reproducible manner.

Presentations

Overview and History of Neuroimaging Meta-analyses

Understanding the role of meta-analyses in neuroimaging and the broad families of methods. Points to cover: Give a brief history of meta-analyses in neuroimaging, including how new methods were developed to suit image-based results and the particular limitations of neuroimaging studies. Explain the main uses of meta-analyses: synthesizing past results, developing new hypotheses, and interpreting novel results. Outline the broad families of methods: coordinate versus image-based methods, and manual versus automated methods. Interactive components: Start with a poll to ask about participants' experience performing and using/reading meta-analyses. As we wait for participants to join the call, give them the opportunity to give a brief answer to "What are meta-analyses used for in neuroimaging?" in a Google Form. The answers will be visualized in a word cloud using pre-prepared code, and we'll share the word cloud when the lecturer talks about the uses of meta-analyses.

Presenter

Angela Laird, Florida International University Miami, FL, United States

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Conventional, or Manual, Meta-analyses

Learning outcome: Understand the process of manually selecting and annotating studies to be included in a meta-analysis. Points to cover: Explain the continued utility of manual meta-analyses, even with a wealth of high-quality, automated tools. Describe some past manual meta-analyses that were important in the field and illustrate several different methods, including some well-done meta-analyses with inconclusive results. Briefly outline the steps and options for manually selecting and annotating studies (including, for example, the role of metaCurious and NeuroVault). Introduce the idea of "semi-automated" meta-analyses, leveraging tools like Neurosynth, NeuroVault, and metaCurious. Explain why it's important to share results images instead of just reporting peak coordinates. Interactive components: Start with a poll asking which exclusion criteria seem necessary for doing a meta-analysis, including some criteria that could bias the results. Later, ask participants to do something easy on MetaCurious, PubMed, or NeuroVault (e.g., start a search string). We will conclude with 5 minutes for participant questions.

Presenter

Katherine Bottenhorn, Florida International University Miami, FL, United States

The Neuroimaging Meta-analytic Ecosystem

Learning outcome: Understand the meta-analysis ecosystem, including which tools and methods can and should be used in the context of meta-analyses, as well as the recent advances of both methods and platforms preparing, hosting, and analyzing image based or coordinate based data for meta-analyses. Points to cover: Note that there are many methods and tools that are relevant to neuroimaging meta-analyses - List the various platform components, Explain what is each component in the ecosystem and what is the purpose and use cases of these components - Explain why we need an interoperable system of services for meta-analysis - Explain the major divisions in the system, the tools that exist, and those that are in development - Explain the standard data formats necessary for the system to work. - Explain where we are in the timeline for making this ecosystem fully functional - Many of the tools are now part of a common ecosystem, mostly implemented in python, and this lecture will give the overview. Interactive components: Ask the audience which type of meta analyses they have or would like to perform. Ask what are the “pain points”. Before explaining the data formats, ask what they think would be necessary to allow all the system’s components to better work together.

Presenter

Thomas Nichols, University of Oxford, Big Data Institute Building, Oxford, United Kingdom

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Large-scale Coordinate-based Meta-analyses

Learning outcome: Understand how to use large-scale automated meta-analyses in novel research in a valid manner. Points to cover: Explain the limitations of conventional manual meta-analysis methods Outline the various methods and datasets that exist for doing large-scale meta-analyses, including BrainMap, NeuroQuery, and NeuroSynth. Describe in greater detail the NeuroSynth approach, which automates study selection and coordinate extraction. This results in less precise selection criteria and less accurate coordinate extraction, but the possibility to perform meta-analysis on a much larger number of studies. Explain when to use automated meta-analyses and point out some common misinterpretations, such as invalid claims of reverse inference. Interactive components: Near the beginning, ask participants to go to NeuroSynth or NeuroQuery and look up something related to their field, and then respond in a poll whether or not the results that they see make sense to them. Then at the end, ask them why these tools might be more or less effective in their particular field (e.g., the tools might not include all of the necessary vocab for a niche field). - We will conclude with 5 minutes for participant questions.

Presenter

Jérôme Dockès, McGill University, ORIGAMI laboratory, McConnell Brain Imaging Centre, The Neuro, Faculty of Medicine and Health Scienc, Montreal, Quebec, Canada

Sources of Error in Meta-analyses

Learning outcome: Understand the sources of statistical error in neuroimaging meta-analyses that participants read and perform. Points to cover: Briefly explain the different types of statistical error (bias versus variance) and what we can do about them. Describe the known sources of error particular to different aspects of a meta-analysis, such as a) coordinate-based vs image-based methods, b) the number of studies included, and c) manual vs automated inclusion criteria. Show that analytic variability occurs at the meta-analysis level as well as the individual-study level. Describe new research on unknown sources of error, including a) methods trends in subfields, such as scanner strength in clinical versus basic studies or the use of clusterwise inference; b) temporal trends, such as before/after major bug fixes in popular software or increasing sample size over time; and c) having various individual studies that draw from the same open dataset, such as the UK BioBank. Demonstrate methods for correcting for different sources of error, such as weighting by sample size. Demonstrate manual and automatic methods for labelling potential sources of error in papers that are to be included in a meta-analysis. Interactive components: After introducing the concept of analytic bias, ask participants to list methodological choices at the individual-study level that they think might introduce spatial bias at the meta-analytic level.

Presenter

Kendra Oudyk, McGill University Montreal, Quebec, Canada

Hands-on Tutorial with NiMARE

Learning outcome: Be able to run basic coordinate-based and image-based meta-analyses in Python Points to cover: Briefly remind participants of the landscape of meta-analysis methods (image vs coordinate). Give a brief overview of NiMARE, the Neuroimaging Meta-Analysis Research Environment. Have participants do the coordinate-based meta-analyses on 21 pain studies, briefly explaining each method (e.g., visualize the different kernels) Have participants do the image-based meta-analyses on 21 pain studies, briefly explaining each method Show which methods can be adapted to correct for different things, such as weighting studies by their sample size. Focus on teaching participants when to use different methods and how to interpret them, as opposed to the mathematical details of each method. Interactive components: Participants will be able to run the tutorial on their own machine, so this component of the course will be entirely interactive.

Presenter

Taylor Salo, Florida International University, Psychology, Miami, FL, United States