Neuroimaging meta-analyses the hard way (manually)

Katie Bottenhorn • Meta-Analysis Educational Course • OHBM 2021

The Plan

I. Neuroimaging meta-analysis recap

II. Why would I do this by hand?

III. How to

IV. “Semi-automated”

V. Why you should share your statistical maps

Recap

Neuroimaging meta-analyses are facilitated by conventions in the field:

- Results are presented as statistical parametric maps...
- With brain activation peaks reported as [x,y,z] coordinates...
- (And sometimes images!)
- In common stereotaxic reference space

Recap

Meta-analytic algorithms make it possible to synthesize such results

- To assess convergent activation patterns across a task or paradigm
- To contrast neural recruitment across cognitive systems
- To compare activation across subject groups
- Or to define regions of interest (ROIs) for future studies

Examples

Phan et al., 2002: subsystems of emotional processing

Buhle et al, 2014: support for a role of cognitive control in emotion regulation

Glahn et al., 2005: schizophrenia beyond hypofrontality

Fox et al., 2015: spontaneous thought extends beyond the default mode network

But why?

Manual vs. automated metas

Manual

- Search publication database/online library for publications
- Pull coordinates and metadata from individual publications (or email authors for images)
- Run meta-analysis on extracted coordinates/images

Automated

- Search neuroimaging database (e.g., BrainMap, Neurosynth) for publications
- Pull coordinates/images and metadata from database
- Run meta-analysis on extracted coordinates/images

Pros & cons of two approaches

Manual	Automated
Pros	
Greater access to potentially relevant publications	Easier access to coordinates/images and metadata
Not limited by bounds of database	Several large databases to choose from
Hands-on quality control	Outsource quality control
Cons	
Time consuming	Inherently limited metadata
Room for error	Size vs. quality trade-off

The case for manual meta-analyses

1. Fewer metadata limitations

Not all publication metadata is included in databases

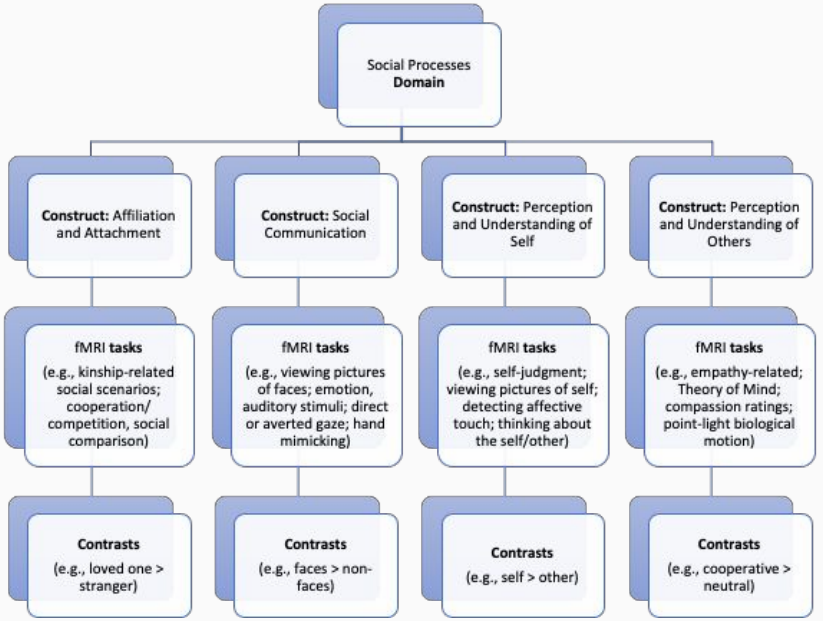
Commonly included:

- Task
- Cognitive construct
- Participant qualities (e.g., age, diagnosis, etc.)

1. *Fewer metadata limitations*

Examples of meta-analyses requiring uncommon metadata:

- Novel/uncommon task definitions
  - Naturalistic fMRI paradigms (Bottenhorn et al., 2019)
  - RDoC social paradigm groupings (Pintos Lobo et al., in prep)
- Uncommon participant qualities
  - Neuroimaging the menstrual cycle (Dubol et al., 2020)
  - Heart rate variability (Thayer et al., 2012)



2. Greater access to publications

Databases contain a subset of the literature

Which subset depends on how the database is populated

- Manually-populated databases (e.g., BrainMap) are often biased by task, cognitive domain
- Automatically-populated databases (e.g., Neurosynth) can be biased by publication year

Now that you're convinced...

Steps

Or, *How to perform a manual neuroimaging meta-analysis*

(for more information, see Müller et al., 2018)

1. Decide on inclusion / exclusion criteria
2. Search for publications
3. Annotate & exclude papers
4. Extract coordinates & metadata
5. Meta-analyze!

What if we wanted to do a meta-analysis of video games in fMRI?

1. Decide on criteria

Fundamentals:

1. Brain activation coordinates reported, or images shared, in standard space
2. Whole-brain analysis (i.e., not small-volume, region of interest analysis)

Everything else depends on your use case.

Example: video games in the scanner

Inclusion:

- Participants play video games in MR bore

Exclusion:

- Coordinates not reported OR no access to images
- Results reported not from video game paradigm
- ROI analysis (i.e., not whole-brain)

2. Search for publications

Good search engine options:

- PubMed/MEDLINE
- Web of Science

Less good, but reasonable search options

- Google Scholar
- Individual journals

Many meta-analytic researchers peruse published reviews and reference lists in other publications for additional papers

Video games in the scanner

PubMed search:

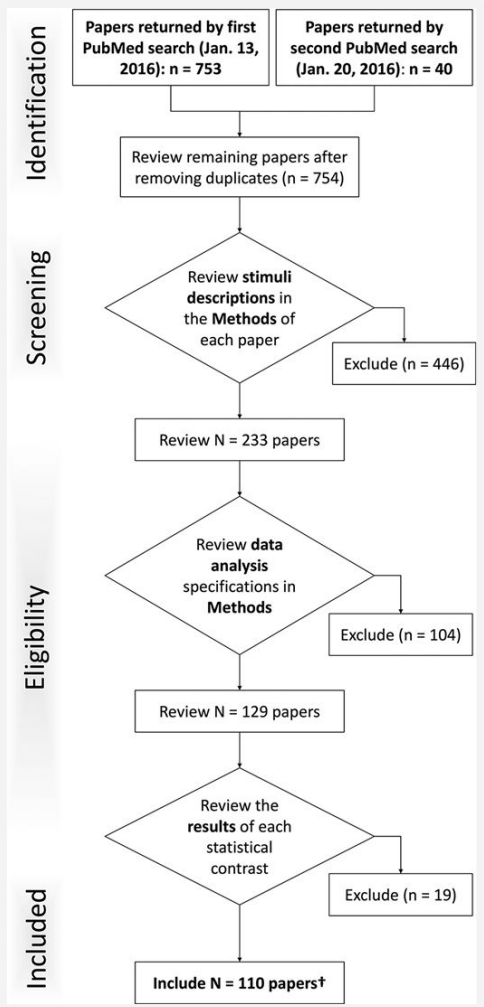
((video game*) OR (videogame*)) AND ((fmri) OR (functional magnetic resonance imaging))

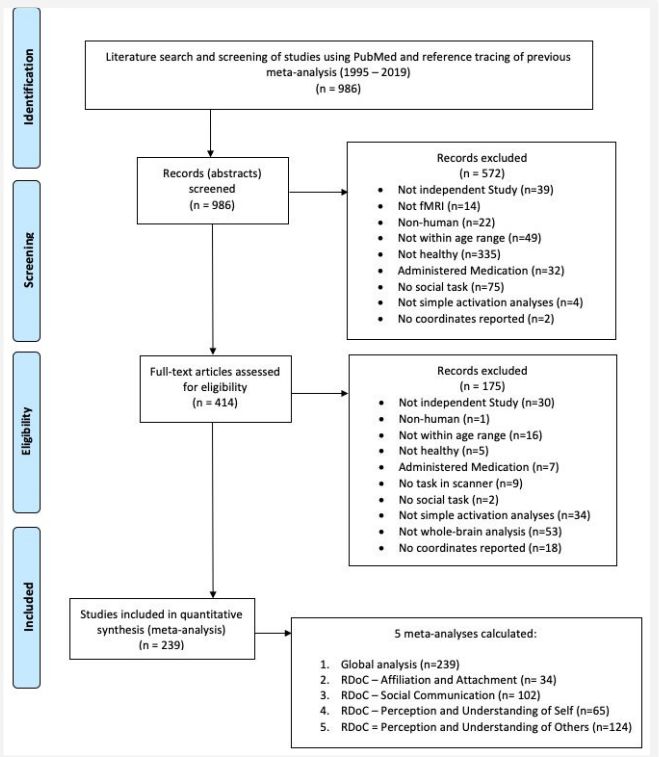
3. Annotate & exclude

Not all papers turned up by your search will meet criteria

See preferred reporting items for systematic reviews and meta-analyses (PRISMA) Checklist for guidance

Review papers in stages and keep track of reason for exclusion





4. Acquire data!

Coordinate-based meta-analyses:

- Extract coordinates from publication
- Separate by statistical analysis (or, *contrast*)

Image-based meta-analyses:

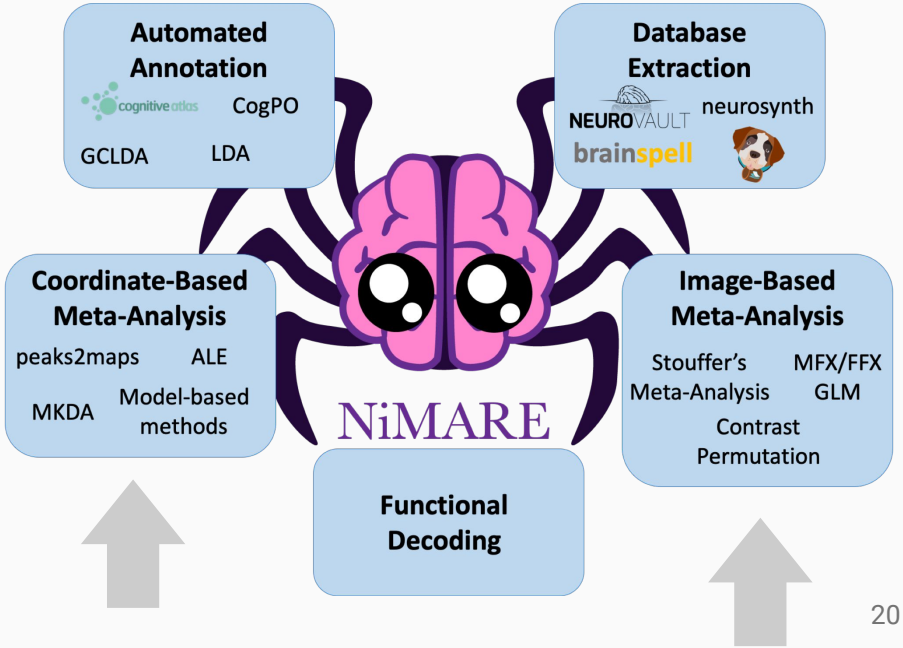
- Fetch images from repository
- Or: email authors to request statistical images

5. Meta-analyze!

This step is almost agnostic to the method of data acquisition/curation

Requirements:

- Coordinate or image data
- Any necessary metadata (i.e., # subjects for most CBMA)
- Meta-analytic algorithm



But what if there were shortcuts?

Semi-automated meta-analysis

1. Decide on inclusion / exclusion criteria
2. Search for publications
3. Annotate & exclude papers
4. Extract coordinates & metadata
5. Meta-analyze!

NEUROVAULT

metaCurious.

neurosynth.org

Neurosynth

Coordinate-based repository

Can help with

- Searching for publications
- Extracting coordinates & metadata

neurosynth.org

NeuroVault

Image-based repository

Can help with

- Searching for publications
- Extracting coordinates & metadata

metaCurious

Web-based dataset curation tool (WIP)

Includes data from Neurosynth

Can help with

- Searching for publications
- Annotating & exclude papers
- Extracting coordinates & metadata

PSA: Share your statistical results as images

Thanks!

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