



Practical Intensity Based Meta-Analysis

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BIG DATA
INSTITUTE



UNIVERSITY OF
OXFORD

2017
OHB M
VANCOUVER
June 25-29, 2017

Practical intensity-based meta-analysis

Coordinate-based meta-analysis



Image-based meta-analysis

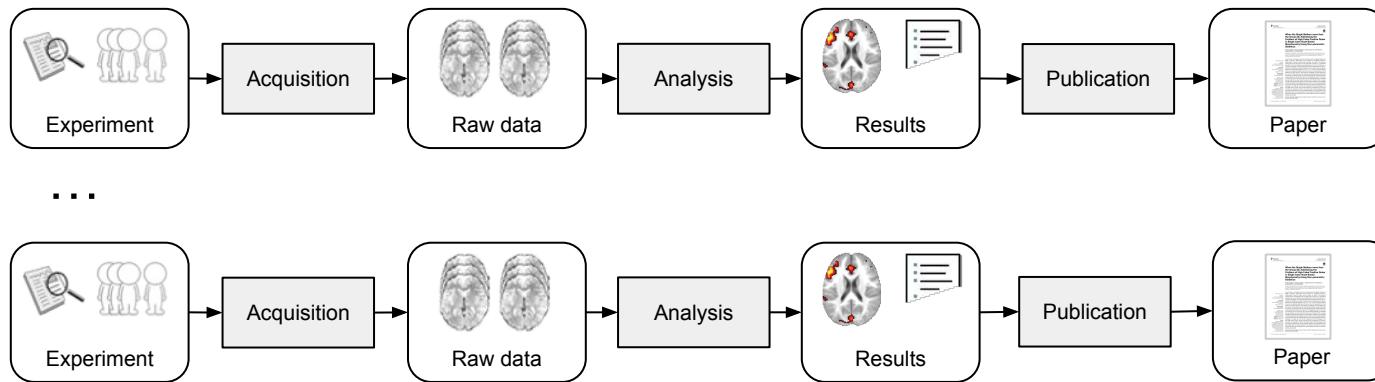


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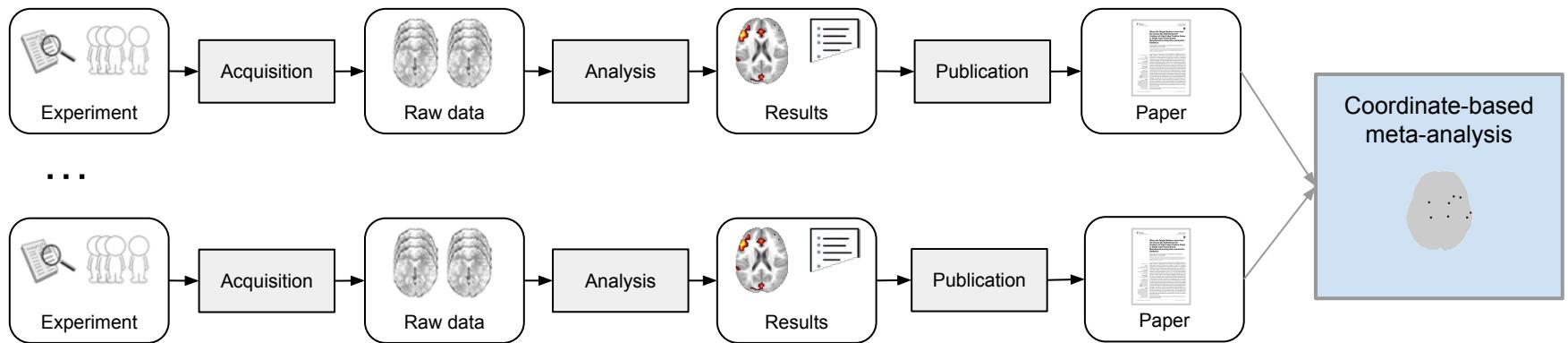
OHBM Neuroimaging Meta-Analysis
Educational course, 25 June 2017

Coordinate-Based & Image-Based Meta-Analyses

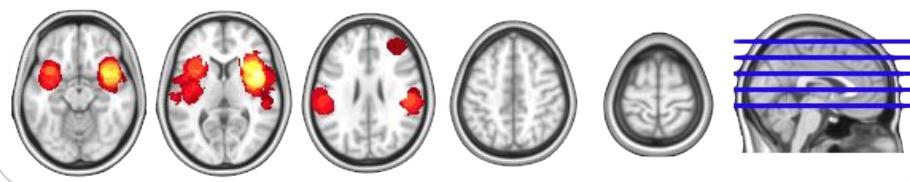
Neuroimaging meta-analyses



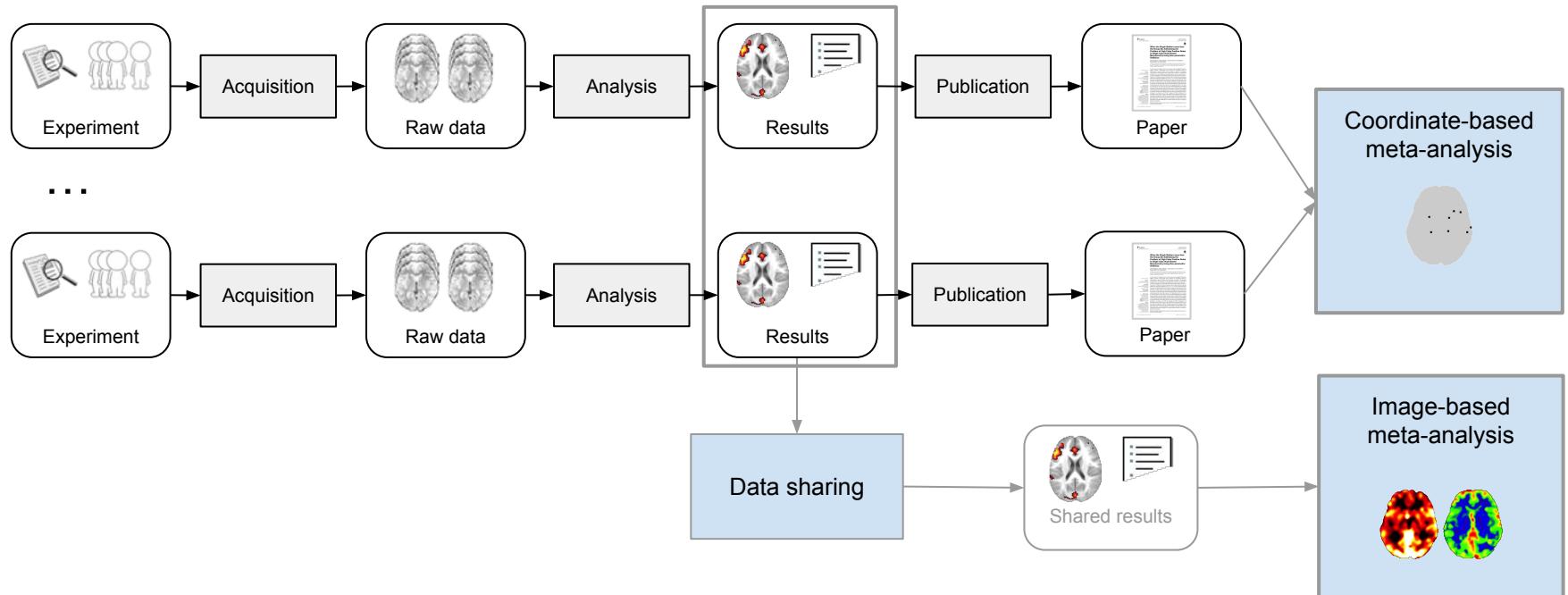
Neuroimaging meta-analyses



Coordinate-based meta-analysis



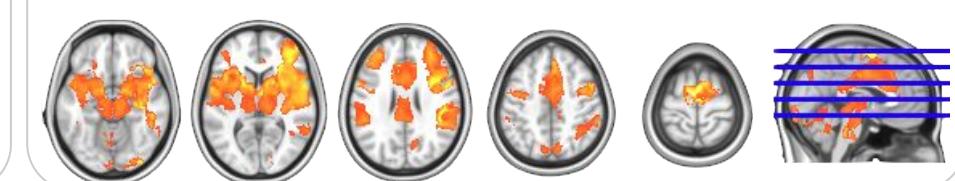
Neuroimaging meta-analyses



Coordinate-based meta-analysis



Image-based meta-analysis



How to perform an image-based
meta-analysis?

Image-based meta-analysis

Subject 1

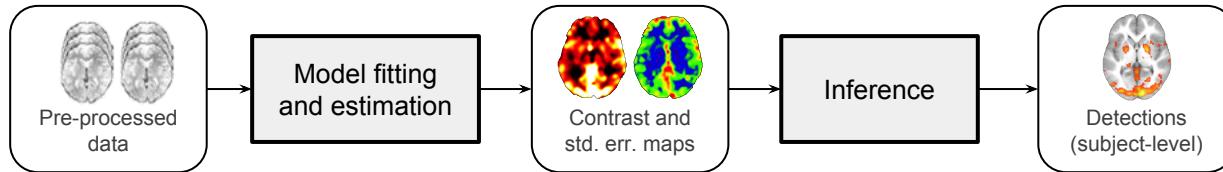


Image-based meta-analysis

...
Subject 1
Subject n

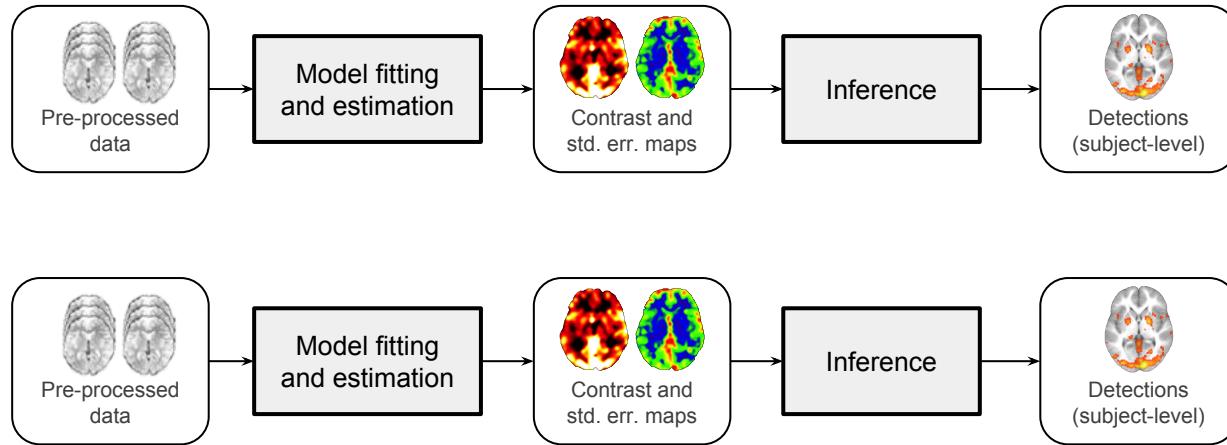


Image-based meta-analysis

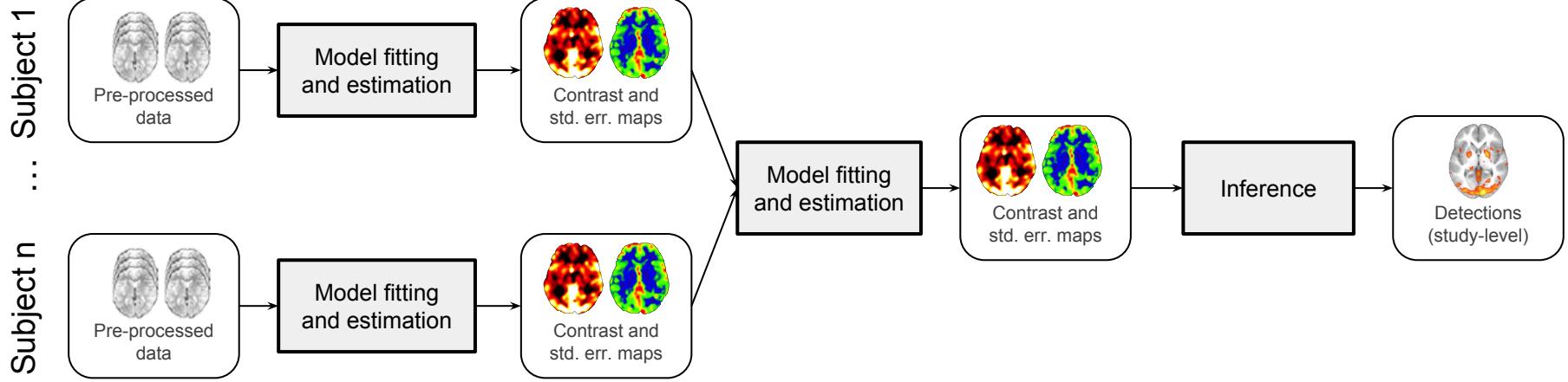


Image-based meta-analysis

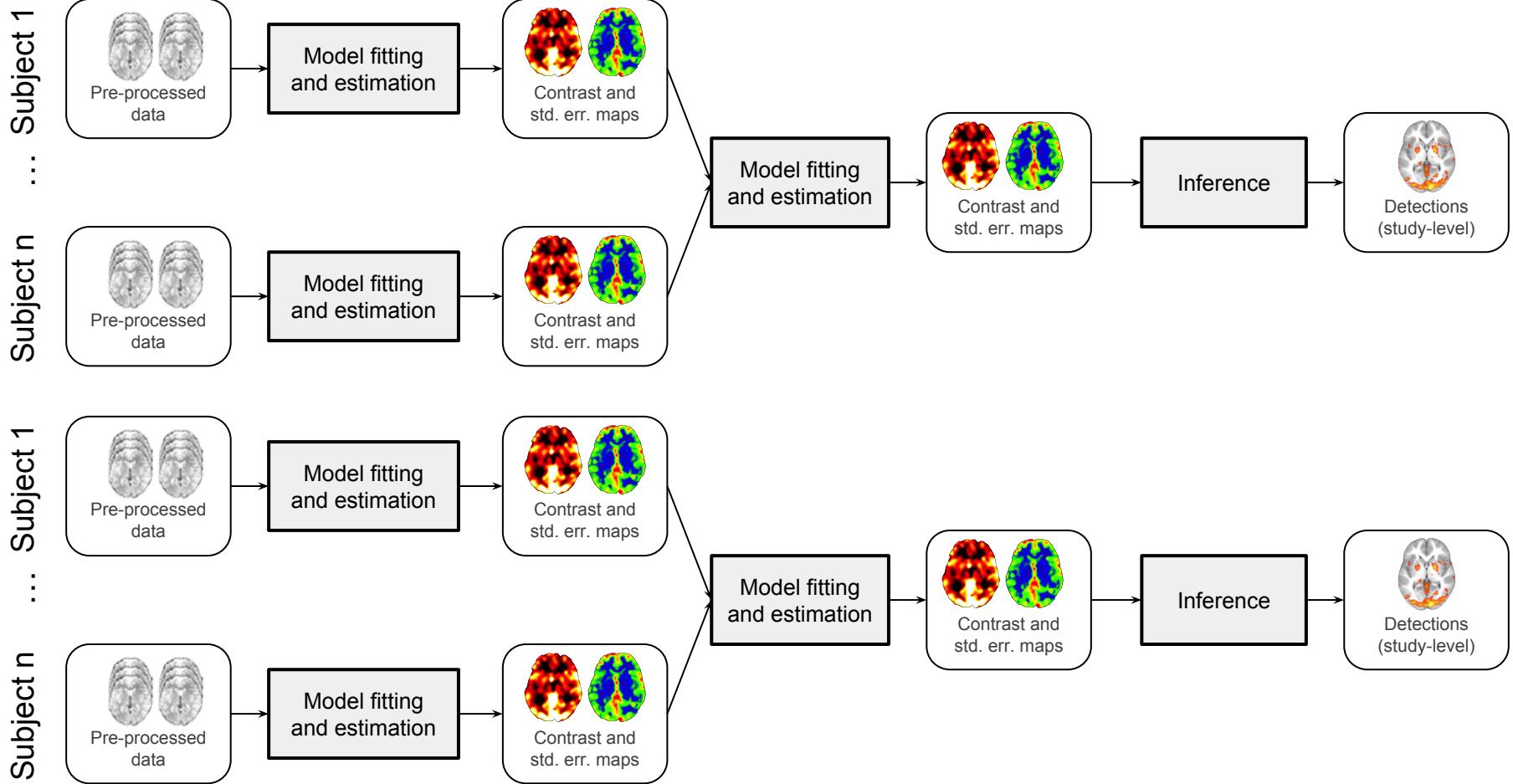


Image-based meta-analysis

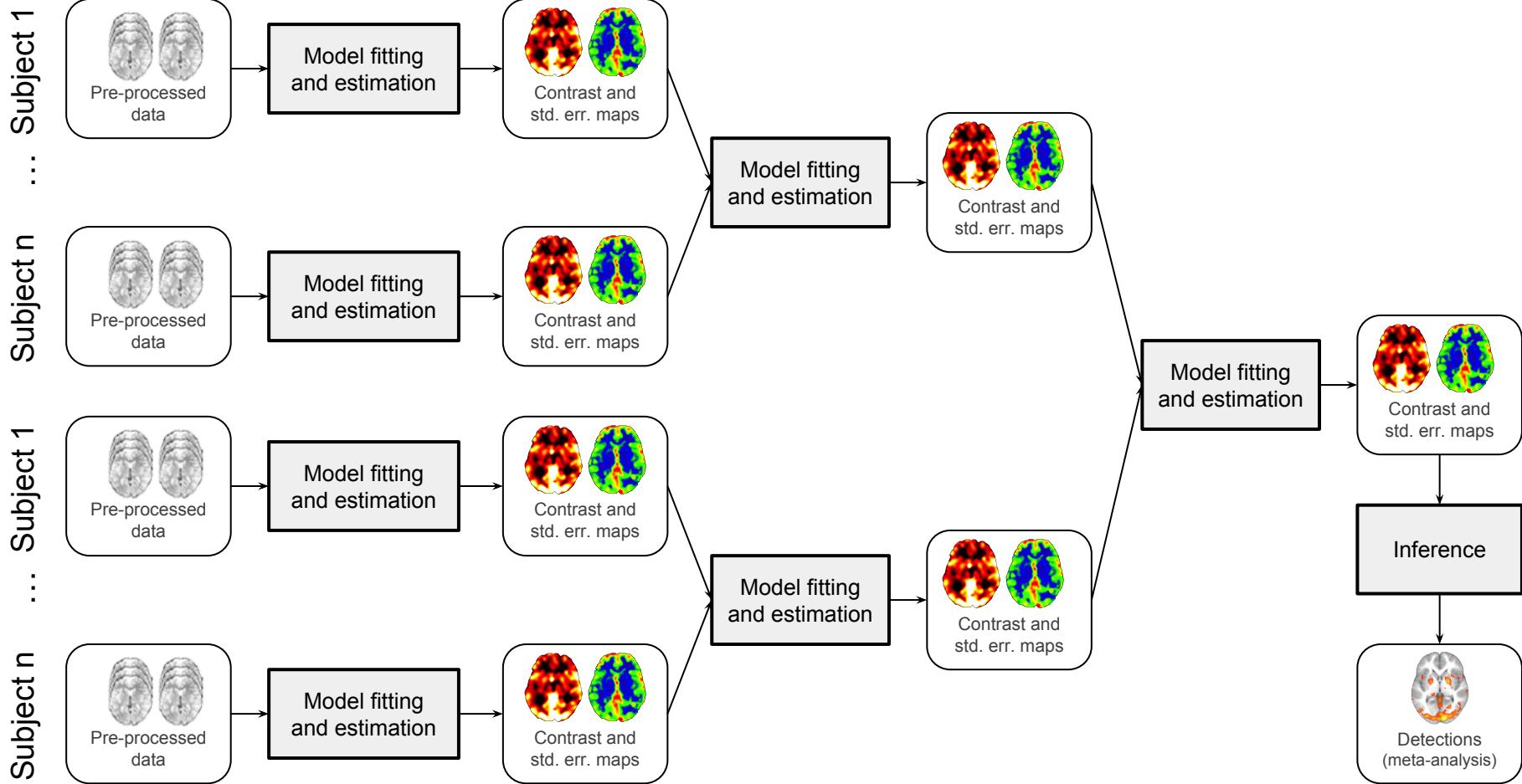


Image-based meta-analysis

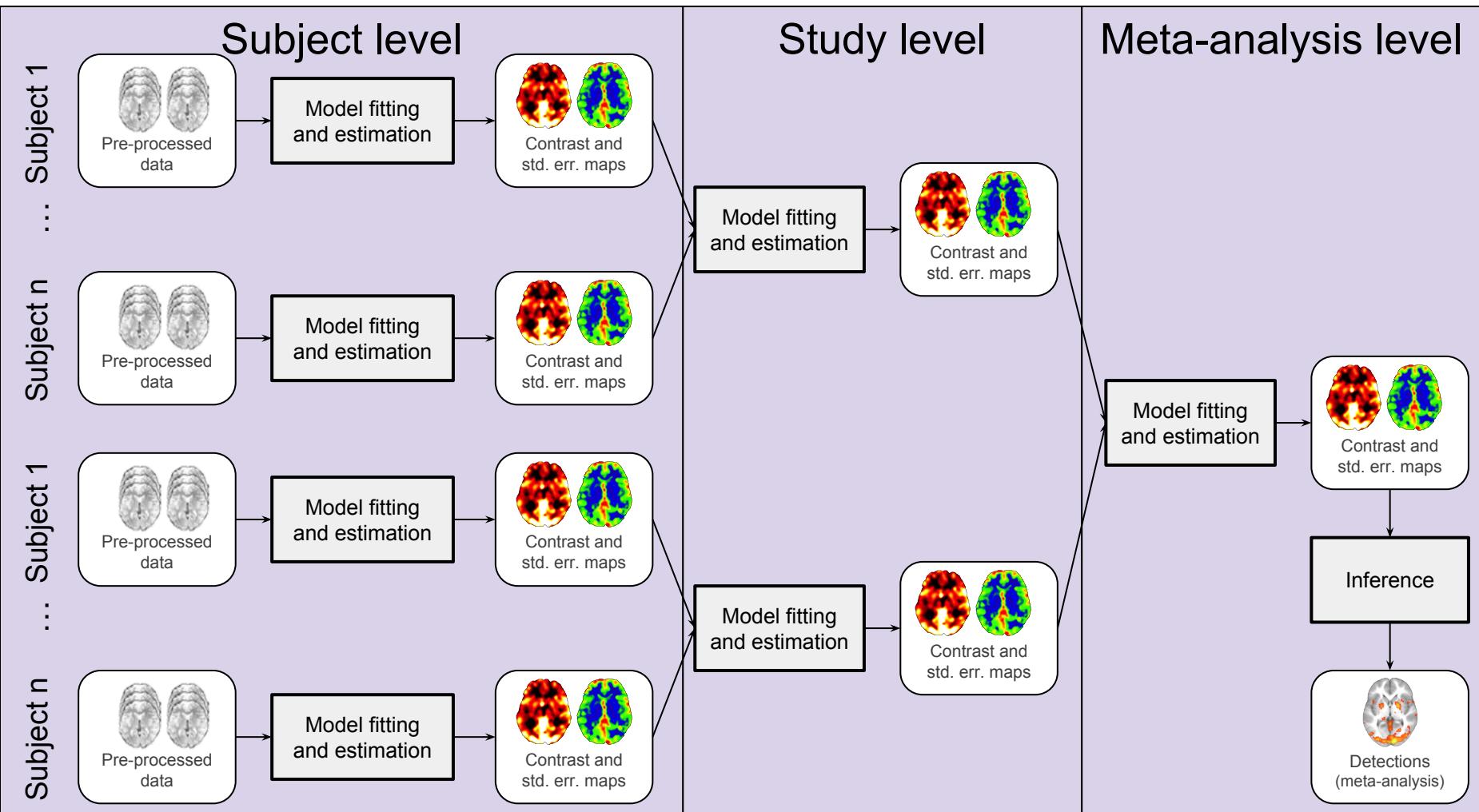


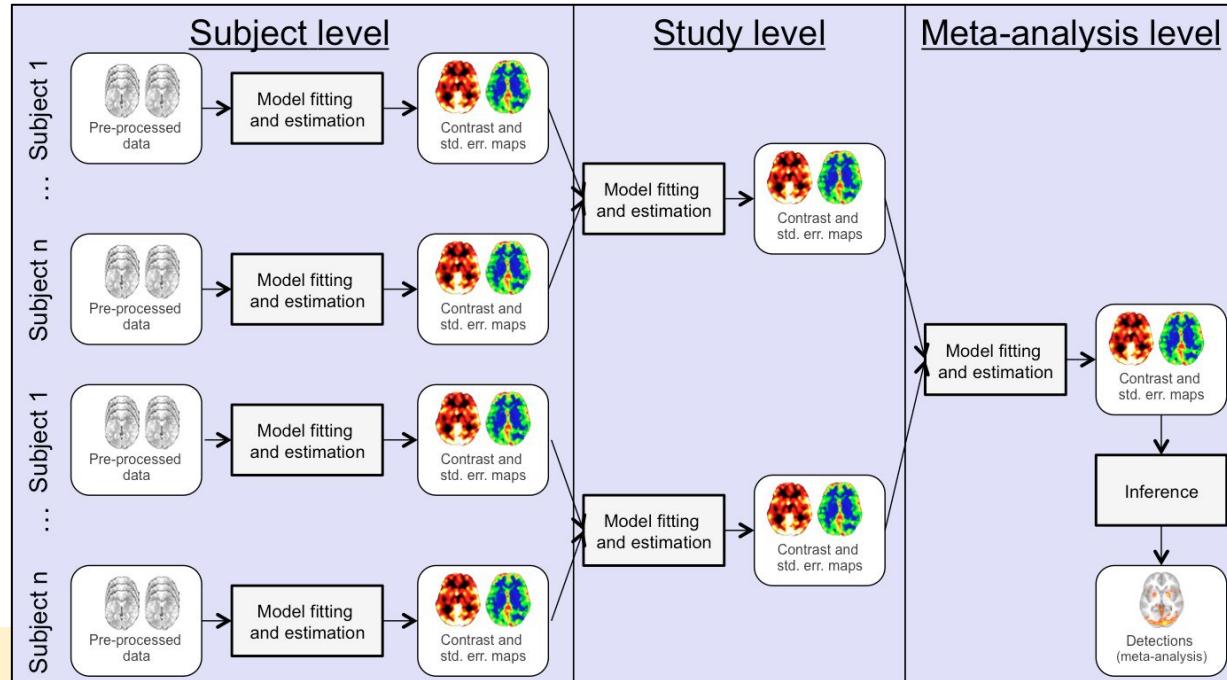
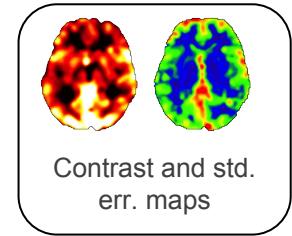
Image-based meta-analysis

- Gold standard:

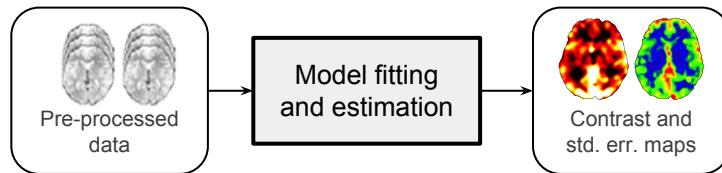
Third-level Mixed-Effects GLM

- Requirements

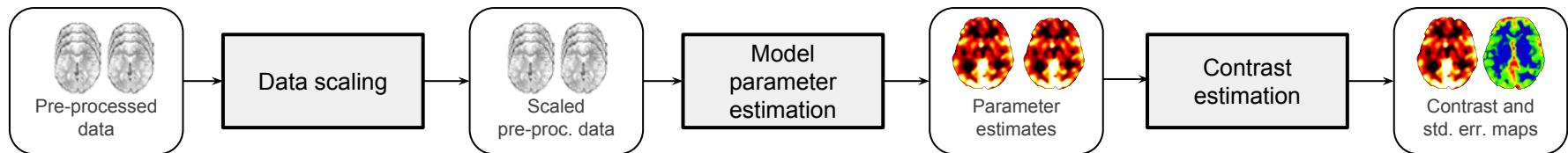
- study-level **Contrast estimates and Standard error maps.**
- **Same units**



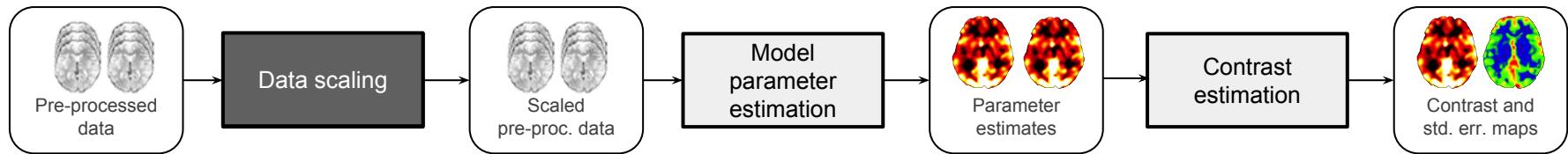
Units of contrast estimates



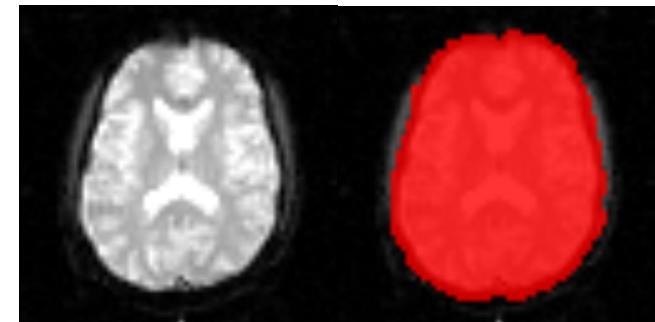
Units of contrast estimates



Units of contrast estimates

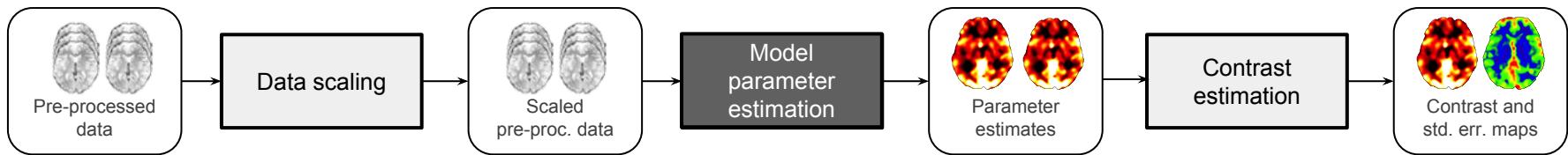


$$\text{scaled_data} = \frac{\text{data} * \text{target}}{\text{est_mean}}$$



Units depend on **mean estimation** and **scaling target**.

Units of contrast estimates

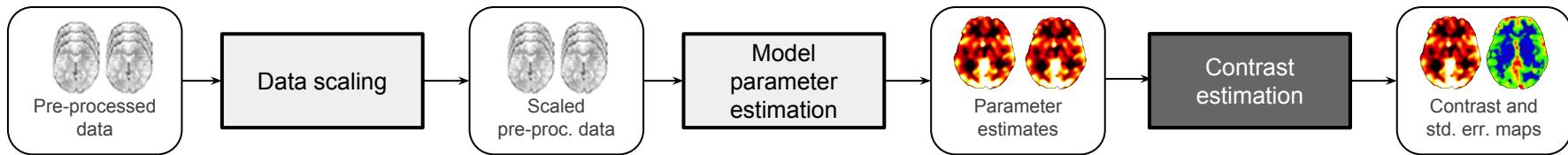


$$Y = \beta + \varepsilon$$

The equation $Y = \beta + \varepsilon$ is displayed, where Y is represented by a matrix with alternating dark and light gray horizontal bands. To the right of the matrix is the equation $\beta + \varepsilon$.

Units depend on **scaling** of explanatory variables

Units of contrast estimates



- Contrast Estimation
 - Linear combination of parameter estimates
 - Final statistics invariant to scale
 - e.g. [1 1 1 1] gives same T's & P's as [¼ ¼ ¼ ¼]

Units depend on **contrast vector**

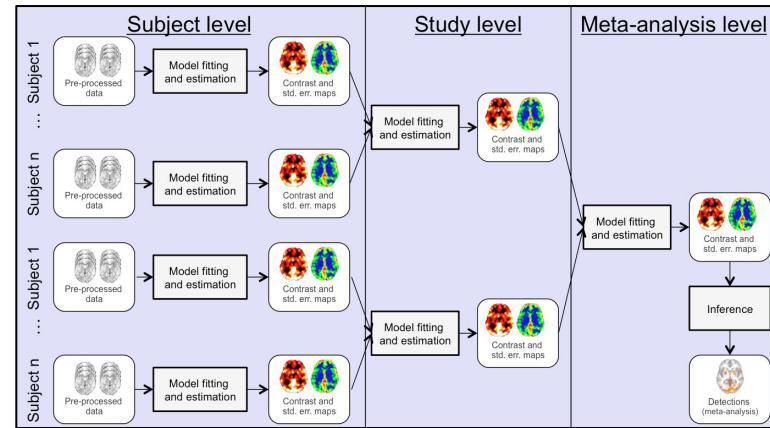
- Rule for contrasts to preserve units
 - Positive elements sum to 1
 - Negative elements sum to -1

Units of contrast estimates

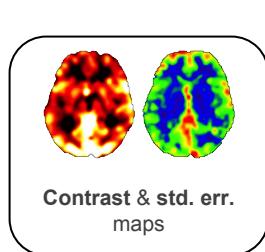
- Gold standard:

Third-level Mixed-Effects GLM

- But...
 - Units will depend on:
 - The scaling of the data (subject-level)
 - The scaling of the predictor(s) (subject- and study-level)
 - The scaling of the contrast (subject- and study-level).
 - Contrast estimates and standard error maps are rarely shared...

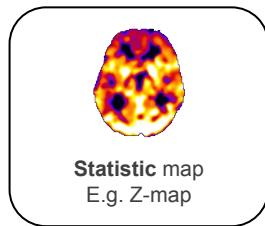


Which images for IBMA?

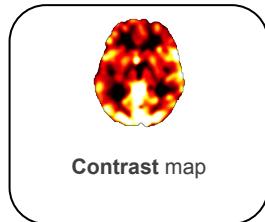


SPM

con_0001.nii
[SPM.mat]



spmT_0001.nii



con_0001.nii

FSL

cope1.nii
varcope1.nii (*squared*)

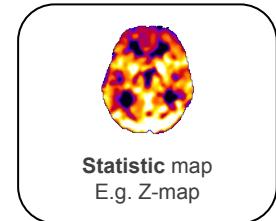
AFNI

3dMEMA_result+tlrc.BRIK[[0]]
[from contrast & stat maps]

3dMEMA_result+tlrc.BRIK[[1]]

3dMEMA_result+tlrc.BRIK[[0]]

IBMA on Z maps



- Fisher's

$$-2 \sum_k \log P_k \sim \chi^2_{2k}$$

- Sum of -log P-values (from T/Z's converted to P's)

- Stouffer's

$$\sqrt{K} \times \frac{1}{K} \sum_k Z_k \sim \mathcal{N}(0, 1)$$

- Average Z, rescaled to N(0,1)

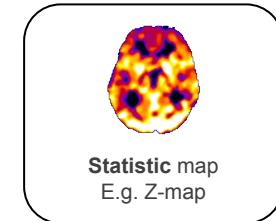
- “Stouffer's Random Effects (RFX)”

$$\sqrt{K} \times \frac{1}{K} \sum_k Z_k \sim \mathcal{N}(0, \sigma_{RFX}^2)$$

- Submit Z's to one-sample t-test

(Slide adapted from Thomas Nichols, OHBM 2015)

IBMA on Z maps + N



+ N

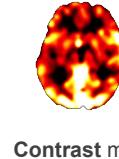
- Weighted Stouffer's

$$\sum_k w_k Z_k \sim \mathcal{N}(0, 1), \quad w_k \propto \sqrt{N_k}$$

- Z's from bigger studies get bigger weights

(Slide adapted from Thomas Nichols, OHBM 2015)

IBMA on Contrast maps

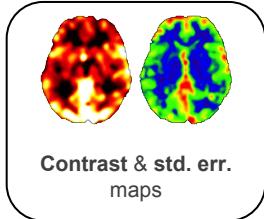


- Random Effects (RFX) GLM

$$\frac{1}{K} \sum_k c\hat{\beta}_k \sim \mathcal{N}(0, \sigma_{\text{RFX}}^2)$$

- Analyze per-study contrasts as “data”

Contrast + standard error maps



- Fixed-Effects (FFX) GLM

$$\frac{1}{K} \sum_k \hat{\theta}_k \sim \mathcal{N}(0, \sum_k \sigma_{\text{FFX},k}^2 / K^2)$$

- *Don't estimate variance, just take from first level*

(Slide adapted from Thomas Nichols, OHBM 2015)

Implementations

- Not all of these options are easily used

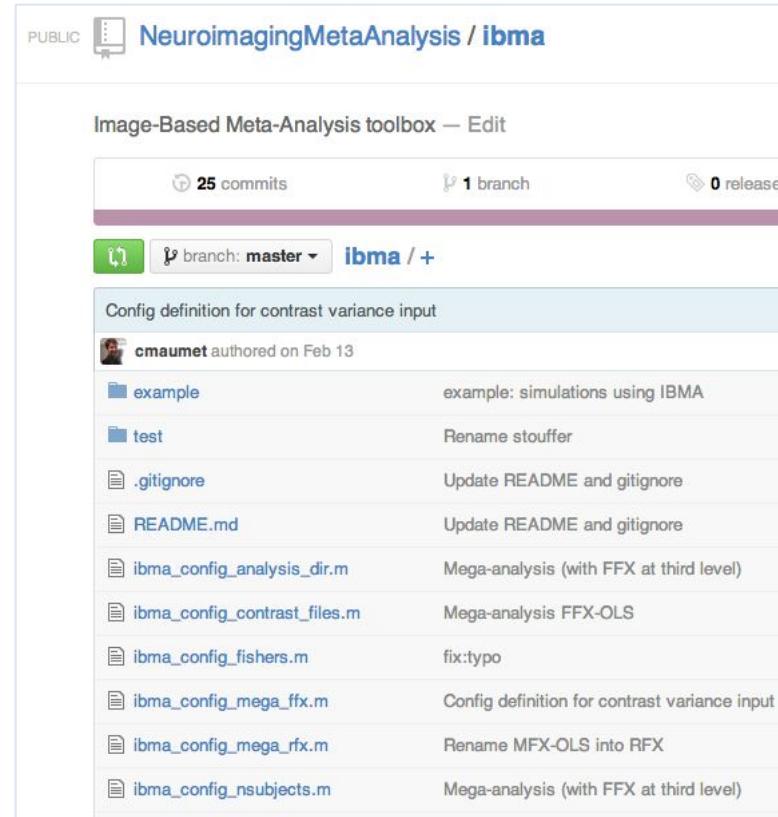
Meta-Analysis Method	Inputs	Neuroimaging Implementation
'Gold Standard' MFX	Con's + SE's	FSL's FEAT SPM <code>spm_mfx</code> AFNI 3dMEMA
RFX GLM	Con's	FSL, SPM, AFNI, etc...
Stouffer's RFX	Z's	
FFX GLM	Con's +SE's	
Fisher's	Z's	n/a
Stouffer's	Z's	
Stouffer's Weighted	Z's + N's	

(Slide from Thomas Nichols, OHBM 2015)

Self Promotion Alert: IBMA toolbox

- SPM Extension
- Still in beta!
 - But welcome all feedback
- Available on GitHub

<https://github.com/NeuroimagingMetaAnalysis/ibma>



Meta-analysis of 21 pain studies

- Results
 - GLM methods similar
 - Z-based methods similar
 - But FFX Z methods more sensitive (as expected)

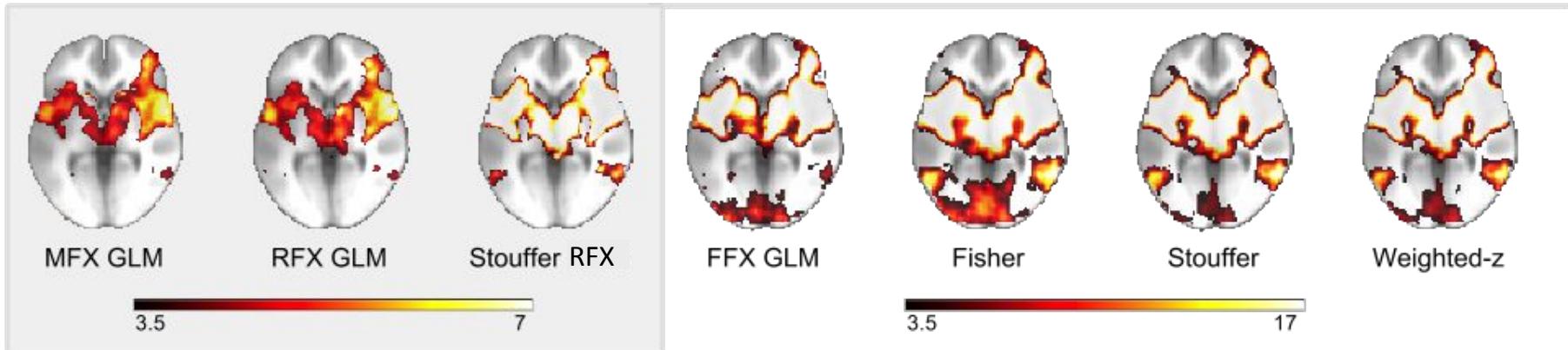


Fig. 1: Result of a meta-analysis of 21 pain studies for 4 fixed-effects (FFX GLM, Fisher, Stouffer, weighted-z) and 2 random-effects (RFX GLM, Stouffer MFX) meta-analytic approaches compared to the reference (MFX GLM) at a threshold of $p < 0.05$ FDR corrected.

Data: Tracey pain group, FMRIB, Oxford.

How to publish your statistic maps?

Share your statistic maps

NeuroVault Collections ▾ FAQ Give feedback

Log in



A public repository of unthresholded statistical maps, parcellations, and atlases of the human brain

What is it?

A place where researchers can publicly store and share unthresholded statistical maps, parcellations, and atlases produced by MRI and PET studies.

Why use it?

- Interactive visualization
- A permanent URL
- Publicly shareable
- Improves meta-analyses

Get started and upload an image!

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A Correspondence between Individual Differences in the Brain's Intrinsic Functional Architecture and the Content and Form of Self-Generated Thoughts

Contributed by ChrisFilipGorgolewski

Krzysztof J. Gorgolewski, Dan Lurie, Sebastian Urchs, Judy A. Kipping, R. Cameron Craddock, Michael P. Milham, Daniel S. Margulies, Jonathan Smallwood

[Link to the paper](#)

[3D View](#)

File View Options

x y z 0
0 -18 18 0

Images Details

Show 7 entries Search:

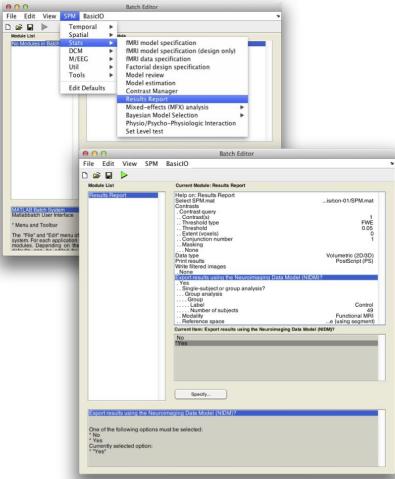
View	ID	Name	Type
	25	fALFF: Past	Z map
	26	fALFF: Future	Z map
	27	fALFF: Past > Future	Z map
	28	fALFF: Positive	Z map
	29	fALFF: Negative	T map
	30	fALFF: Positive > Negative	Z map
	31	fALFF: Social Cognition	Z map

Showing 1 to 7 of 30 entries [First](#) [Previous](#) [Next](#) [Last](#)

<http://neurovault.org>

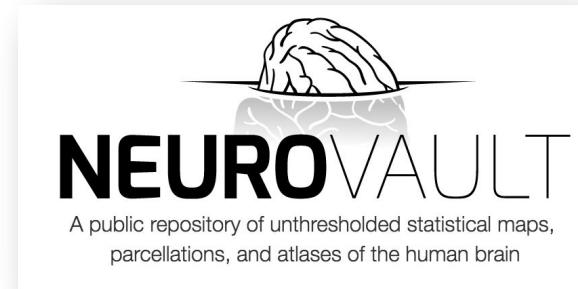
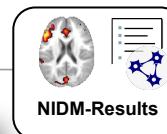
From SPM & FSL

SPM



Name	Size	Kind
beta_0001.nii	2.4 MB	NIFTI
con_0001.nii	2.4 MB	NIFTI
mask.nii	593 KB	NIFTI
nidm_001.nidm.zip	4.1 MB	ZIP archive
Res.nii	4.7 MB	NIFTI
RPV.nii	4.7 MB	NIFTI
SPM.mat	484 KB	MATLAB Data
spmT_0001.nii	2.4 MB	NIFTI

Name	Size	Kind
design.con	126 bytes	Document
design.fsf	20 KB	Document
design.grp	131 bytes	Document
design.icon	28 bytes	Document
cope1.feat	--	Folder
cope2.feat	--	Folder
inputreg	--	Folder
logs	--	Folder
bg_image.nii.gz	3.4 MB	gzip compressed archive
mask.nii.gz	15 KB	gzip compressed archive
mean_image.nii.gz	2.8 MB	gzip compressed archive
report.html	10 KB	HTML document
report_regress.html	55 KB	HTML document
report_res.html	17 KB	HTML document
report_stats.html	495 bytes	HTML document
report.html	922 bytes	HTML document
design.mat	732 bytes	MATLAB Data
design_cov.ppm	6 KB	OpenOffice.app Document
design.ppm	219 KB	OpenOffice.app Document
design_cov.png	106 bytes	Portable Network Graphics Image
design.png	1 KB	Portable Network Graphics Image
fsl_ds107_group.nidm.zip	13.6 MB	ZIP archive



```
$ nidmfsl fsl_ds107_group 49 -g Control
```

<http://nidm.nidash.org/getting-started/>

Conclusions

- When data available, **Image-Based** preferred to **Coordinate-Based** meta-analysis

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- Few tools for Z-based IBMA, but underway...

Conclusions

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- **In practice**, it is **difficult** to use the gold standard **Mixed-Effects GLM**
- When only contrast estimates are available, **RFX GLM** is a practical & valid approach
- Few tools for Z-based IBMA, but underway...
- Data sharing tools: **NeuroVault**, NIDM-Results

Thank you!



This work is supported by