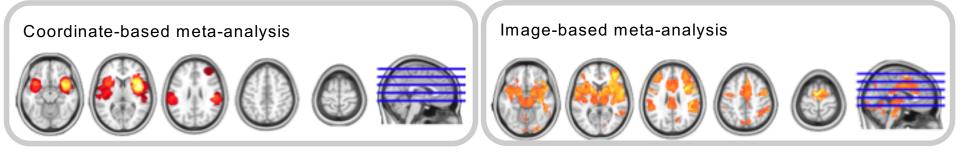






Practical intensity-based meta-analysis



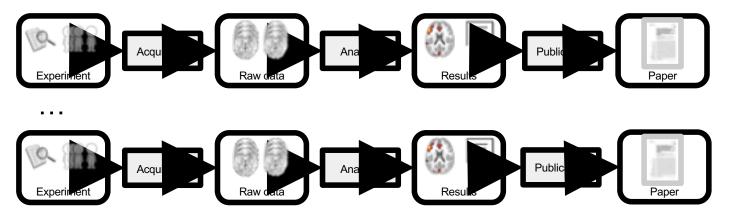
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Presented by Thomas Nichols

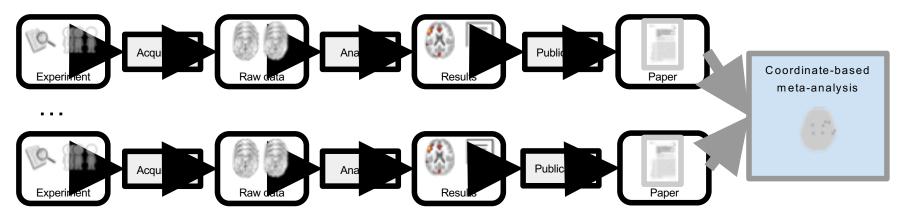
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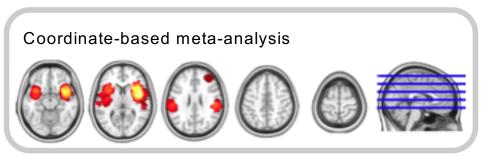
Coordinate-Based & Image-Based Meta-Analyses

Neuroimaging meta-analyses



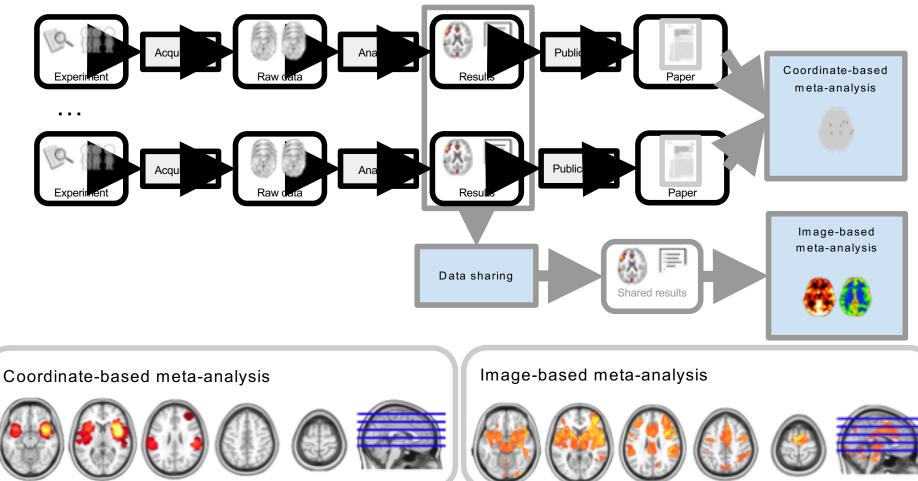
Neuroimaging meta-analyses





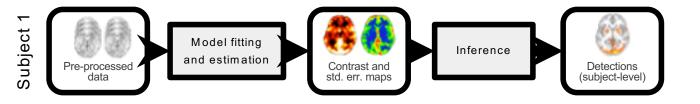
4

Neuroimaging meta-analyses

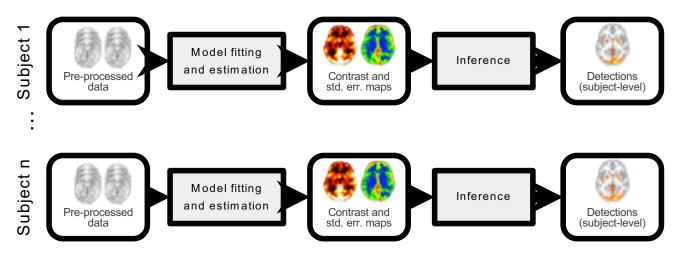


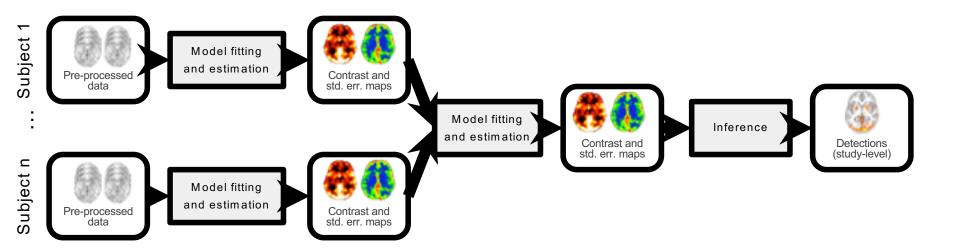
5

How to perform an image-based metaanalysis?

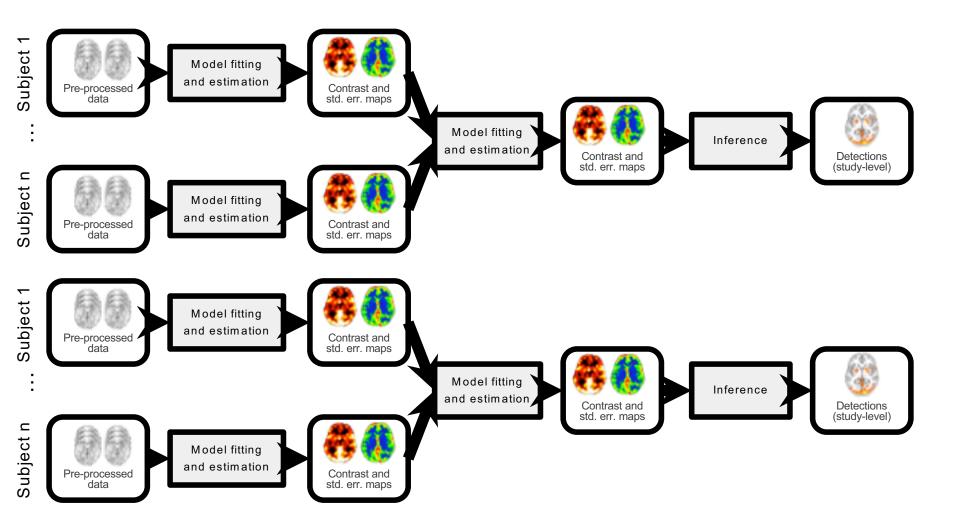


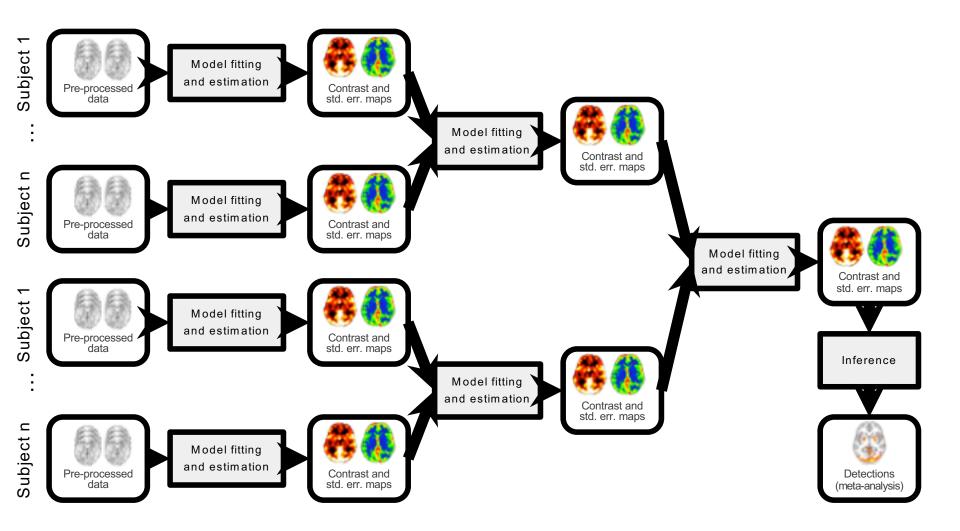
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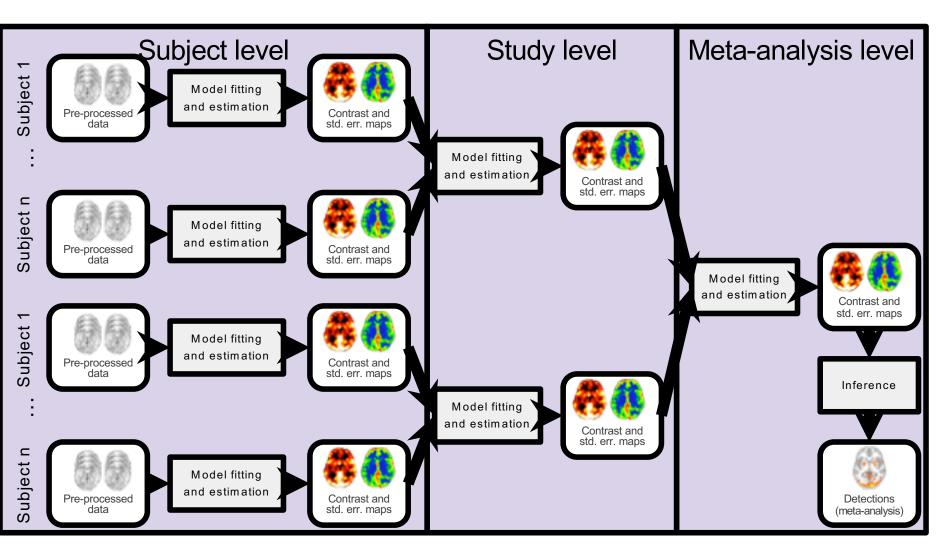




9

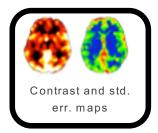






• Gold standard:

Third-level Mixed-Effects GLM

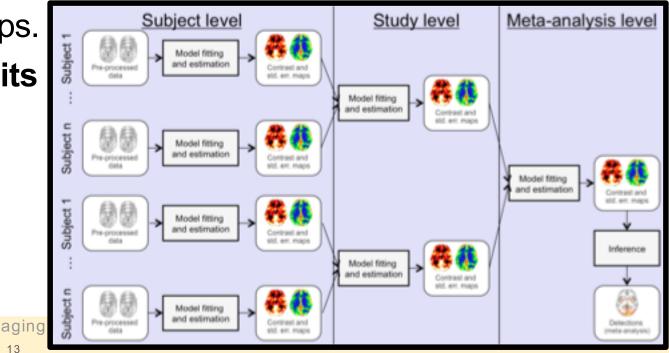


- Requirements
 - study-level Contrast estimates and Standard

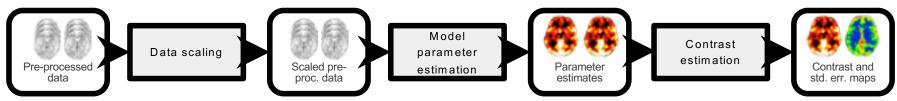
error maps.

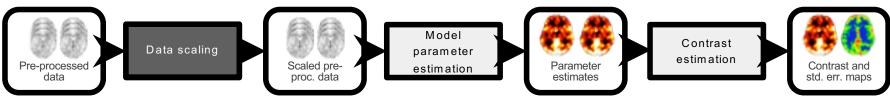
– Same **units**



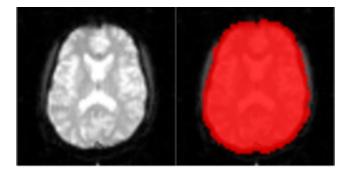






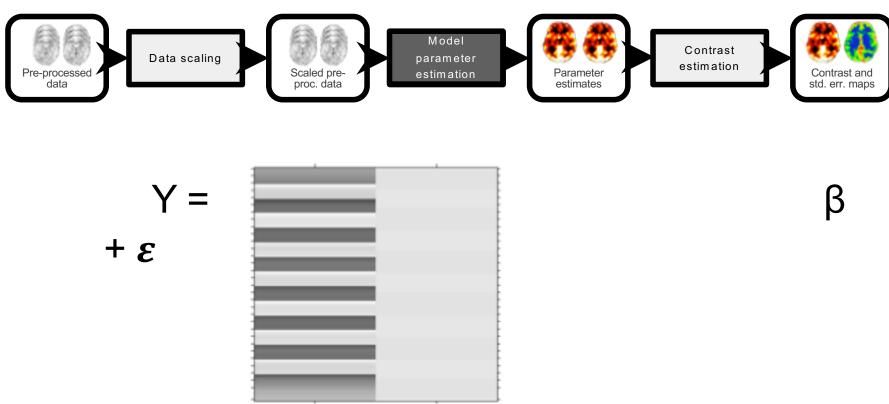


$$scaled_data = \frac{data * target}{est_mean}$$



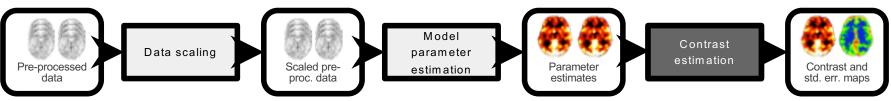
Units depend on **mean estimation** and **scaling target**.

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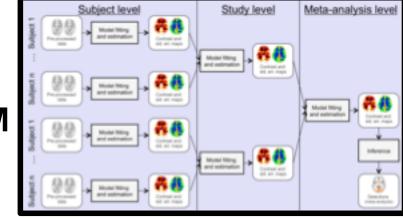
Units depend on **scaling** of **explanatory variables**

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- Contrast Estimation
 - Linear combination of parameter estimates
 - Final statistics invariant to scale
 - e.g. [1111] gives same T's & P's as [1/4 1/4 1/4 1/4]
- Units depend on contrast vector
 - Rule for contrasts to preserve units
 - Positive elements sum to 1
 - Negative elements sum to -1

- 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...



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Which images for IBMA?







Contrast & std. err. maps	con_0001.nii [SPM.mat]	cope1.nii varcope1.nii (<i>squared</i>)	3dMEMA_result+tlrc.BRIK[[0]] [from contrast & stat maps]
Statistic map E.g. Z-map	spmT_0001.nii	tstat1.nii.gz zstat1.nii.gz	3dMEMA_result+tlrc.BRIK[[1]]
Contrast map	con_0001.nii	cope1.nii	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)"

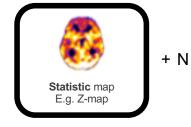
$$\sqrt{K} \times \frac{1}{K} \sum_{k} Z_k \sim \mathcal{N}(0, \sigma_{RFX}^2)$$

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

(Slide adapted from Thomas Nichols, OHBM 2015)

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IBMA on Z maps + 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) Camille Maumet - OHBM Neuroimaging Meta-Analysis Educational course

IBMA on Contrast maps

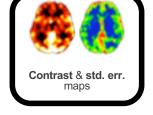


 Random Effects (RFX) GLM $\frac{1}{K} \sum_{k} c \hat{\beta}_k \sim \mathcal{N}(0, \sigma_{\text{RFX}}^2)$

Analyze per-study contrasts as "data"

Contrast + standard error maps

Fixed-Effects (FFX) GLM



 $\frac{1}{K}\sum_{k}\hat{\theta}_{k}\sim\mathcal{N}(0,\sum_{k}\sigma_{\mathrm{FFX},k}^{2}/K^{2})$ – *Don't* estimate variance, just take from first level

(Slide adapted from Thomas Nichols, OHBM 2015) Camille Maumet - OHBM Neuroimaging Meta-Analysis Educational course

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 spm_mfx AFNI 3dMEMA	
RFX GLM Stouffer's RFX	Con's Z's	FSL, SPM, AFNI, etc	
FFX GLM Fisher's Stouffer's Stouffer's Weighted	Con's +SE's Z's Z's Z's + N's	n/a	

(Slide from Thomas Nichols, OHBM 2015)

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Self Promotion Alert: IBMA toolbox

- SPM Extension
- Still in beta!
 - But welcome all feedback

NeuroimagingMetaAnaly	@ Unwatch * 2		
Image-Based Meta-Analysis toolbo	x — Edit		
3 25 commits	₽ ¶ branch	\odot 0 releases	() 1 contributor
P branch: master + Ibma / -	+		
Config definition for contrast variance input	at a start of the		
E cmaumet authored on Feb 13			latest commit 824a17b513 📴
ill example	example: simulations us	sing IBMA	5 months ago
IIII test	Rename stouffer		5 months ago
🖹 .gitignore	Update README and g	itignore	6 months ago
README.md	Update README and gitignore		6 months ago
lbma_config_analysis_dr.m	Mega-analysis (with FF)	K at third level)	6 months ago
ibma_config_contrast_files.m	Mega-analysis FFX-OLS	3	6 months ago
ibma_config_fishers.m	fix:typo		5 months ago
ibma_config_mega_ftx.m	Config definition for con	trast variance input	5 months ago
ibma_config_mega_rfx.m	Rename MFX-OLS into	RFX	5 months ago
ibma_config_nsubjects.m	Mega-analysis (with FF)	K at third level)	6 months ago

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)

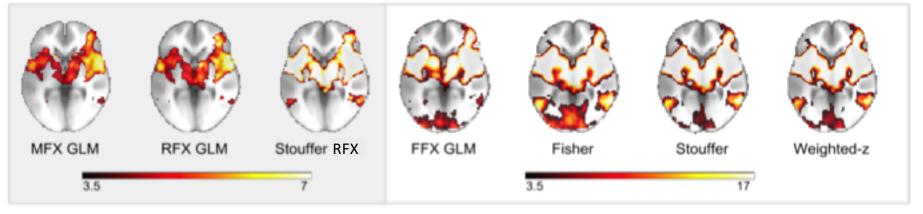
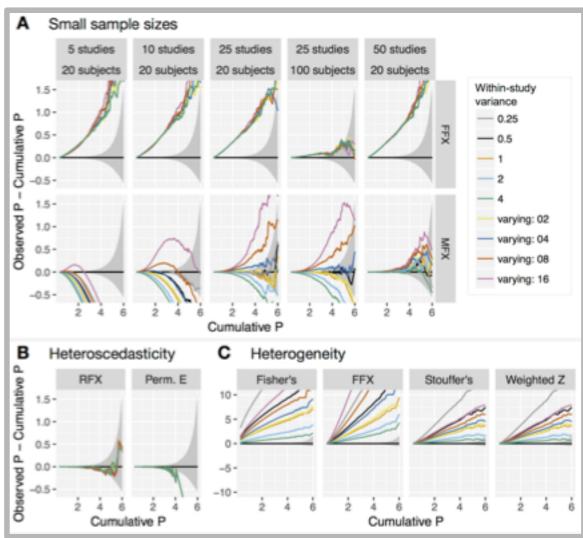


Fig. 1: Result of a meta-analysis of 21 pain studies for 4 fixed-effects (FFX GLM, Fisher, Stouffer, weighted-z) and 2 random-effects (RFX GLM, Stouffer MFX) meta-analytic approaches compared to the reference (MFX GLM) at a threshold of p<0.05 FDR corrected.

Data: Tracey pain group, FMRIB, Oxford.

Self Promotion Alert: Robustness of the meta-analytic estimators

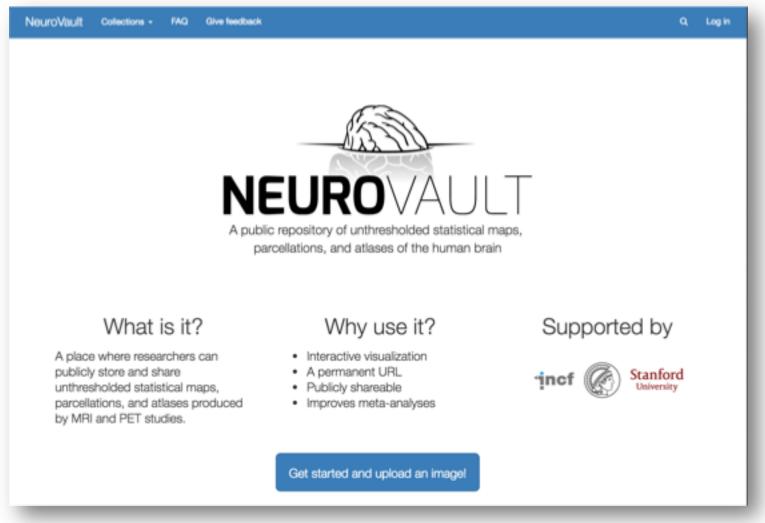
Poster 2653



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How to publish your statistic maps?

Share your statistic maps



http://neurovault.org

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Share your statistic maps

NeuroVault Collections - FAQ Give feedback

ો Login

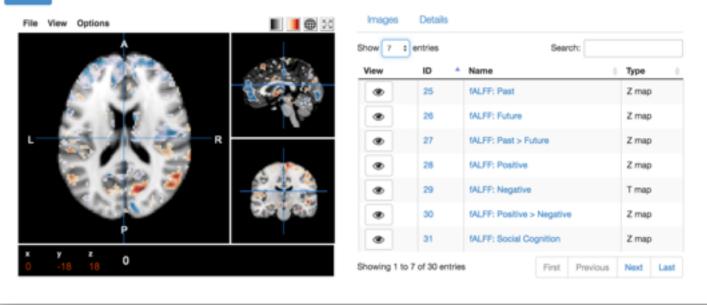
A Correspondence between Individual Differences in the Brain's Intrinsic Functional Architecture and the Content and Form of Self-Generated Thoughts

Contributed by ChrisFiloGorgolewski

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

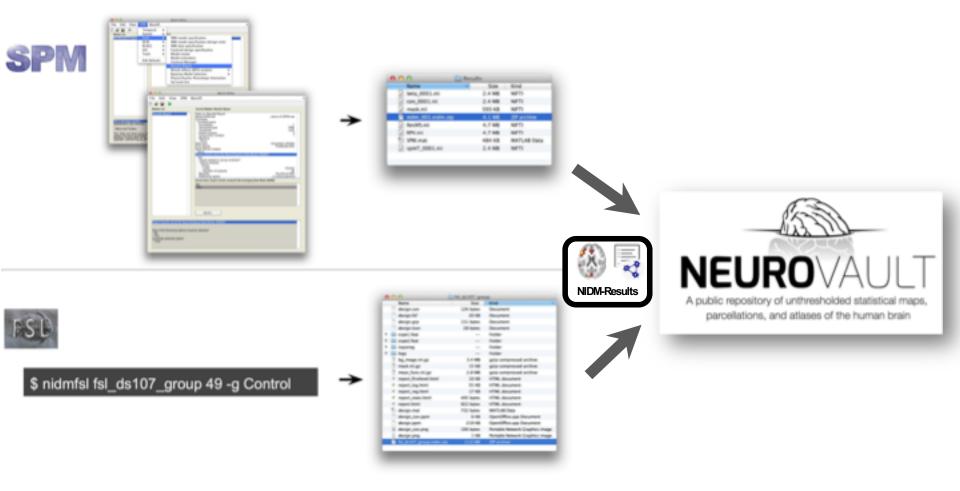
3D View



http://neurovault.org

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From SPM & FSL



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

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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!

