The role of analysis team in fMRI results: The problem and a potential solution

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Analytic flexibility in fMRI

Analytic flexibility in fMRI

Table 1 | Pre-processing parameters.

Despiking		
Despiking using AFNI	No despiking	
Slice-timing correction		
Slice-timing correction	No slice-timing correction	
Spatial normalization		
Normalization of functional images to the SPM EPI template	Normalization of anatomical images to the SPM T1 template	Normalization with segmentation using unified normalization
Spatial smoothing		
Smoothing with kernel of 4 mm FWHM	Smoothing with kernel of 8 mm FWHM	Smoothing with kernel of 12 mm FWHM

Table 2 | Model estimation parameters.

Normalization-modeling order			
Normalize before modeling	Model before normalization		
High-pass filtering			
High-pass filtering using a cutoff of 128 s	No high-pass filtering		
Temporal autocorrelation correction			
AR(1) modeling	No correction for temporal autocorrelation		
Run concatenation			
Runs concatenated before model estimation	No run concatenation		
Model basis set			
Hemodynamic response function	Finite impulse response[1], time points 3–4 versus baseline	Finite impulse response[1], time by condition interaction	
Head motion regression			
Six regressors[2]	Twelve regressors[3]	Twenty-four regressors[4]	No motion regression

[1] *Eight basis functions.*
[2] *Raw motion parameters.*
[3] *Raw and time-shifted motion parameters.*
[4] *Raw, time-shifted, squared, and time-shifted squared motion parameters.*

Table 3 | Statistical thresholding parameters.

	Uncorrected single-voxel threshold	Corrected single-voxel threshold	Cluster size threshold
Monte Carlo @ $p < 0.01$	$p < 0.01$	n/a	Determined by simulation
Monte Carlo @ $p < 0.001$	$p < 0.001$	n/a	Determined by simulation
Monte Carlo @ $p < 0.0001$	$p < 0.0001$	n/a	Determined by simulation
False discovery rate	n/a	$p < 0.05$	n/a
Gaussian random field theory	n/a	$p < 0.05$	n/a

[Carp, 2012]

Analytic flexibility in fMRI

Results can differ over

- Analysis pipelines [Carp, 2012]
- Software versions [Gronenschild et al., 2012]
- Operating systems [Glatard et al., 2015]

Realistic analytic flexibility?

Neuroimaging Analysis Replication and Prediction Study (NARPS)

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- 1 dataset - task fMRI
- 70 analysis teams
- Return whole-brain group-level statistical maps

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The preprint is out (I have not read it; no spoilers, please!)

The present study

Describing the problem

How do analyses impact results?

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How do analyses impact results?

Exploring a solution
Is the consensus result better?

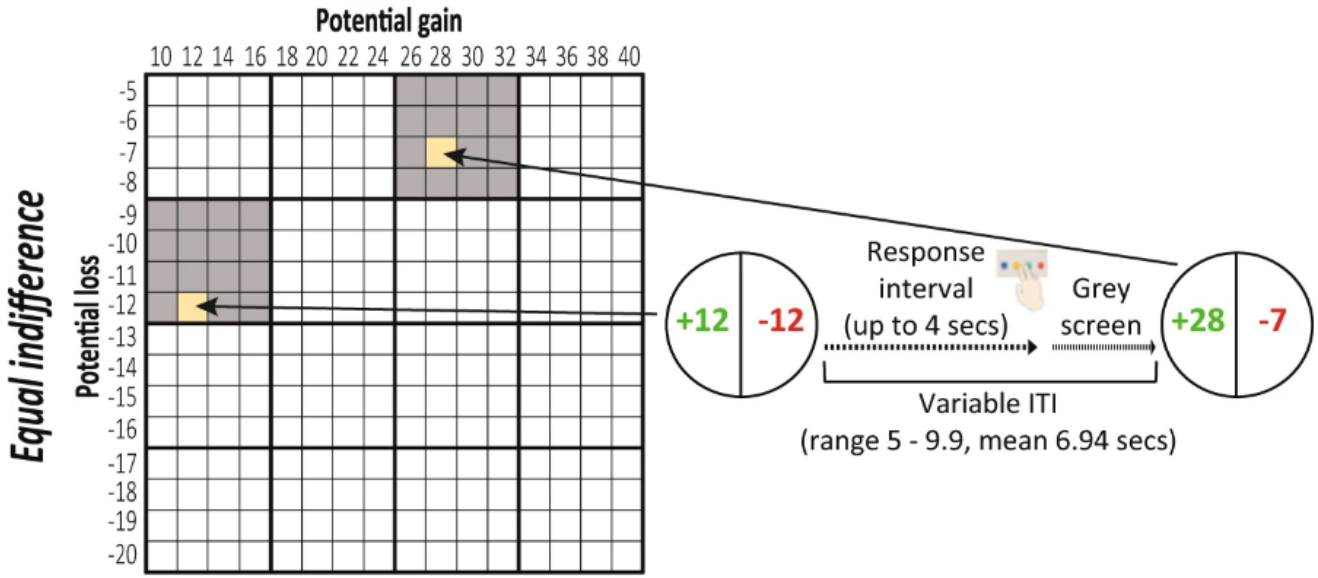
Methods: Original dataset

Neuroimaging Analysis Replication and Prediction Study (NARPS)

- 1 dataset - task fMRI
- **54** analysis teams (some disqualified)
- Whole-brain group-level statistical maps (z-maps)

Methods: Original dataset

NARPS Paradigm



[Botvinik-Nezer et al., 2019]

Methods: Analysis summary

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How do analyses impact results?

- Describe pipeline choices (*descriptive*)
- Visualize analytic range for different methods (*descriptive*)
- Associate methods & results (*PLS*, *permutation test*, *bootstrapping*)

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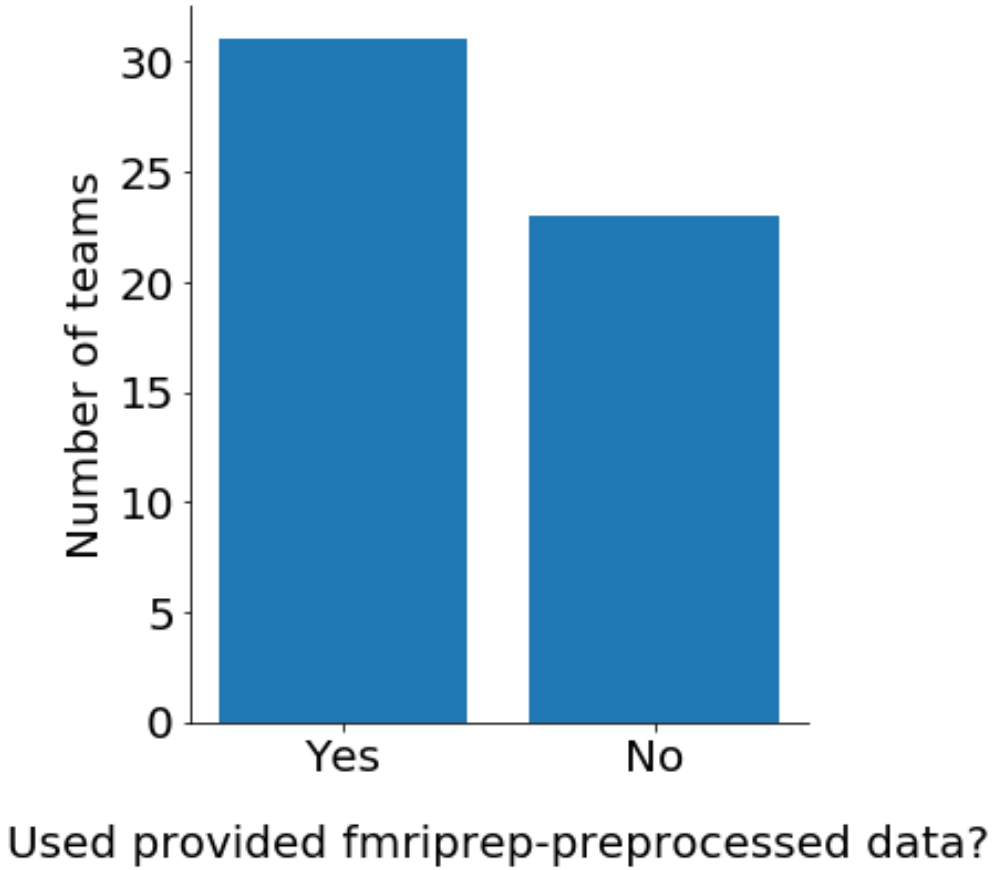
Exploring a solution

Is the consensus result better?

- Obtain the consensus result (*meta-analysis*)
- Compare consensus & online meta-analysis (*Spearman's correlation*, *online meta-analyses*, *spin test*)

Describing the problem: Pipeline choices



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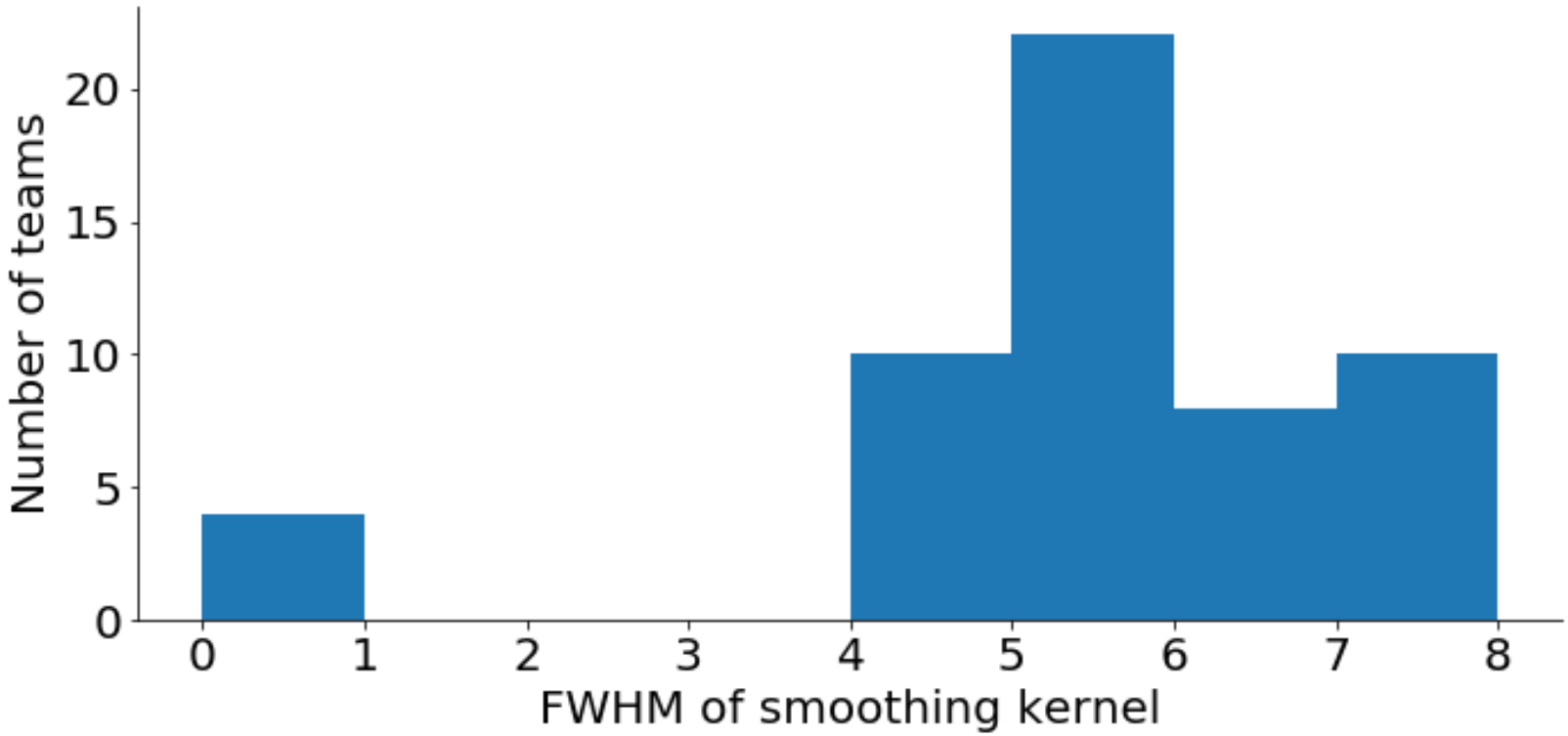

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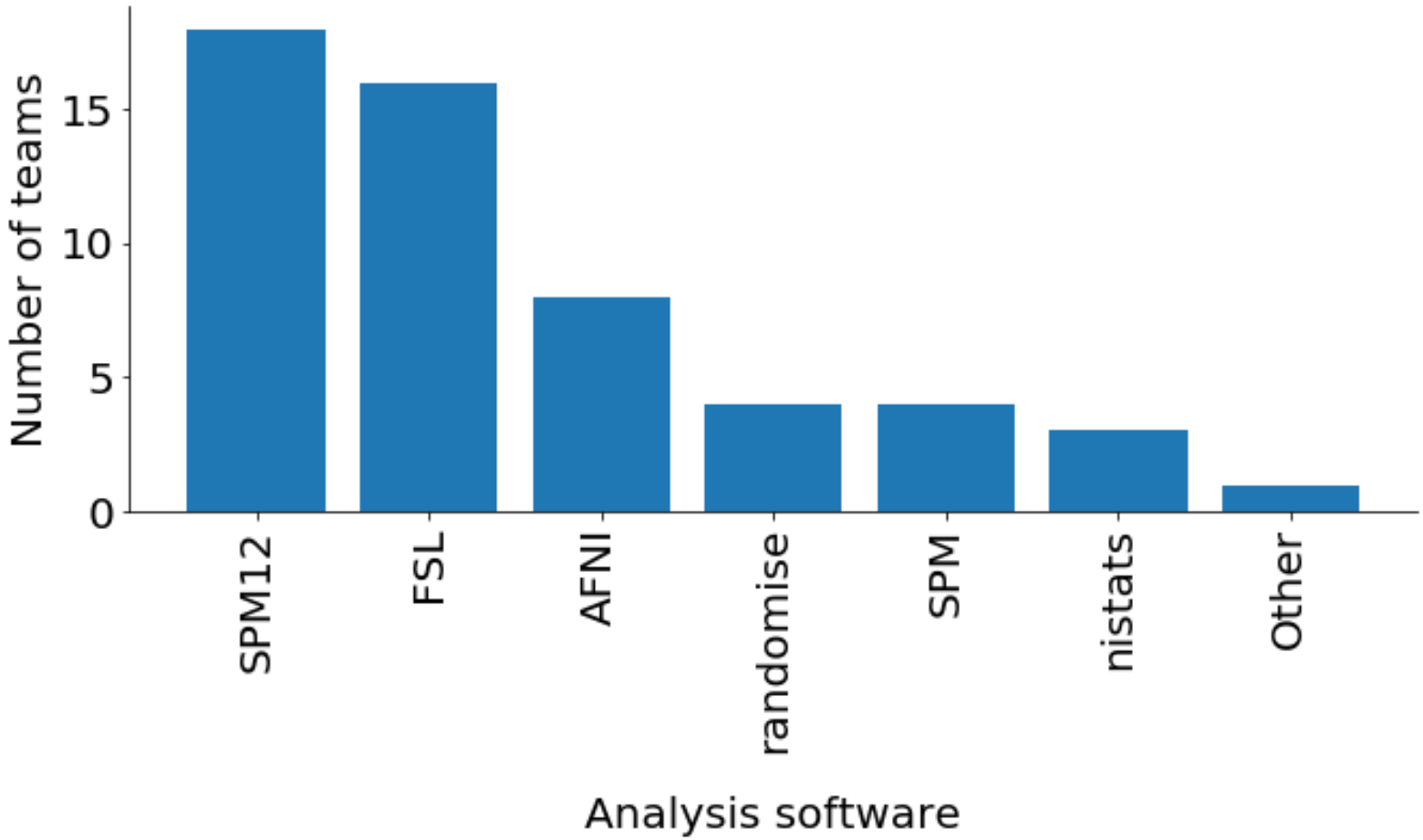

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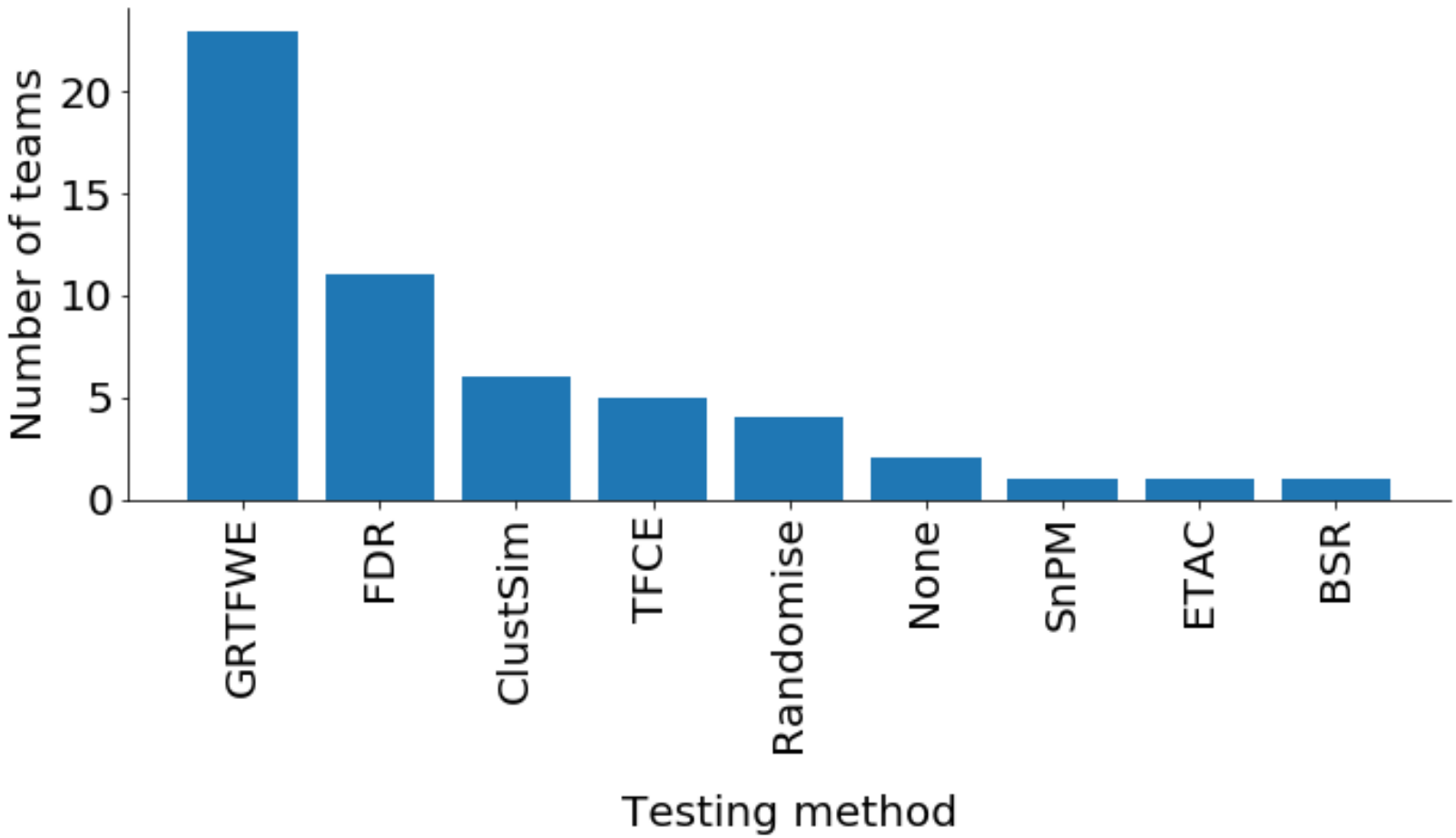
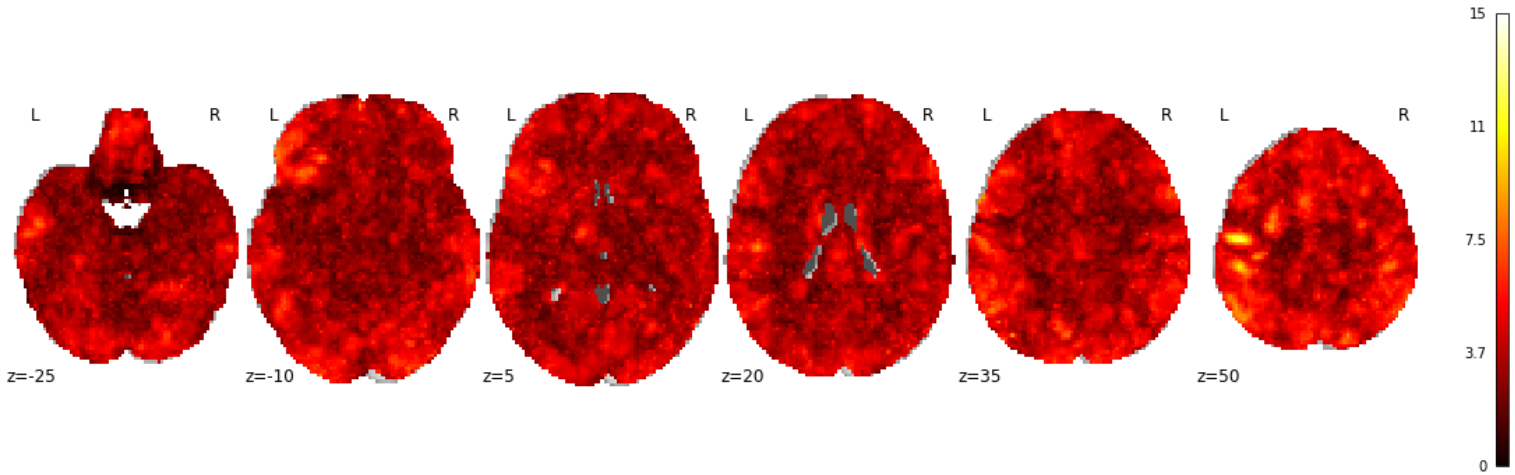
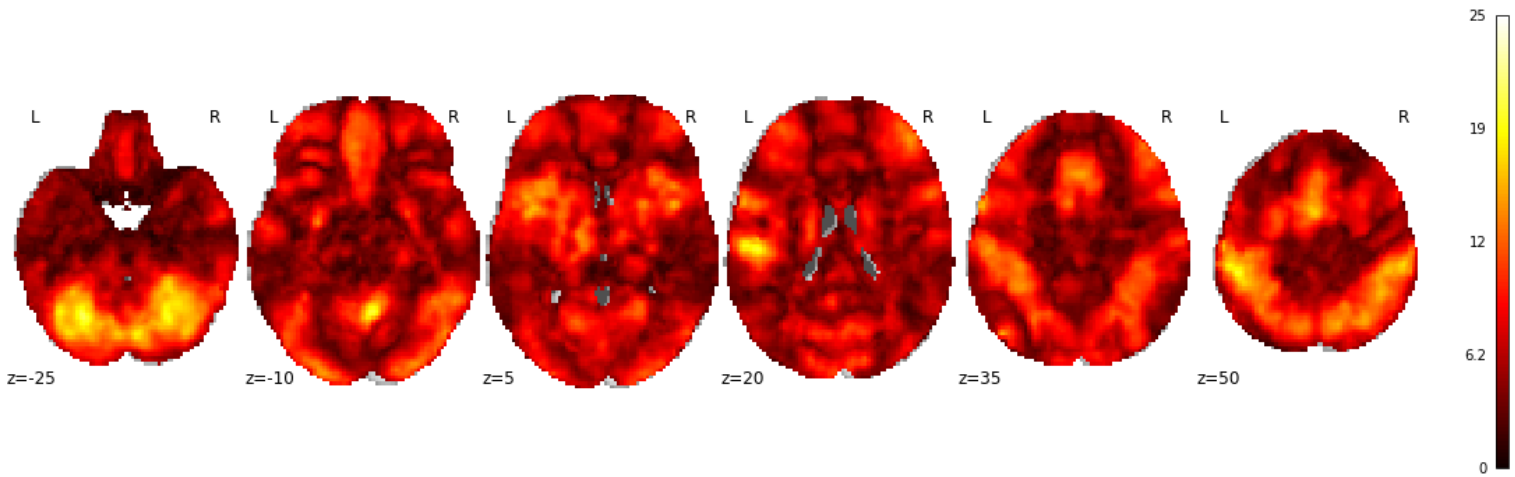


Describing the problem: Analytic range

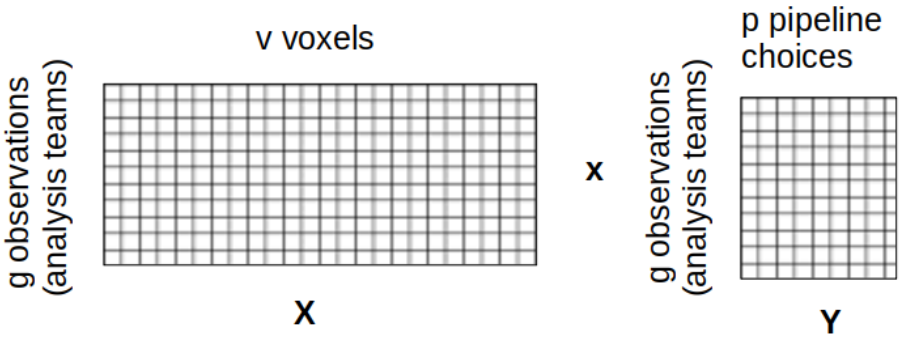
FSL analytic range of z-stats

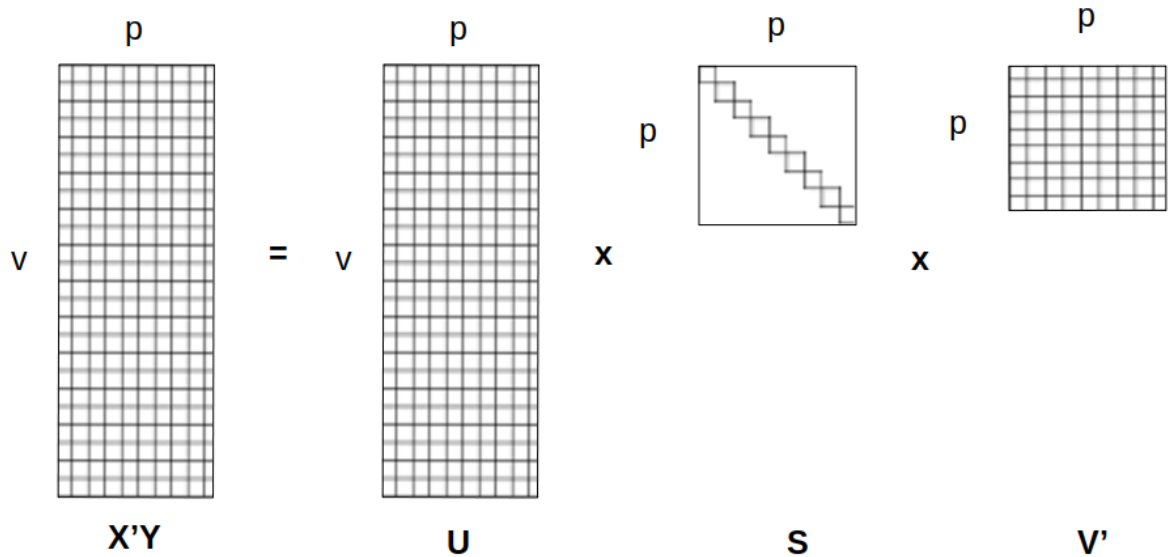


SPM12 analytic range of z-stats



Describing the problem: Associate methods & results





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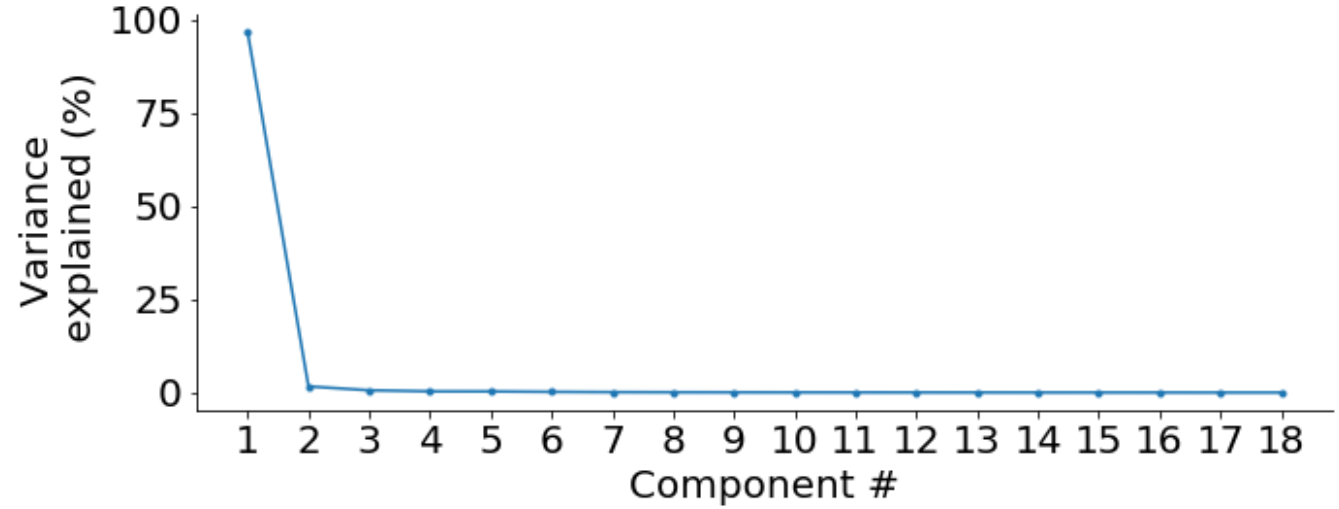

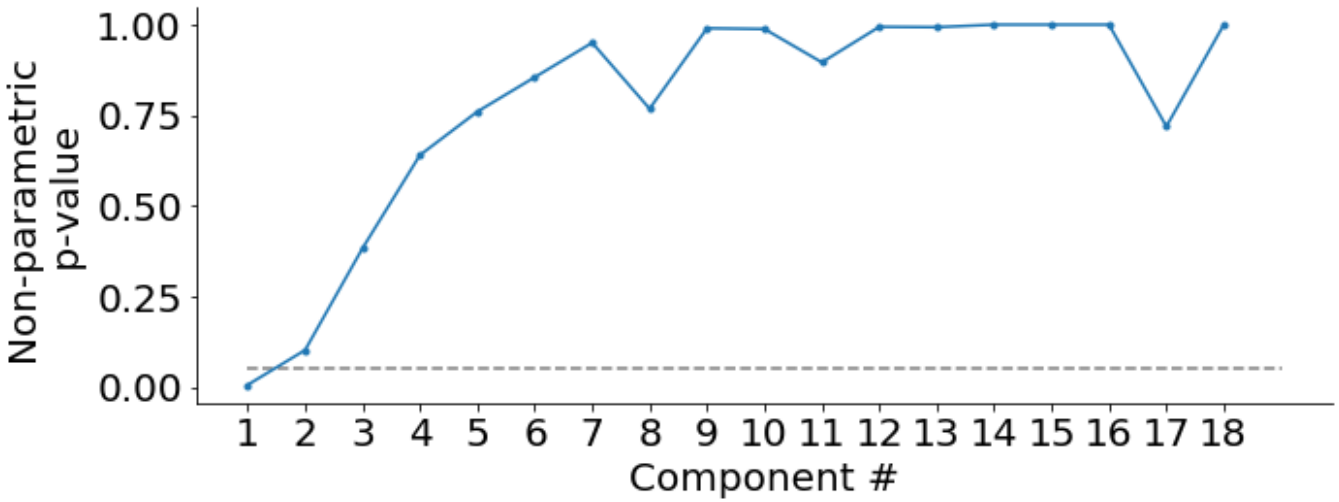

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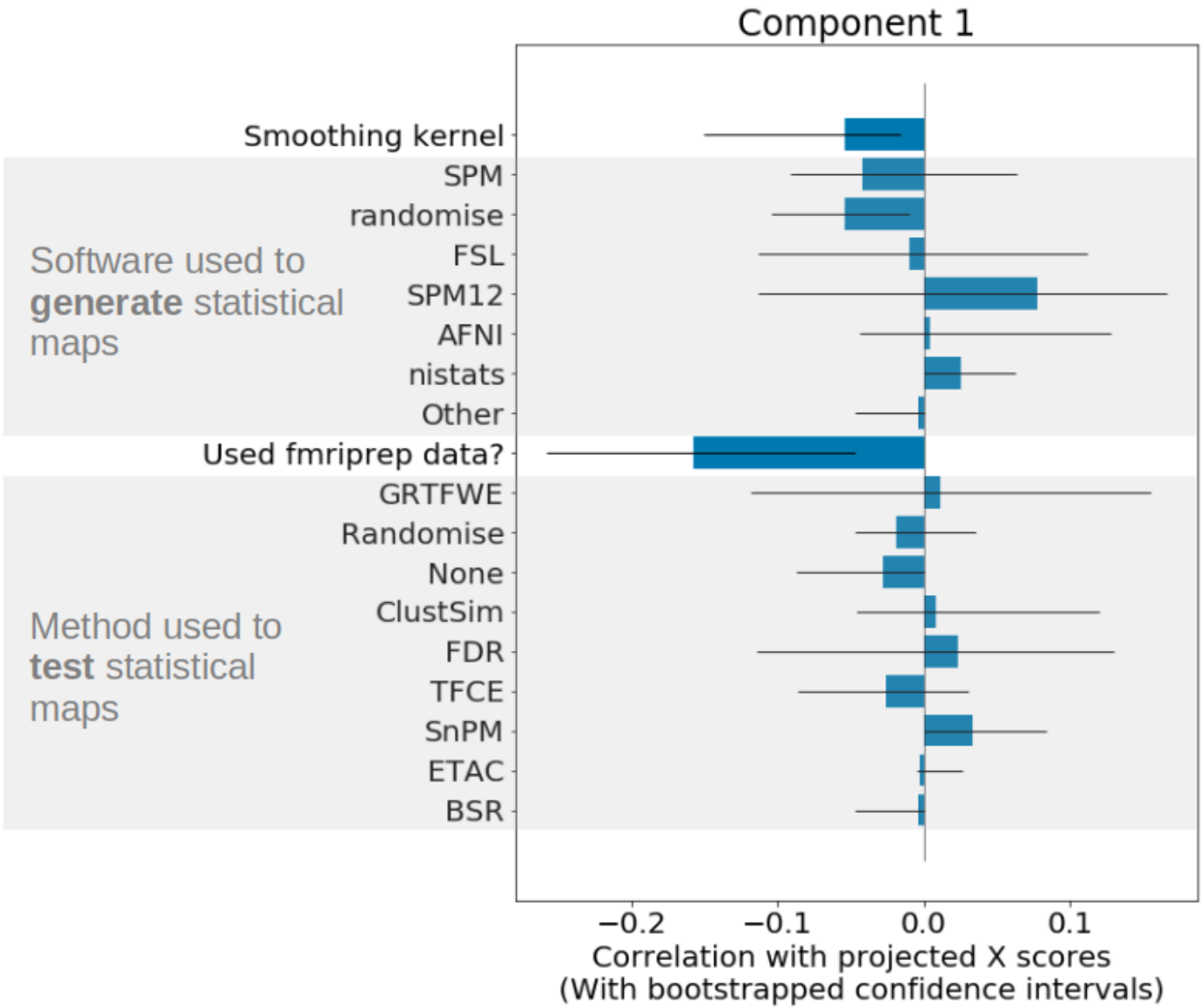

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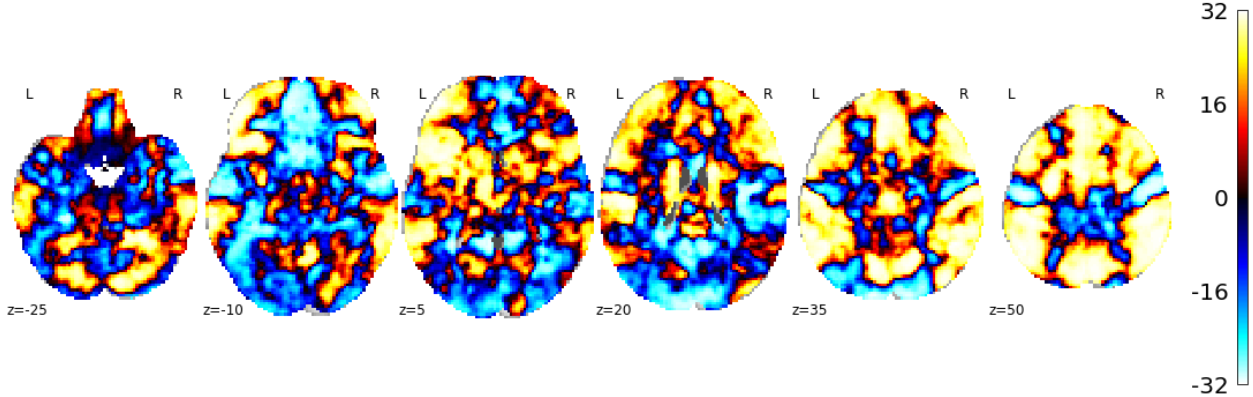
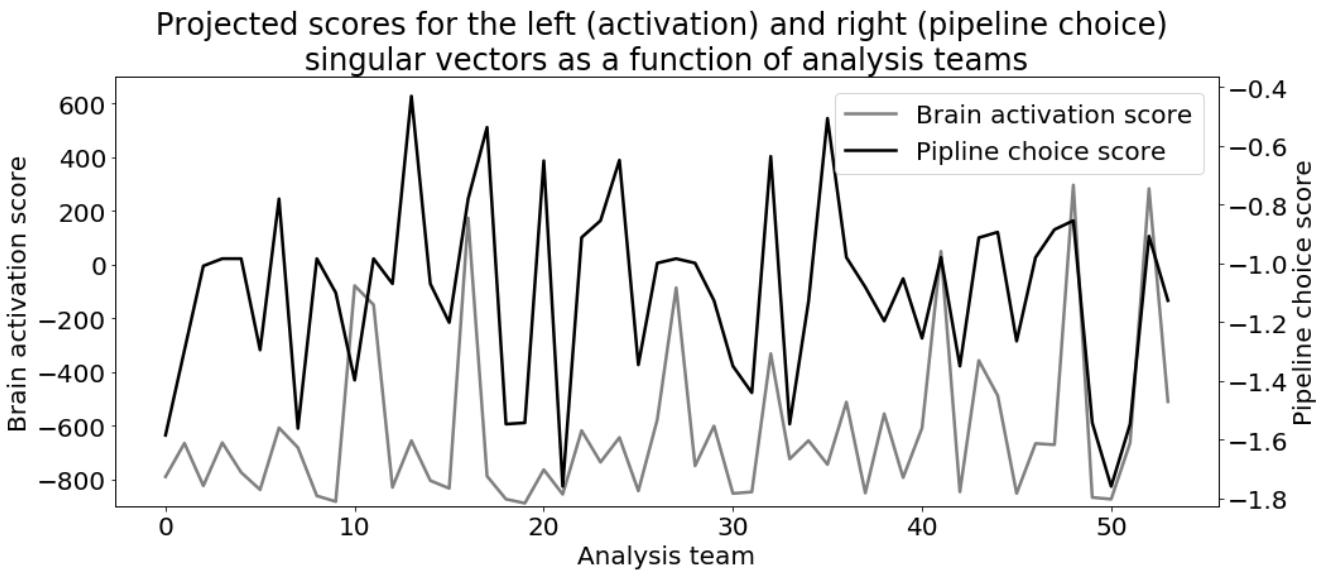
Bootstrap ratios





Exploring solutions

Is the consensus result better?

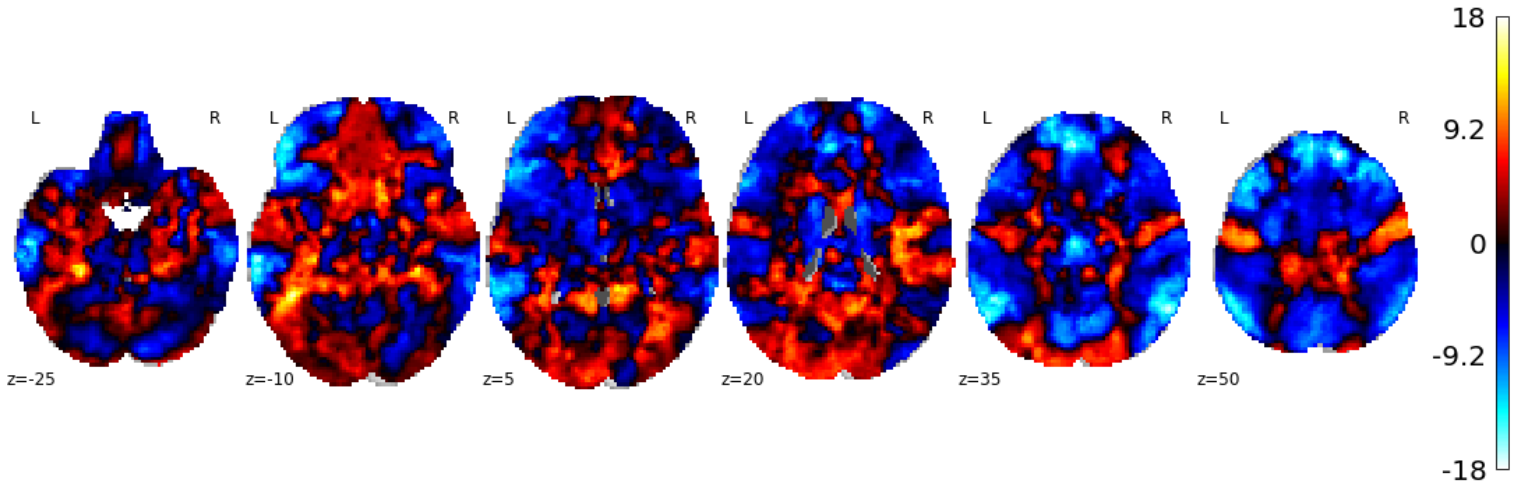
Exploring solutions: Consensus result

Image-based meta-analysis (FFX GLM)

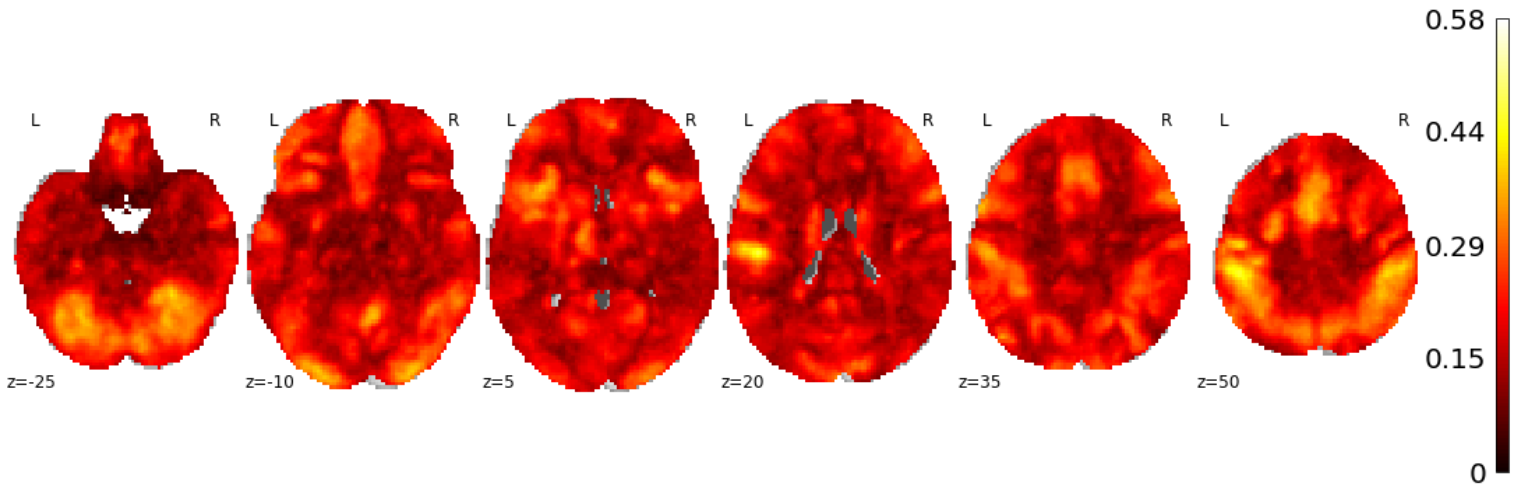
Exploring solutions: Consensus result

Image-based meta-analysis (FFX GLM)

Level-3 t-map

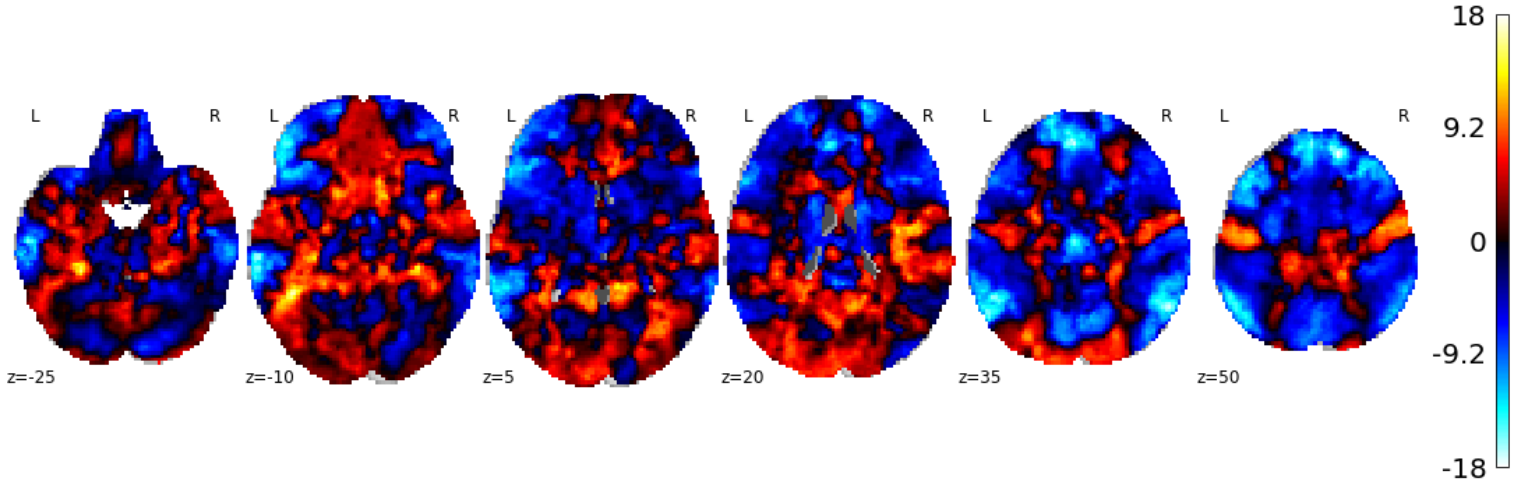


Standard-error map

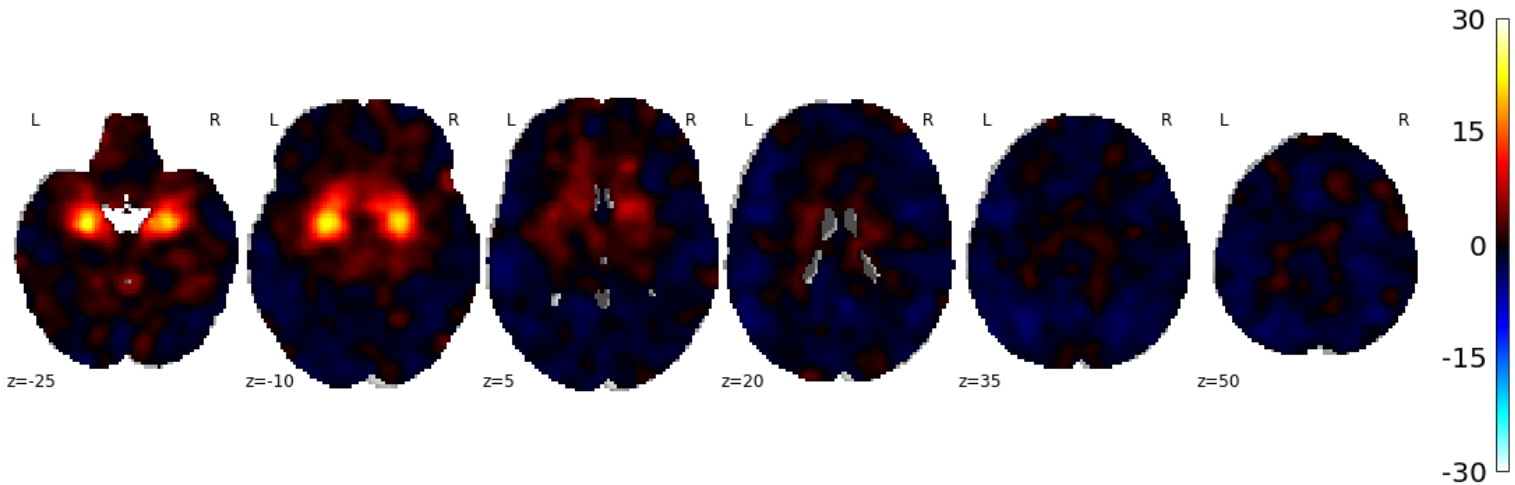


Exploring solutions: Comparing to online meta-analysis

Level-3 t-map



NeuroQuery z-map: "Loss aversion in decision-making under risk"



Exploring solutions: Comparing to online meta-analysis

Spearman's correlation in surface space.

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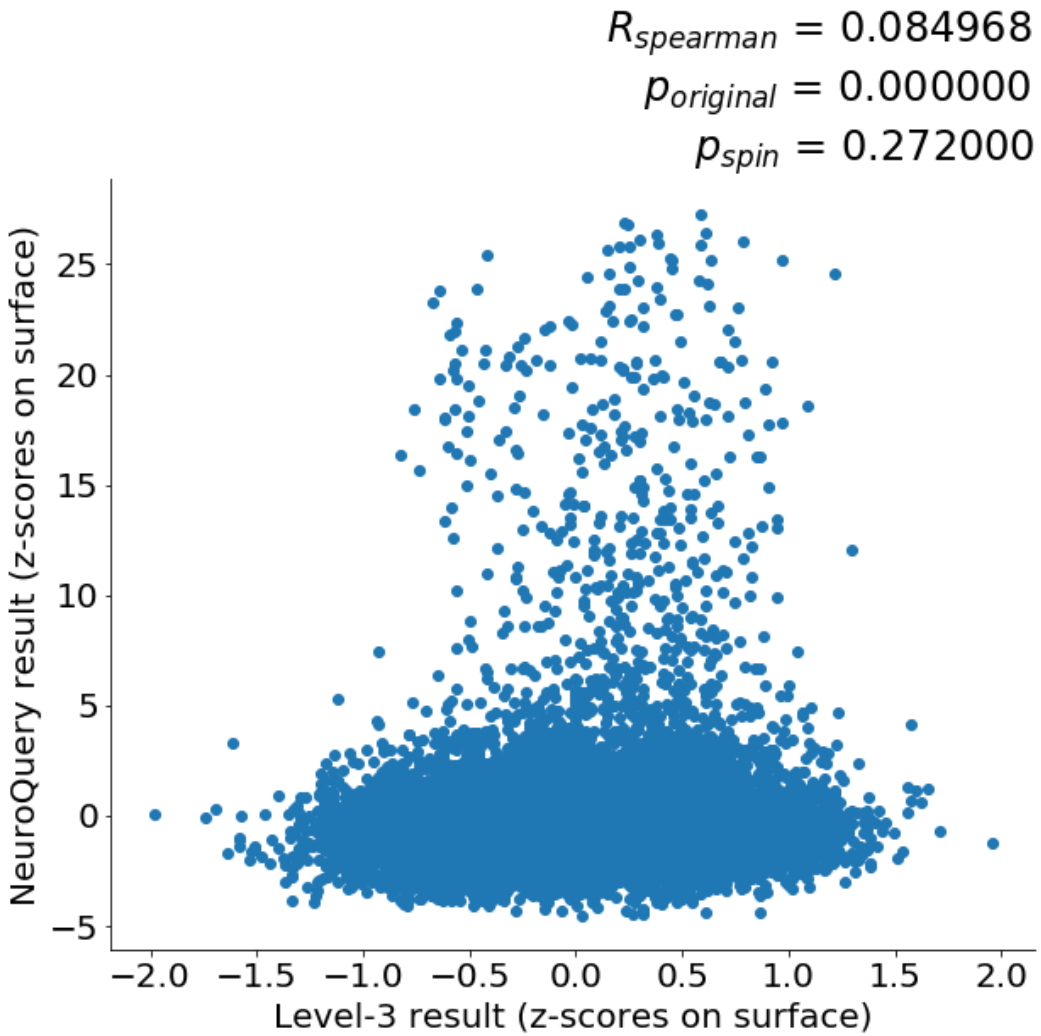

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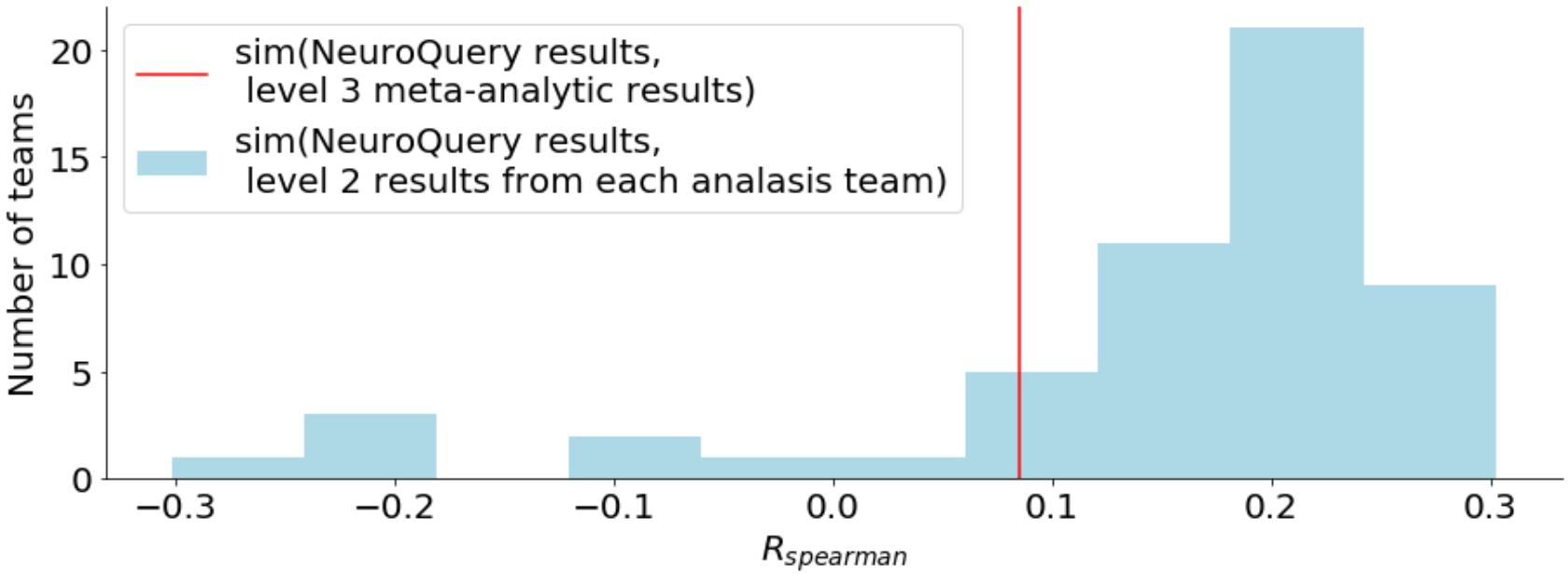

Discussion

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How do analyses impact results?

- Somewhat consistent with past results [Carp, 2012]
- Important methodological choices: preprocessing, smoothing kernel, software
- Next step: compare maps across choices (e.g., yes/no used fmriprep data)

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Exploring a solution

Is the consensus result better?

- Not according to how we defined 'better'

Discussion

Limitations

- Questions about data
- PLS on dummy variables
- Online meta-analysis as 'ground truth'

Acknowledgments

- Alex Perez: meta-analysis
- Peer Herholz: Docker
- Ross Markello: PLS, spin test
- BrainSpace: spin test code
- The rest of my lab: feedback on methods & presentation

References I

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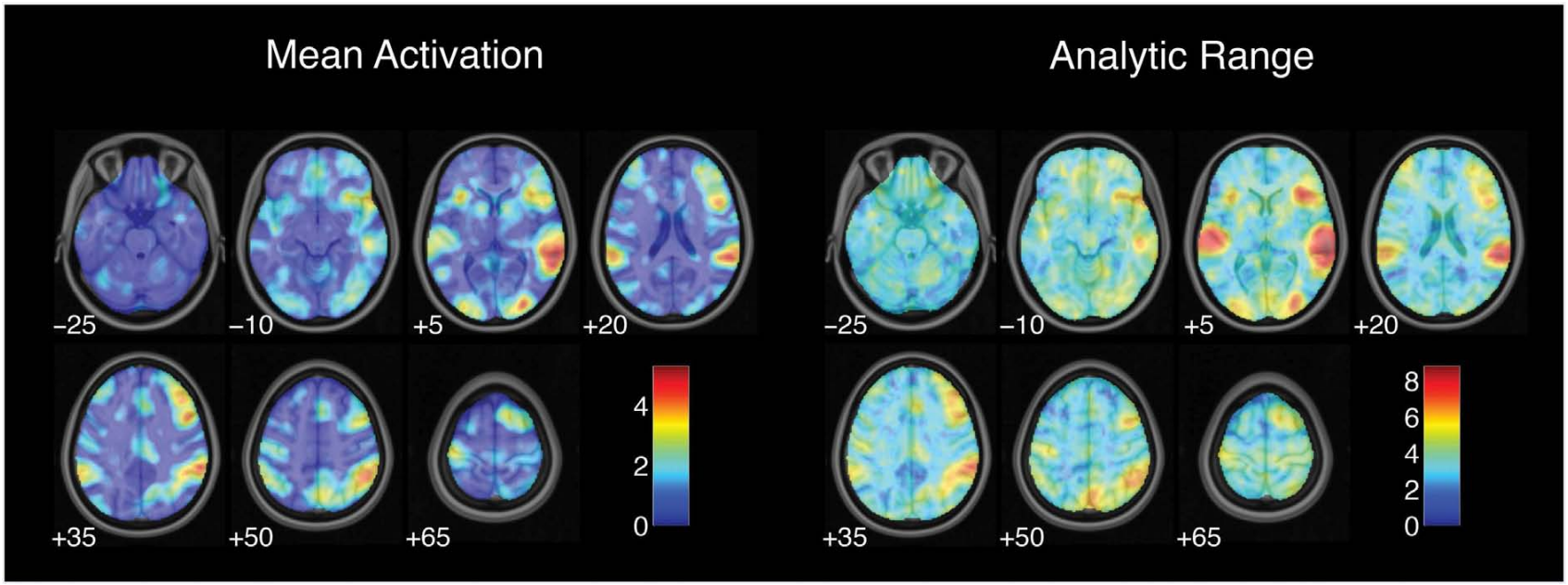
PloS one, 7(6):e38234.

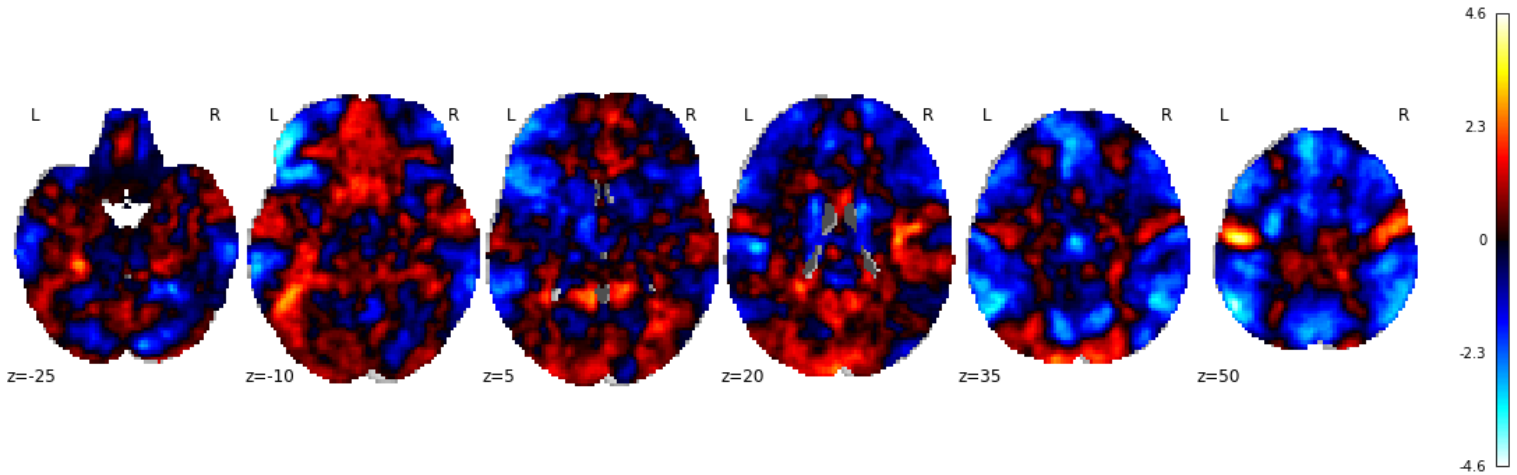
Exploring solutions: Mean activation & analytic range



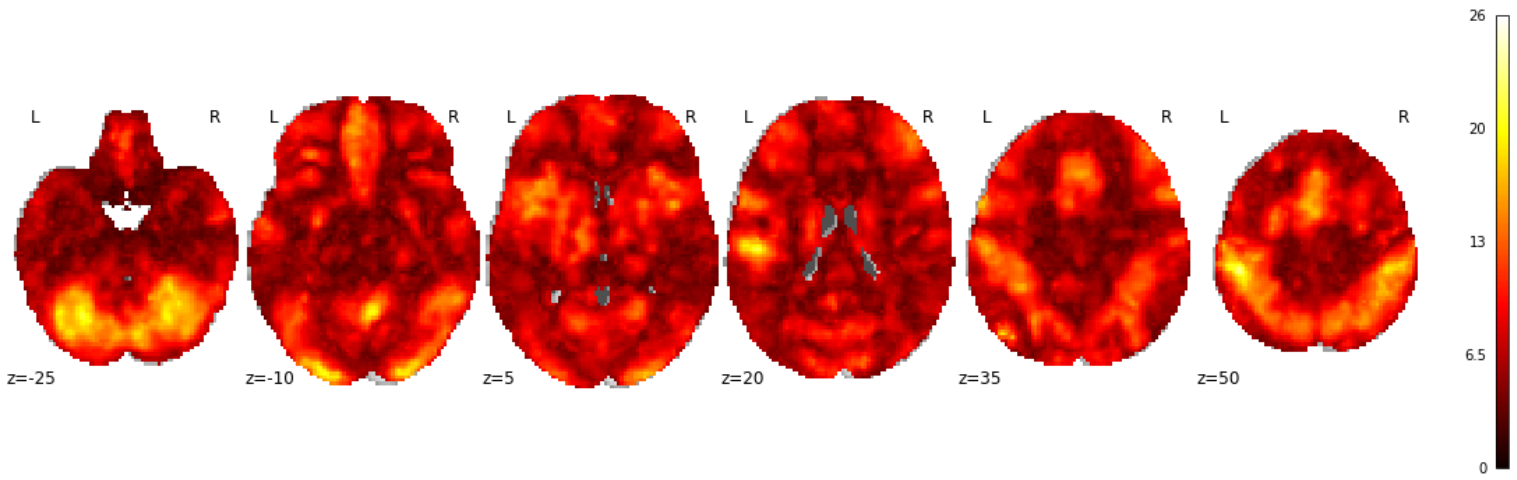
[Carp, 2012]

Exploring solutions: Mean activation & analytic range

Mean activation

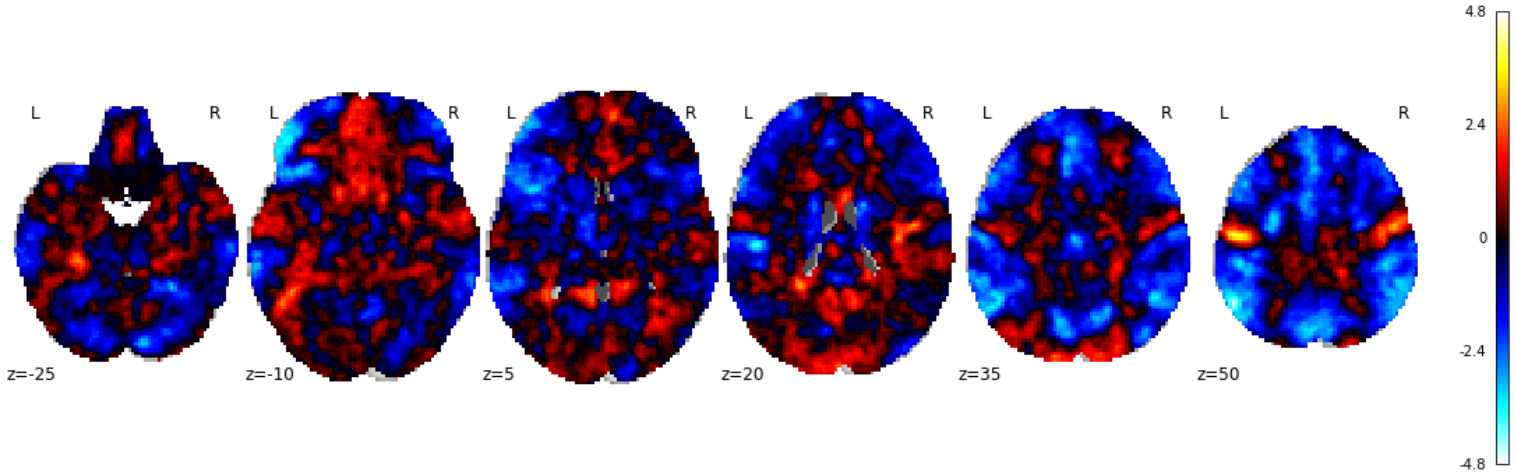


Analytic range

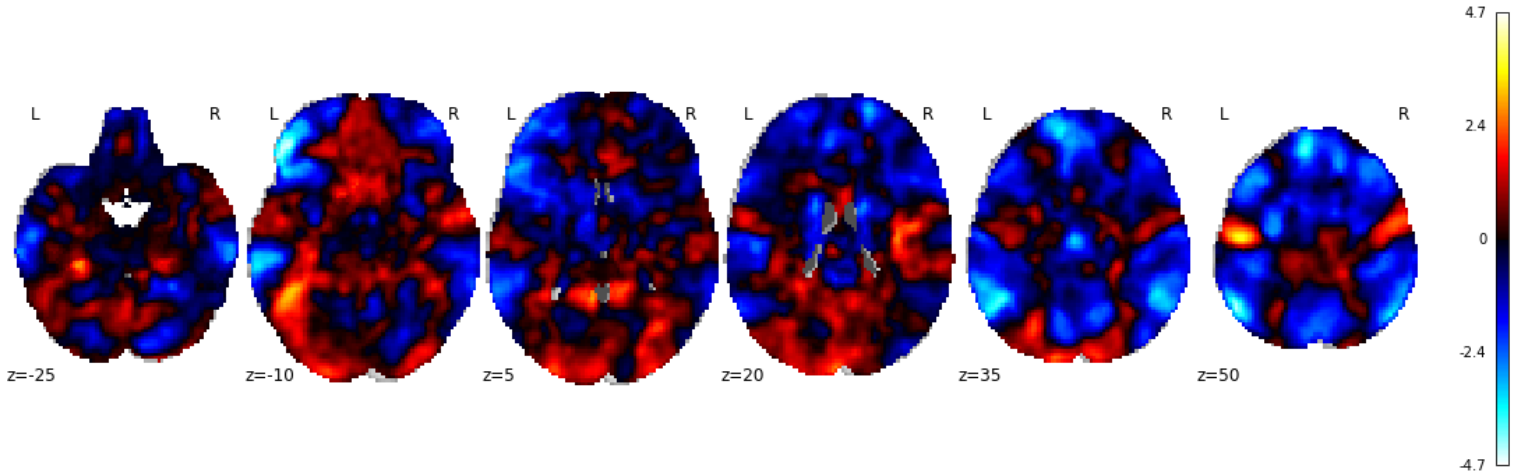


Exploring solutions: Mean activation & analytic range

FSL mean activation



SPM12 mean activation



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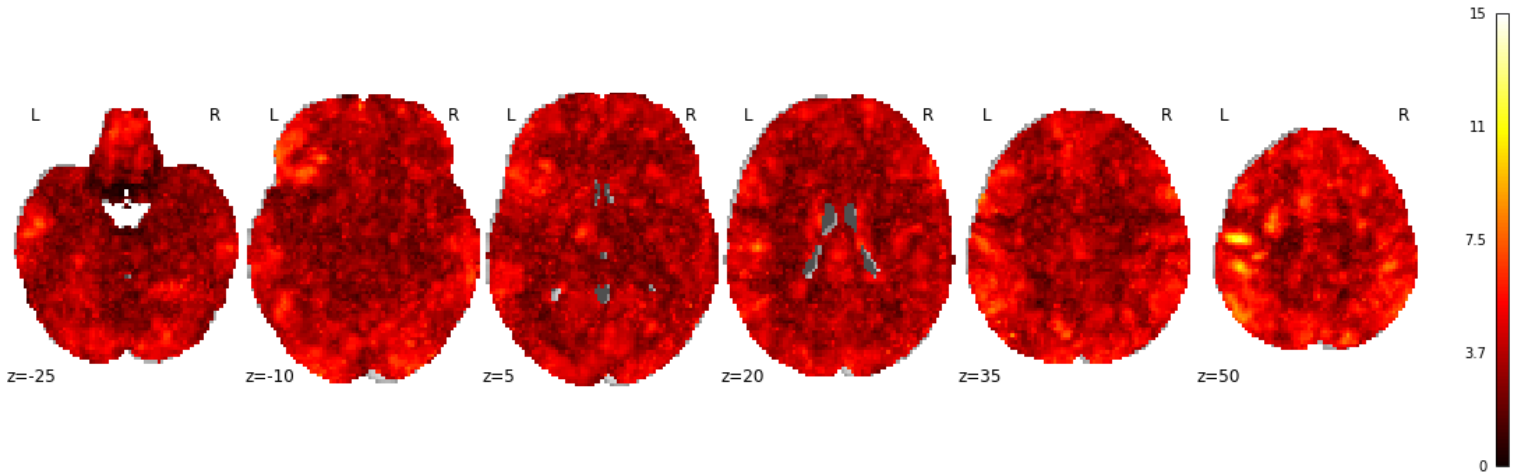

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