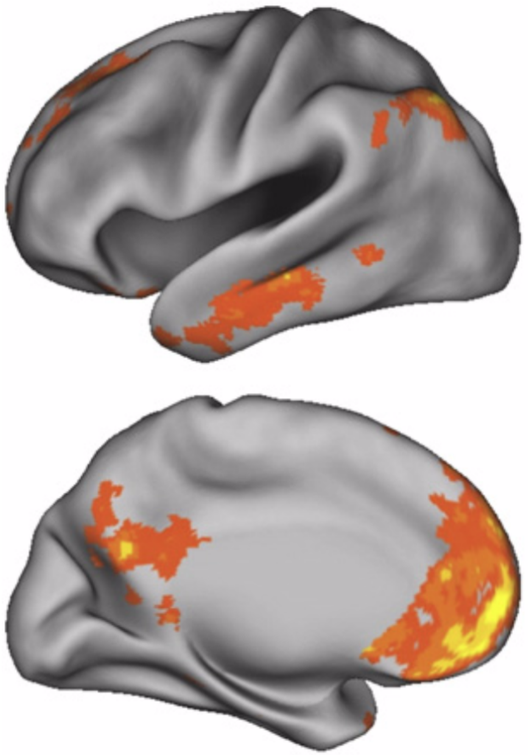
Network modeling analysis

- Resting state preprocessing
- Node definition and edge calculation
- Group analysis and challenges
- Comparison of resting state methods

Careful cleanup required

- Structured artefacts much more of a problem for rfMRI than task-fMRI
  - No model of expected activation
  - Instead based on correlating timeseries with each other

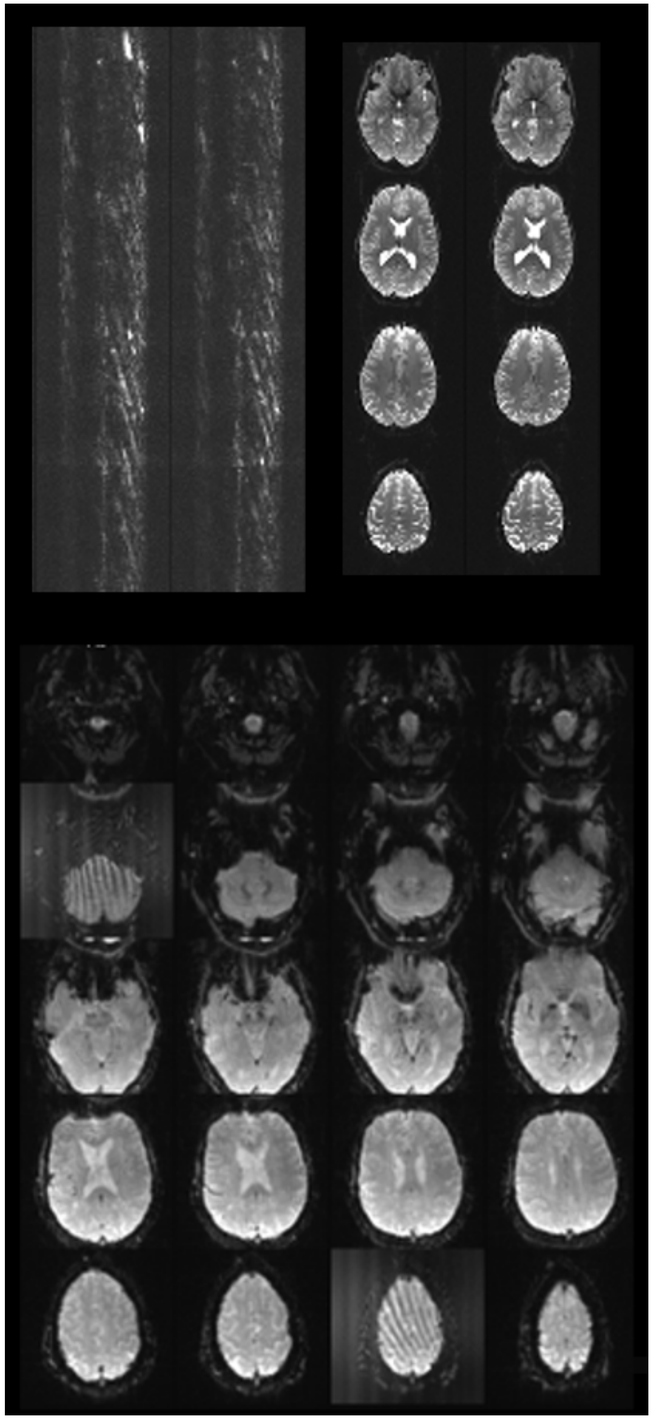
Low motion > high motion



Van Dijk et al (2012)

Noise sources

- Head motion
- Cardiac & breathing cycles
- Scanner artifacts



Bijsterbosch et al (2017)

Preprocessing overview

Conventional preprocessing steps

- Motion & distortion correction
- Slice timing correction
- High pass temporal filtering
- Spatial smoothing
- Registration

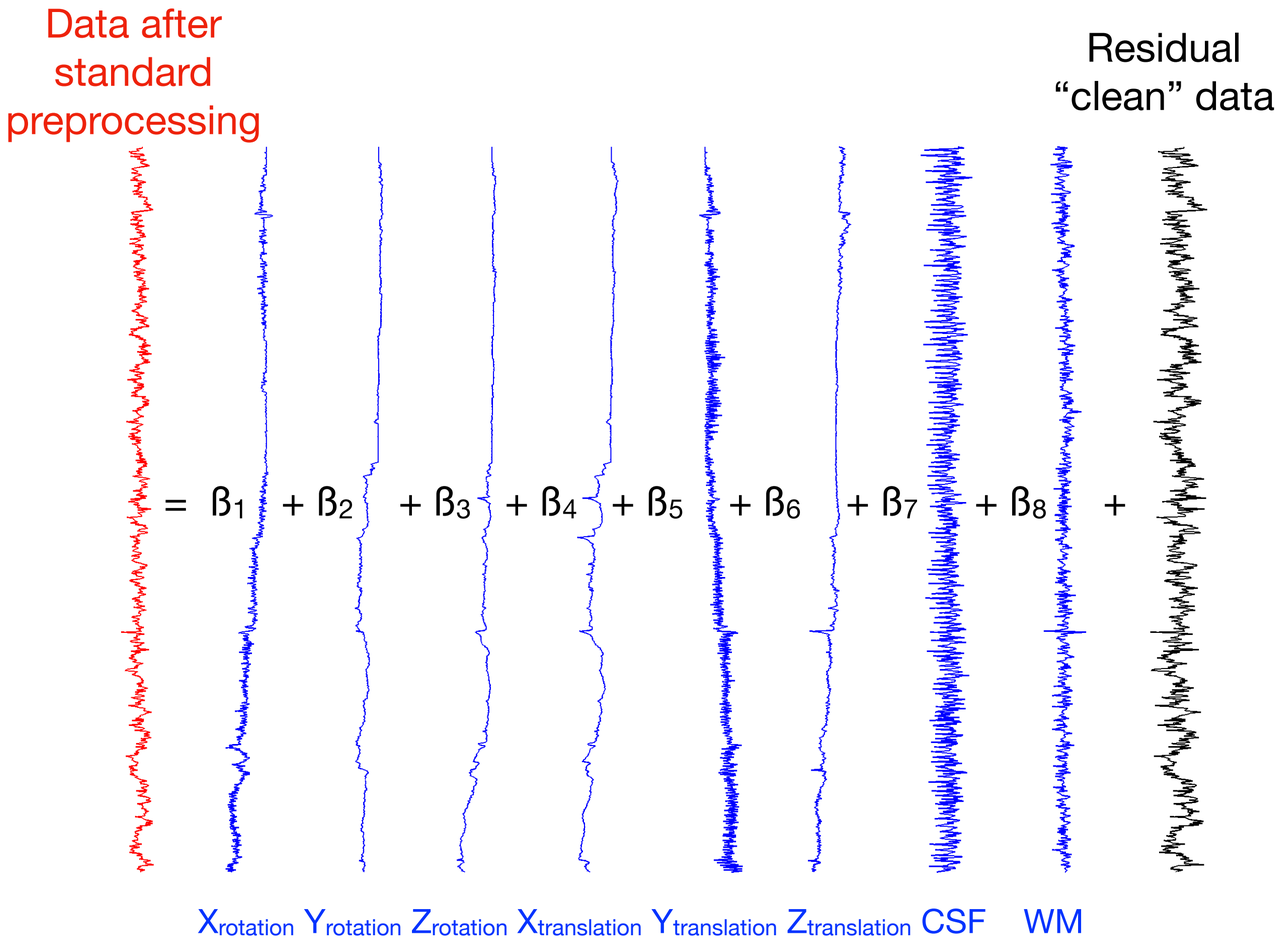
Noise reduction steps (use at least one of these)

- Nuisance regression
- Low pass temporal filtering
- Volume censoring
- Global signal regression
- ICA-based clean-up
- Physiological noise regression

Bijsterbosch et al (2017)

Nuisance regression

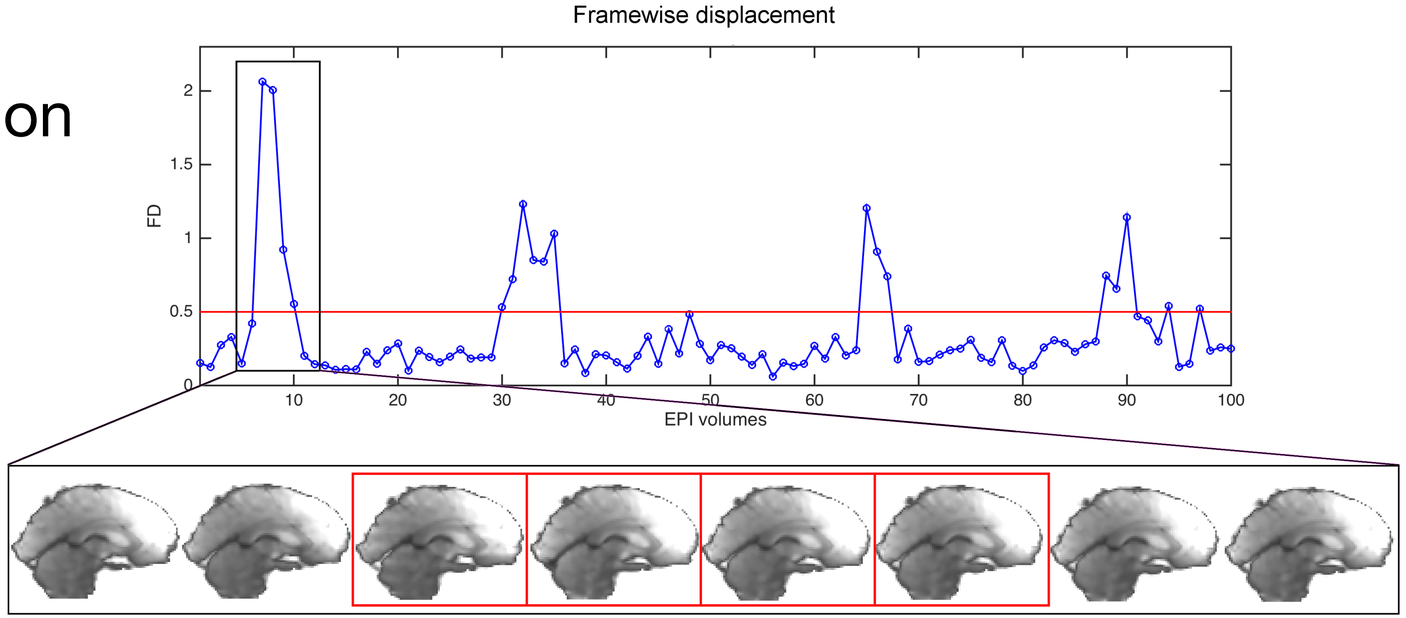
- Head motion parameters
- White-matter / CSF
- Use GLM to remove nuisance timeseries
- Perform analysis on residuals
- “CompCor” method (PCA-based)



Muschelli et al (2014)

Volume censoring

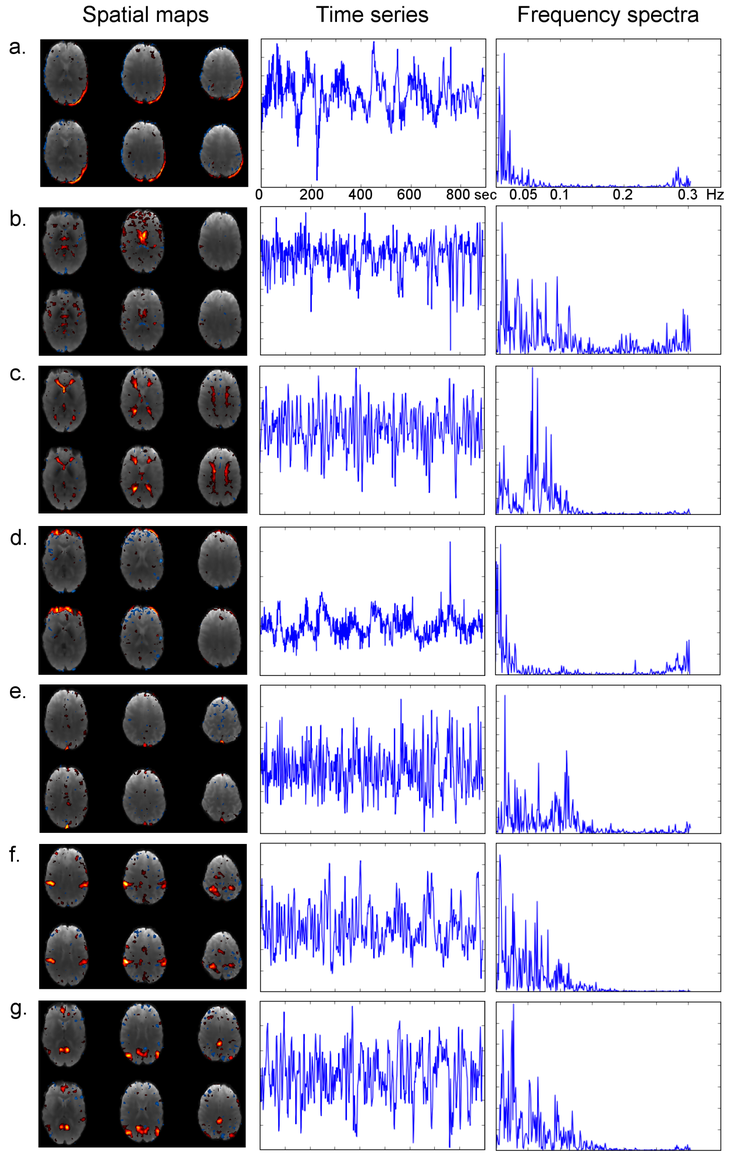
- Remove volumes with high motion
- Very effective to fully remove large motion effects
- But, does not remove small motion effects and other noise sources
- Also known as scrubbing, spike regression, de-spiking



Power et al (2012, 2013, 2014; Bijsterbosch et al (2017)

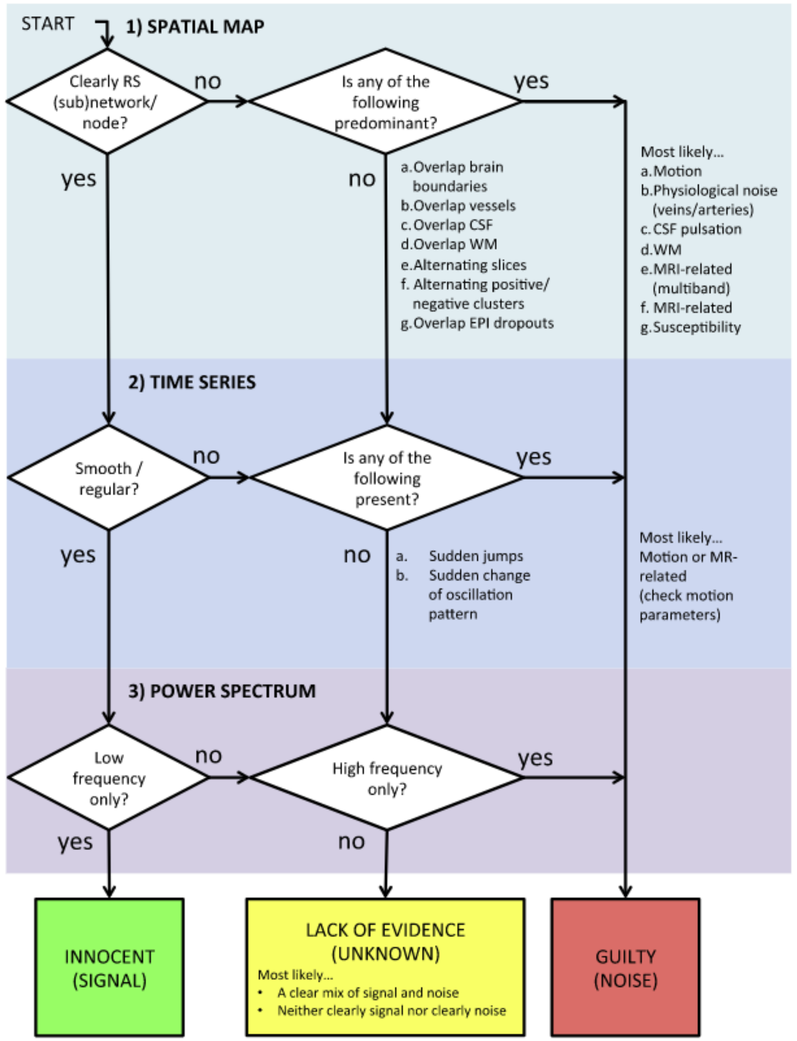
ICA based cleanup

- Semi-Automatic labelling methods available (ICA-FIX, ICA-AROMA)
- Removes most types of artefacts (motion, physiology, scanner)
- But, does not capture global (spatially extended) noise



Salimi-Khorshidi et al (2014), *Pruim et al (2015)*, *Bijsterbosch et al (2017)*

Cleanup: classification



Griffanti et al (2017)

FIX

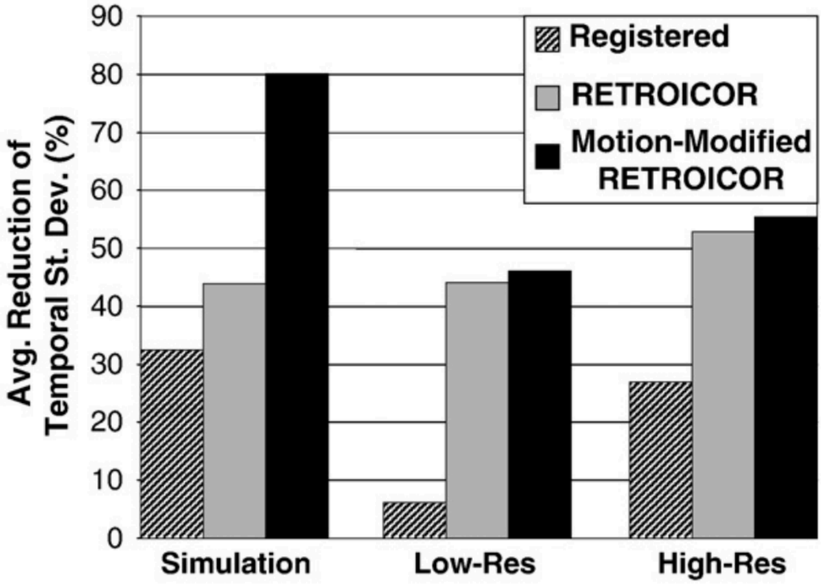
- fsl.fmrib.ox.ac.uk/fsl/fslwiki/FIX
- Classifier with many features
- Requires manually labelled training data
- 99% accuracy on high-quality data

ICA-AROMA

- github.com/rhr-pruim/ICA-AROMA
- Simple classifier with only 4 features
- No training data required
- Mainly designed for motion artefacts

Physiological noise regression

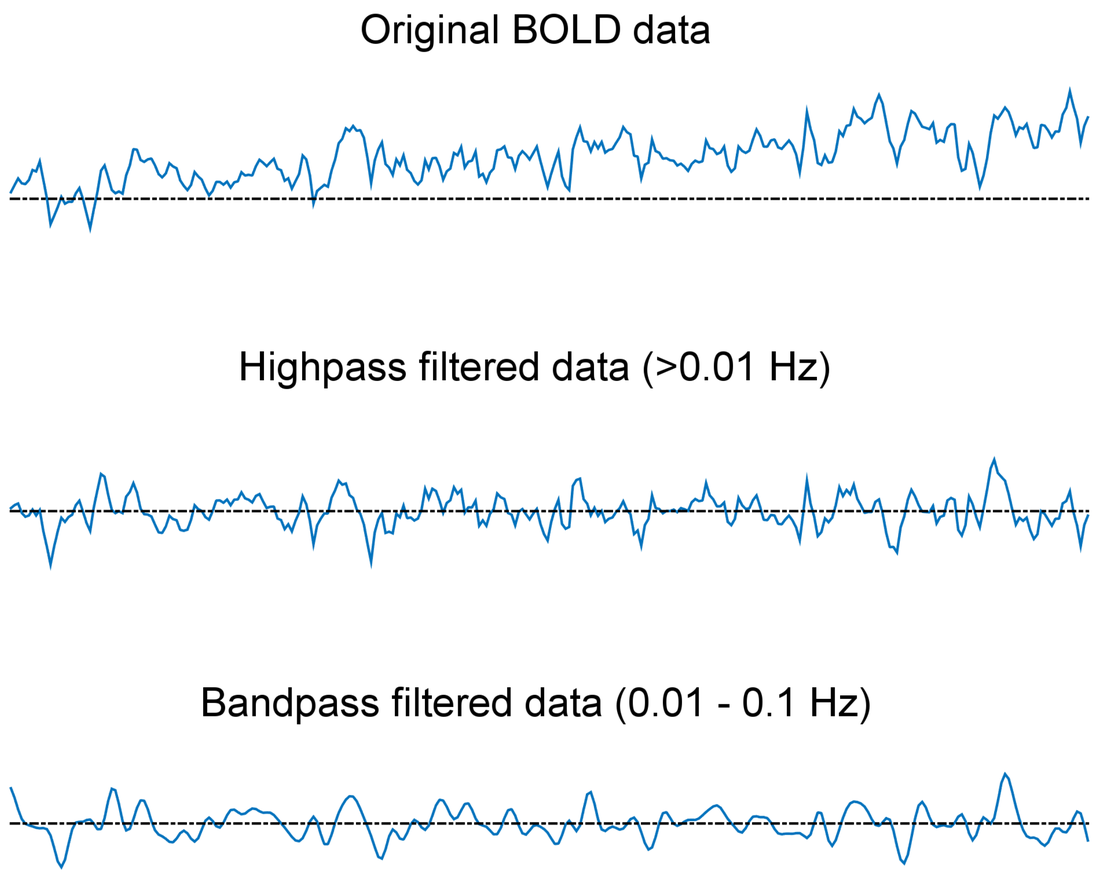
- PNM, RETROICOR
- Requires physiological measurements during scan
- Generates regressors based on physiological data



Glover et al (2000), *Jones et al (2008)*

Lowpass temporal filtering

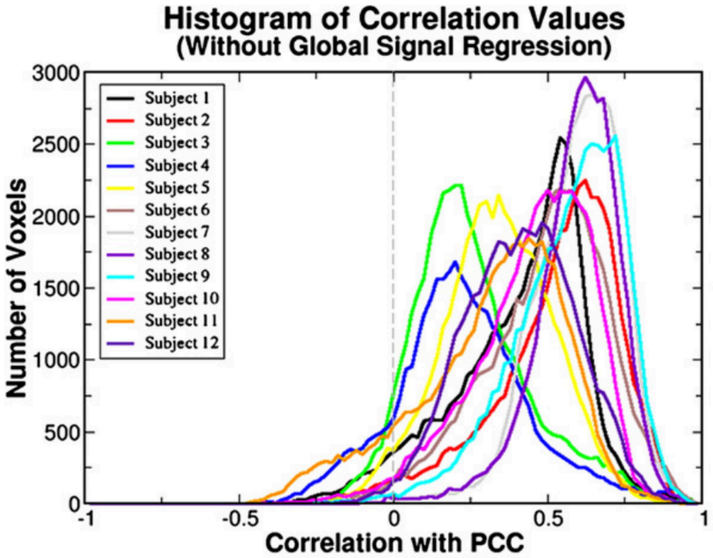
- E.g., common to remove frequencies > 0.1Hz
- May remove useful signal
- Not guaranteed to remove much artefact

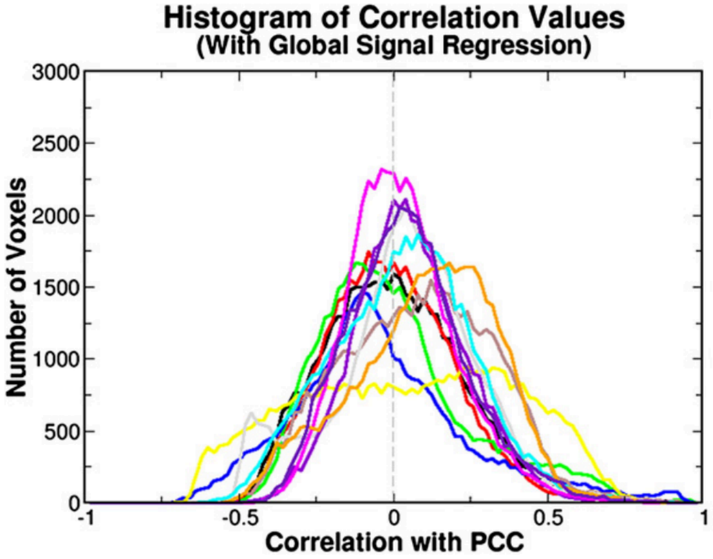


Bijsterbosch et al (2017)

Global signal regression

- Regress out mean timeseries across all voxels (or all grey matter voxels)
- Shifts connectivity values to be zero mean
- Therefore, more negative correlations
- Not necessary if using partial correlation





Murphy et al (2009)

Clean-up comparison

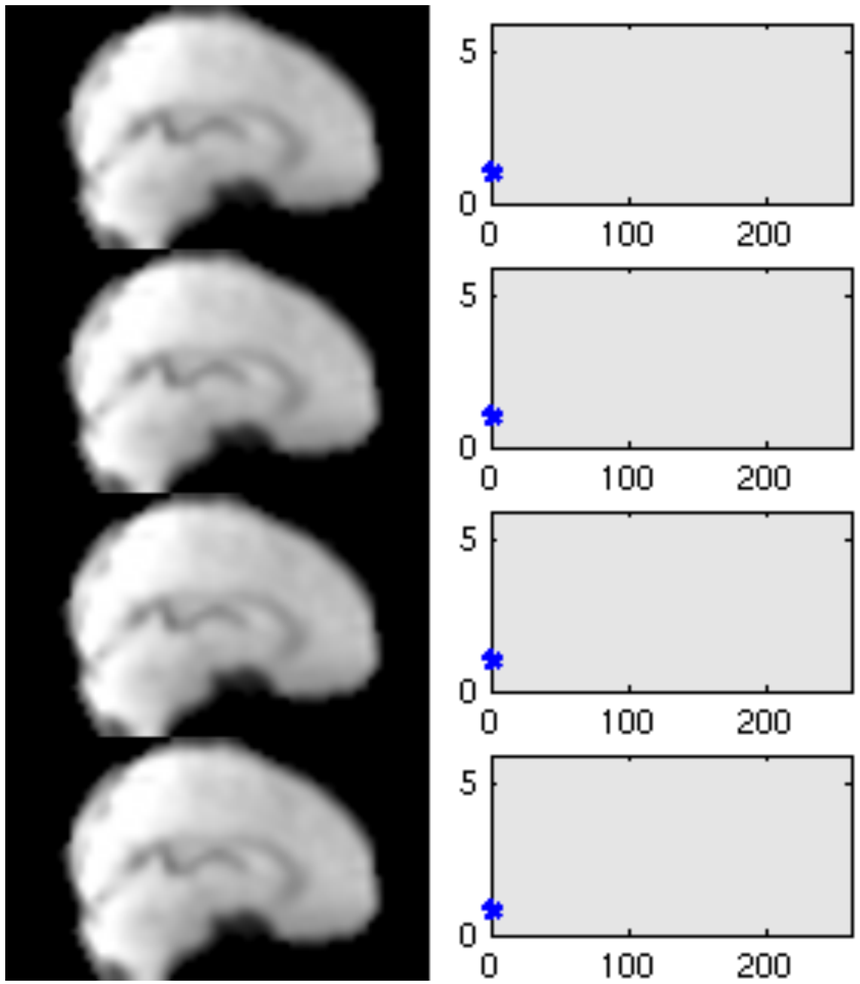
Clean-up comparison

no additional correction

24RP-regression

24RP + volume censoring

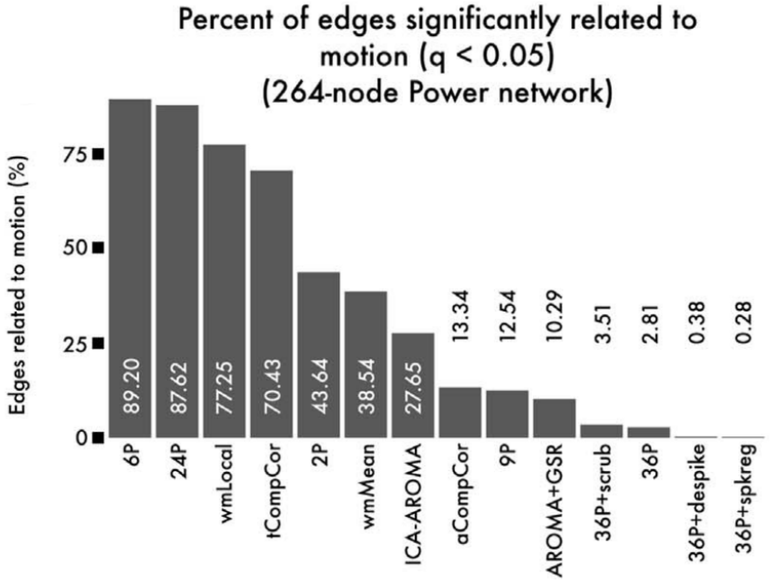
ICA-AROMA

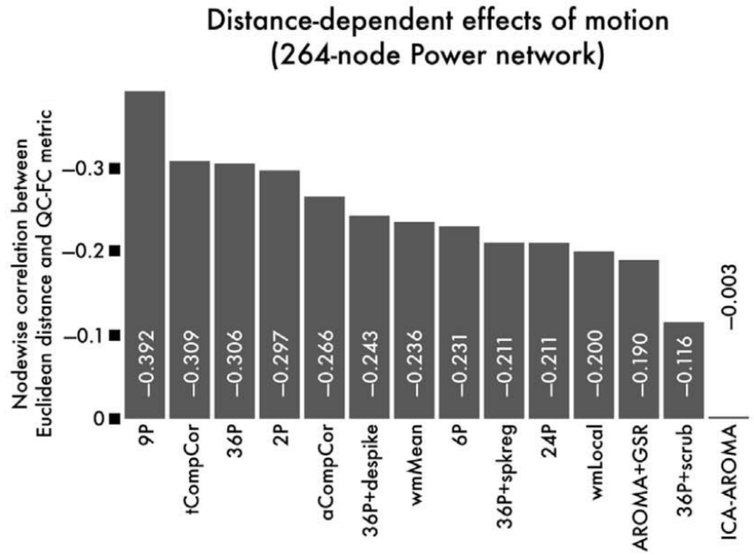


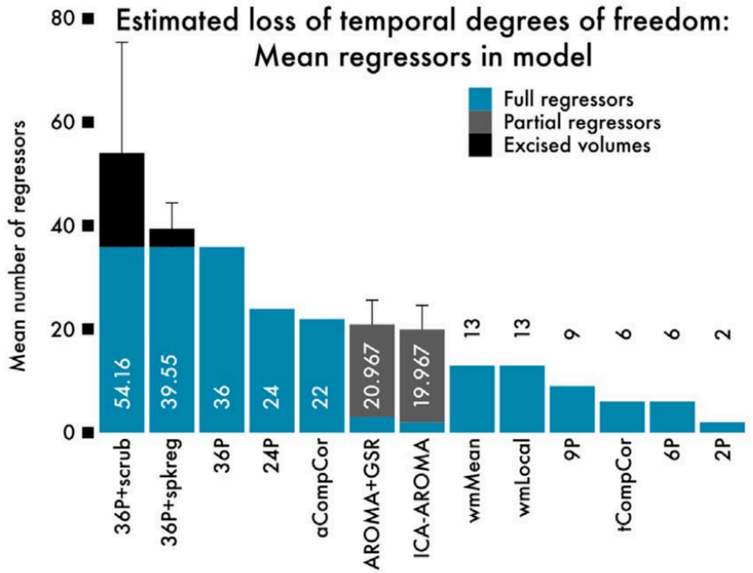
FMRI data

DVARS

Clean-up comparison







Ciric et al (2017)

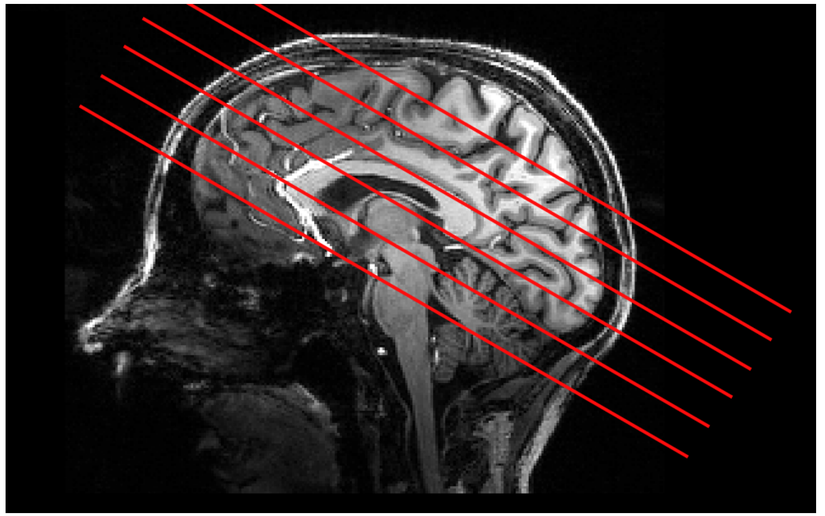
Summary and advice

Preprocessing advice

- Read up on the latest literature
- Nuisance regression is not enough
- Low-pass filtering is not enough & often not necessary when using other approaches
- Use ICA-based methods and/or volume censoring
- Use physiological noise regression when interested in brainstem or other vulnerable brain regions
- If using global signal regression, also show results without

Data acquisition advice

- Just a guide, may vary depending on study aims!
- Whole brain coverage, voxelsize: 2 - 3 mm
- Scan duration:
  - 10-15 minutes per scan
  - Potentially multiple scans
- Repetition time: ideally close to 1 second (multiband/ multiplexed imaging)
- Paradigm: eyes open, fixation cross
- Auxiliary data: physiology, sleep



Bijsterbosch et al (2017)

Resources

- FSL mailing list
- Book (Amazon/ OUP)
- All references on the bottom of slides contain ‘clickable’ links