Pipeline overview

Generic blueprint

1. Data acquisition

2. Data preprocessing

3. Single-subject analysis

4. Group-level analysis

5. Statistical inference

Generic blueprint

Aims:

- Obtain good quality and consistent data
- Optimise SNR

1. Data acquisition
2. Data preprocessing
3. Single-subject analysis
4. Group-level analysis
5. Statistical inference

Keep in mind:

- Many trade-offs
- Consider drop-out and distortions
- What are the most important regions?

Generic blueprint

1. Data acquisition
2. Data preprocessing
3. Single-subject analysis
4. Group-level analysis
5. Statistical inference

Aims:

- Reduce noise in data
- Prepare data for analysis
- Prepare data for group comparison

Keep in mind:

- Requires careful checking
- Can add additional steps if necessary

Generic blueprint

1. Data acquisition
2. Data preprocessing
3. Single-subject analysis
4. Group-level analysis
5. Statistical inference

Aims:

- Obtain measure of interest for each subject (often an image)

Keep in mind:

- Differs considerably between modalities

Generic blueprint

Aims:

- Compare single-subject results across group
- Group mean/ t-test/ correlation

1. Data acquisition
2. Data preprocessing
3. Single-subject analysis
4. Group-level analysis
5. Statistical inference

Keep in mind:

- Can have additional layer to average over sessions
- Account for confounding variables

Generic blueprint

Aims:

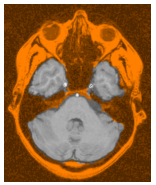
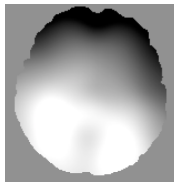
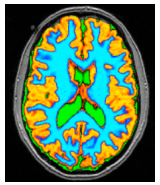
- P-values
- Reliability of results
- Generalise to population

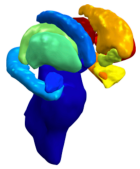
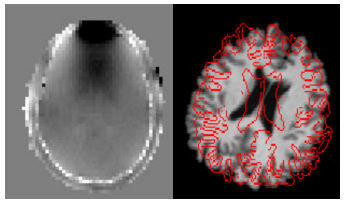
1. Data acquisition
2. Data preprocessing
3. Single-subject analysis
4. Group-level analysis
5. Statistical inference

Keep in mind:

- Need enough subjects to have power
- Cannot interpret null results

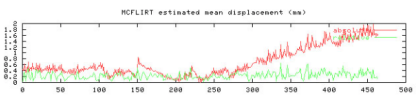
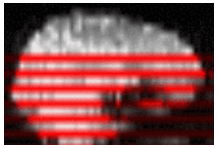
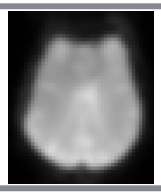
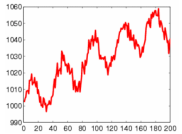
What we covered so far

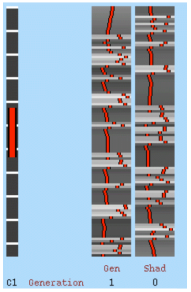
Structural data:

Brain extraction | Bias field correction | Segmentation | VBM or vertex analysis | Registration & unwarping

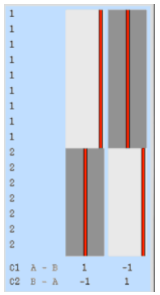





Functional data:

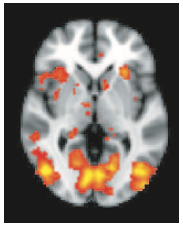
Motion correction | Slice timing correction | Spatial filtering | Temporal filtering



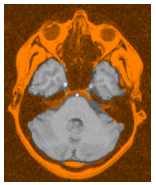
Regressors & contrasts | First level GLM

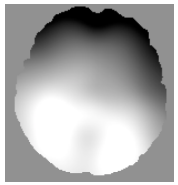


Regressors & contrasts | Group level GLM | Thresholding & correction



Preprocessing





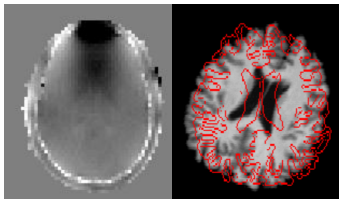
Structural data:

Brain extraction

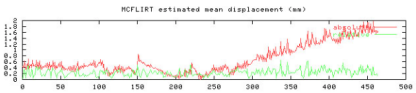
Bias field correction

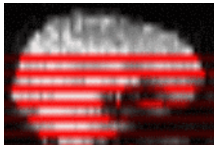
Segmentation

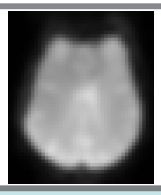
VBM or vertex analysis

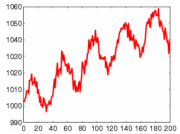


Registration & unwarping









Functional data:

Motion correction

Slice timing correction

Spatial filtering

Temporal filtering

Regressors & contrasts

First level GLM

Regressors & contrasts

Group level GLM

Thresholding & correction

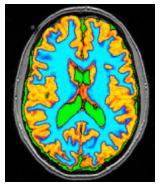
Structural preprocessing summary

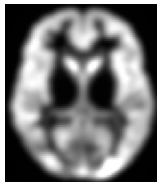
Brain extraction	Remove non-brain tissue to help with registration. Needs to be very precise.
Bias field correction	Corrects for B1 inhomogeneities
Registration	Put images into same space (standard space for group analysis)

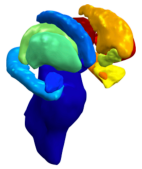
fMRI preprocessing summary

Brain extraction	Remove non-brain tissue to help with registration
Motion Correction	Get consistent anatomical coordinates (always do this)
Slice Timing	Get consistent acquisition timing (use temporal derivative instead)
Spatial Smoothing	Improve SNR & validate GRF
Temporal Filtering	Highpass: Remove *slow* drifts
Registration & unwarping	Unwarping corrects for B0 inhomogeneities. Registration images into same space (standard space for group analysis)

Single-subject analysis







Structural data:

Brain extraction

Bias field correction

Segmentation

VBM or vertex analysis

Registration & unwarping

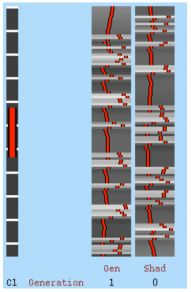
Functional data:

Motion correction

Slice timing correction

Spatial filtering

Temporal filtering



Regressors & contrasts

First level GLM

Regressors & contrasts

Group level GLM

Thresholding & correction

Structural single-subject summary

Segmentation	Tissue-type segmentation (FAST), sub-cortical segmentation (FIRST), white matter hyperintensities (BIANCA)
Voxel-based morphometry	To detect differences in local grey matter volume. Jacobian modulation and spatial smoothing.
Vertex analysis	To run shape analysis on subcortical structures. *first_utils* uses bvars output from FIRST to perform vertex analysis (4D output image of all subject meshes)

fMRI single-subject summary

EVs/ regressors	Design matrix: model of predicted responses based on stimuli presented at each time point
GLM	Estimate parameter estimates for each EV so that the linear combination best fits the data
Contrasts (F or t)	Maths on parameter estimates to ask research questions. Result is a COPE image per contrast

Group-level analysis

Structural data:

Brain extraction

Bias field correction

Segmentation

VBM or vertex analysis

Registration & unwarping

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Motion correction

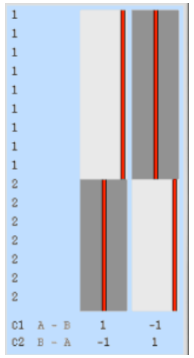
Slice timing correction

Spatial filtering

Temporal filtering

Regressors & contrasts

First level GLM



Regressors & contrasts

Group level GLM

Thresholding & correction

Group-level analysis summary

EVs/ regressors	Design matrix: one entry per subject. Can describe subject groups, confounds etc
GLM	*Structural*: inputs are smoothed, modulated GM volumes (VBM) or single subject subcortical meshes (vertex analysis) *fMRI*: inputs are first-level COPE and VARCOPE images.
Contrasts (F or t)	*Structural*: tests differences in GM density or shape *fMRI*: Each group-level contrast is tested for each of the subject-level contrasts

Statistical inference

Structural data:

Brain extraction

Bias field correction

Segmentation

VBM or vertex analysis

Registration & unwarping

Functional data:

Motion correction

Slice timing correction

Spatial filtering

Temporal filtering

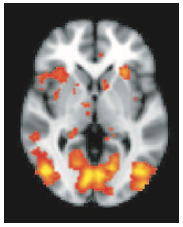
Regressors & contrasts

First level GLM

Regressors & contrasts

Group level GLM

Thresholding & correction



Statistical inference summary

Fixed effects vs mixed effects	Averaging across multiple sessions Generalisation to population
OLS vs FLAME vs Randomise	Quick, doesn't use VARCOPEs Uses COPEs & VARCOPEs Non-parametric
Multiple comparison correction (FWE/ FDR)	Gaussian Random Field (voxel or cluster based) TFCE

What we covered so far

Structural data:

Brain extraction

Bias field correction

Segmentation

VBM or vertex analysis

Registration & unwarping

Preprocessing

Functional data:

Motion correction

Slice timing correction

Spatial filtering

Temporal filtering

Regressors & contrasts

First level GLM

Single-subject analysis

Regressors & contrasts

Group level GLM

Thresholding & correction

Group-level analysis

Statistical inference

Looking ahead:
resting state
diffusion

Generic blueprint

1. Data acquisition

2. Data preprocessing

3. Single-subject analysis

4. Group-level analysis

5. Statistical inference

Resting state analysis

1. Data acquisition → Consider using multiband
2. Data preprocessing
3. Single-subject analysis
4. Group-level analysis
5. Statistical inference

Resting state analysis

1. Data acquisition → Consider using multiband
2. Data preprocessing → Need to apply extra noise-reduction steps (ICA)
3. Single-subject analysis
4. Group-level analysis
5. Statistical inference

Resting state analysis

1. Data acquisition → Consider using multiband
2. Data preprocessing → Need to apply extra noise-reduction steps (ICA)
3. Single-subject analysis →
4. Group-level analysis → Group ICA+dual regression/ Network analysis (FSLnets)
5. Statistical inference →

Diffusion analysis

1. Data acquisition → Diffusion directions
Blip-up/blip-down
Multi shell
2. Data preprocessing
3. Single-subject analysis
4. Group-level analysis
5. Statistical inference

Diffusion analysis

1. Data acquisition → Diffusion directions
Blip-up/blip-down
Multi shell
2. Data preprocessing → Need to correct for eddy currents
3. Single-subject analysis
4. Group-level analysis
5. Statistical inference

Diffusion analysis

1. Data acquisition → Diffusion directions
Blip-up/blip-down
Multi shell
2. Data preprocessing → Need to correct for eddy currents
3. Single-subject analysis → Fractional anisotropy/ mean diffusivity/ tractography
4. Group-level analysis
5. Statistical inference

Enjoy the rest of the course!