Resting state fMRI and ICA

- Introduction to resting state
- Independent Component Analysis
- Single subject
- Multi-subject ICA
- Dual regression
Energy consumption in the brain

- Brain < 2% body weight but consumes ~20% of total energy
- estimated 60-80% of this energy used to support communication between cells
- task-evoked activity accounts for ~1%

Why study the brain at rest?

- Localisation versus connectivity
- Understand the inherent functional organisation of the brain
- Clinical/ cognitive biomarker
- Pragmatic benefits: can be done in any population, with relatively little setup and expertise required

Principles of resting state analysis

- Many different methods available for analysis
- All have one assumption in common:
  - i.e. definition of functional connectivity is based on a statistical dependency between timeseries
  - Differences between methods lie in the way these similarities are estimated and/or represented

If two brain regions show similarities in their BOLD timeseries, they are functionally connected
Types of connectivity

- Functional connectivity
  - Statistical dependency
- Dynamic connectivity
  - Changes in functional connectivity over time
- Effective connectivity
  - Directional influence
- Anatomical (structural) connectivity
  - Presence of a white matter tract
Features of resting state data
Replicable networks

Large-scale inherent organisation is reproducibly found across studies and approaches

Grey matter networks

Resting state network structure is localised in grey matter
Relationship to task

Resting state networks are similar to task activation patterns at group and single subject level.

Functional vs structural connectivity

Functional connectivity is related to structural connectivity

Honey et al (2009), Damoiseaux & Greicius (2009)
Low frequency fluctuations?

power spectra for 5 RSNs in low-TR data (mean of all 5 in black)

Cordes et al (2001)
Low frequency fluctuations?

- BOLD decreases as $1/f$
- Degrees of freedom increase as $\sqrt{f}$
Low frequency fluctuations?

- BOLD decreases as $1/f$
- Degrees of freedom increase as $\sqrt{f}$
- Combined effect contributes to RSN estimation across frequency range!
Electrophysiology of BOLD connectivity

Analysis overview
Overview of resting state methods

Voxel-based methods

Node-based methods
Overview of resting state methods

Voxel-based methods

- Seed-based correlation analysis
  - SCA
- Independent component analysis
  - ICA
- Amplitude of low frequency fluctuations
  - ALLF/fALLF
- Regional homogeneity
  - ReHo

Node-based methods

- Network modelling analysis
  - FSLnets
- Graph theory analysis
  - Such as degree, hub, path length
- Dynamic causal modelling
  - DCM
- Non-stationary methods
  - Such as windowed analyses
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Introduction to Resting State fMRI Functional Connectivity

Bijsterbosch
Smith
Beckmann

Spontaneous ‘resting-state’ fluctuations in neuronal activity offer insights into the inherent organization of the human brain, and may provide markers for diagnosis and treatment of mental disorders. Resting state functional magnetic resonance imaging (fMRI) can be used to investigate intrinsic functional connectivity networks, which are identified based on similarities in the signal measured from different brain regions.

From data acquisition to interpretation of results, Introduction to Resting State fMRI Functional Connectivity discusses a wide range of approaches without requiring any previous knowledge of resting state fMRI, making it highly accessible to readers from a broad range of backgrounds.

Supplemented with online datasets and examples to enable the reader to obtain hands-on experience working with real data, this primer provides a practical and approachable introduction for those new to the field of resting state fMRI.

The Oxford Neuroimaging Primers are short texts aimed at new researchers or advanced undergraduates from the biological, medical or physical sciences. They are intended to provide a thorough understanding of the ways in which neuroimaging data can be analyzed and how that relates to acquisition and interpretation. Each primer has been written so that it is a stand-alone introduction to a particular area of neuroimaging, and the primers also work together to provide a comprehensive foundation for this increasingly influential field.

Resources

• FSL mailing list

• Book (Amazon/ OUP)

• All references on the bottom of slides contain ‘clickable’ links