Life After JAI:
From Accelerators to Brains

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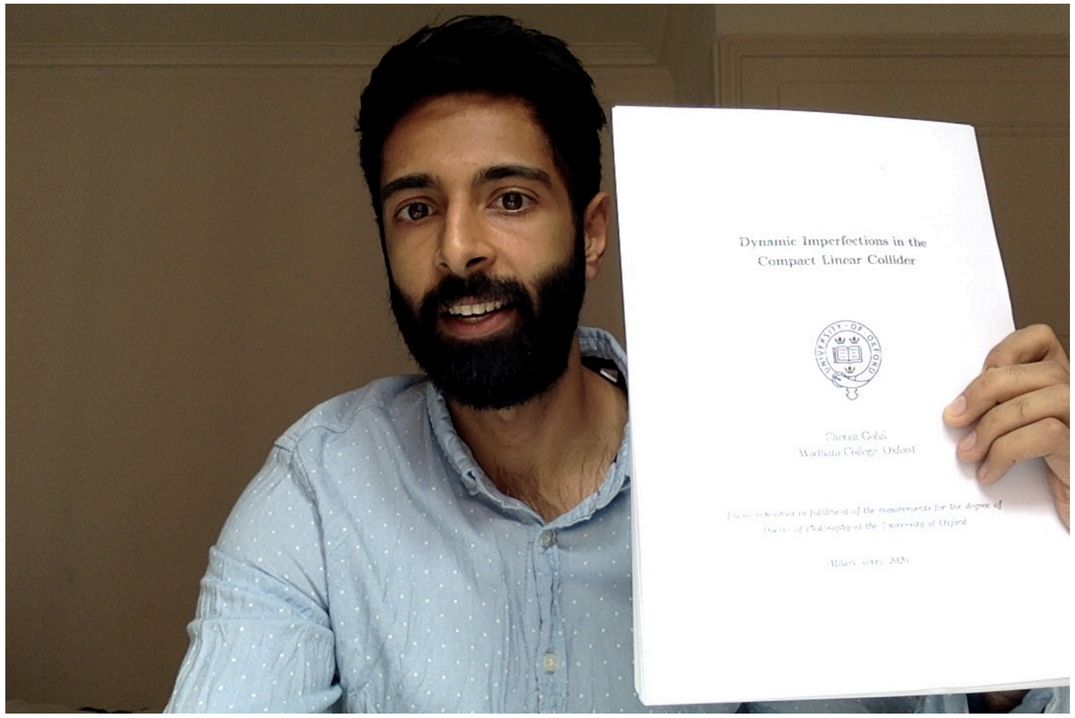
“Is there a life after the JAI?” - Neven Blaskovic Kraljevic (2023)

Life at the JAI

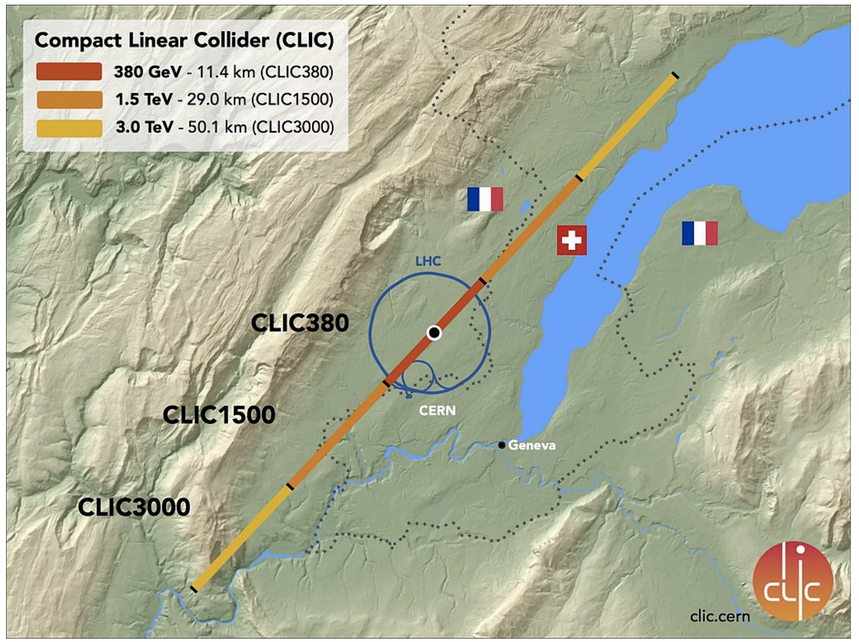
About Me

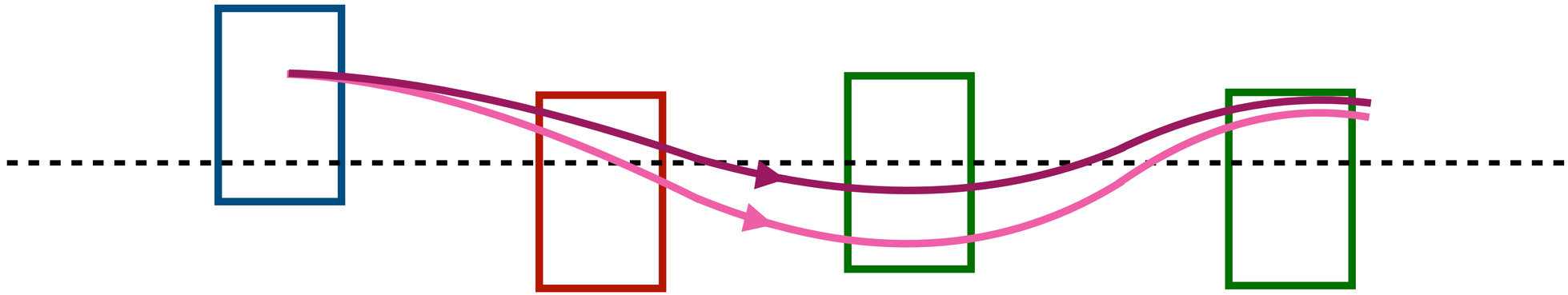
- Was a DPhil student from 2016-2020.
- Supervised by Phil Burrows (JAI) and Daniel Schulte (CERN).
- Worked on:
  - Surveying magnetic fields at accelerator facilities.
  - Simulating the impact of stray magnetic fields on beam dynamics.



CLIC's Sensitivity to nT Magnetic Fields

- CLIC target's nm beam sizes at collision.
- Imperfections misalign the beam and cause emittance growth.
- Simulations show nT magnetic fields can significantly impact luminosity.

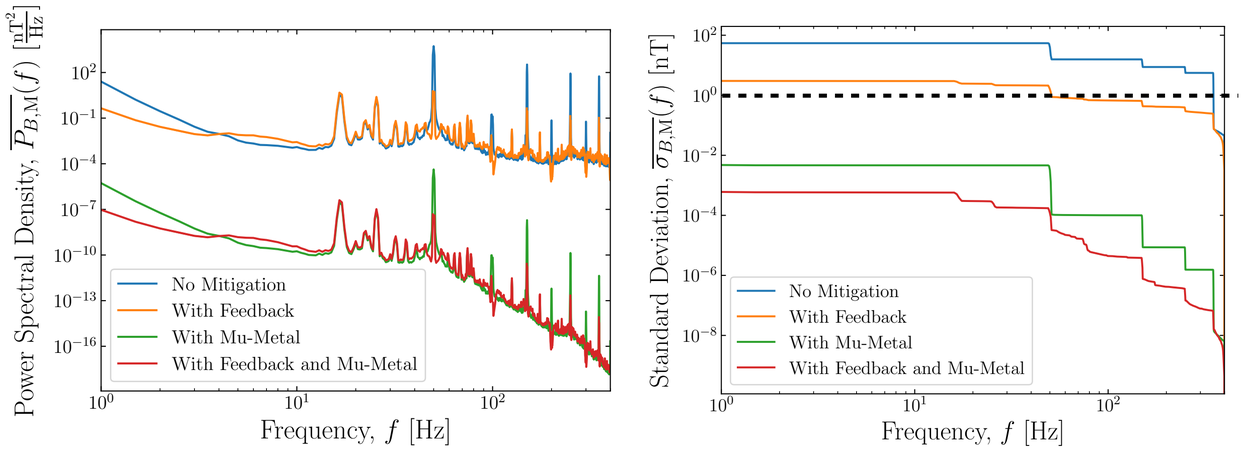




Different energy particles take different trajectories.

Stray Magnetic Fields in Accelerators

- What is the magnetic field environment in an accelerator?



Shielding the beam line is an effective mitigation technique

What did I learn?

- Experimental design.
- Data analysis:
  - Computational modelling (simulation, coding); machine learning.
- Transferable skills:
  - Working independently; time management; organisation; communication; problem solving.

Life after the JAI

Postdoctoral Researcher in Machine Learning and Brain Imaging

- Now I’m a postdoc in the Psychiatry Department at Oxford.
- Been here for 3 (!) years.
- I apply modern machine learning techniques to brain data.
  - Want to understand healthy and abnormal brain activity.

Measuring Brain Activity

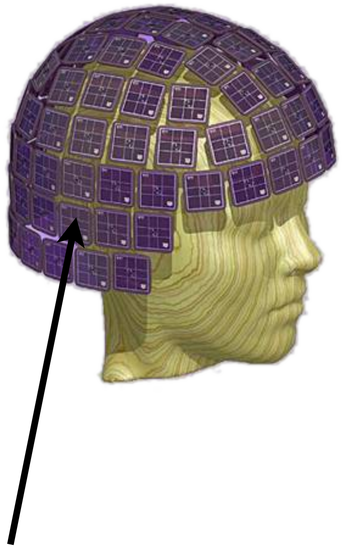
- Multiple ‘types’ of brain activity can be measured.
- Data is recorded when performing a task or at rest.
- My work focuses on MEG (magnetoencephalography).
  - Gives access to very fast processes.

fMRI

MEG

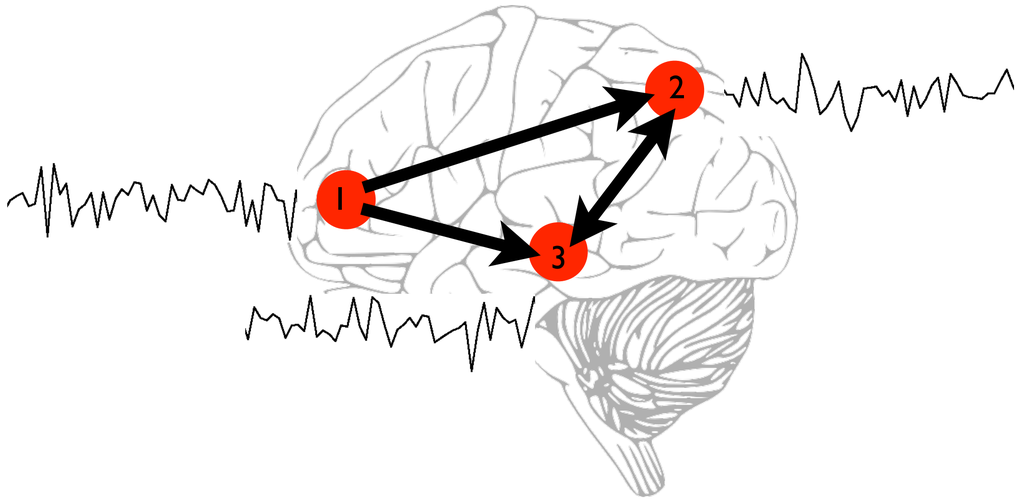
EEG

Measuring Brain Activity



SQUIDs

(Super-conducting Quantum Interference Devices)



Record the magnetic field around the head

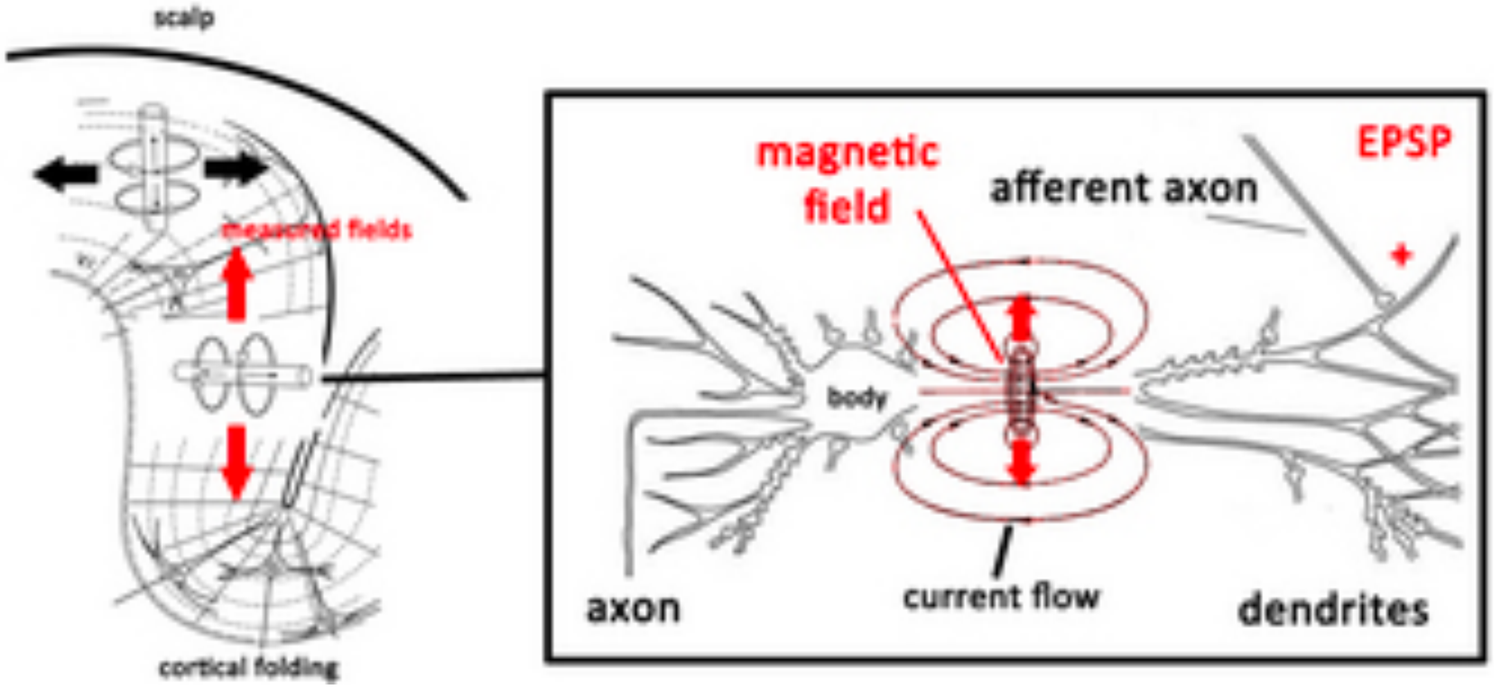
Discretise the brain into a grid.

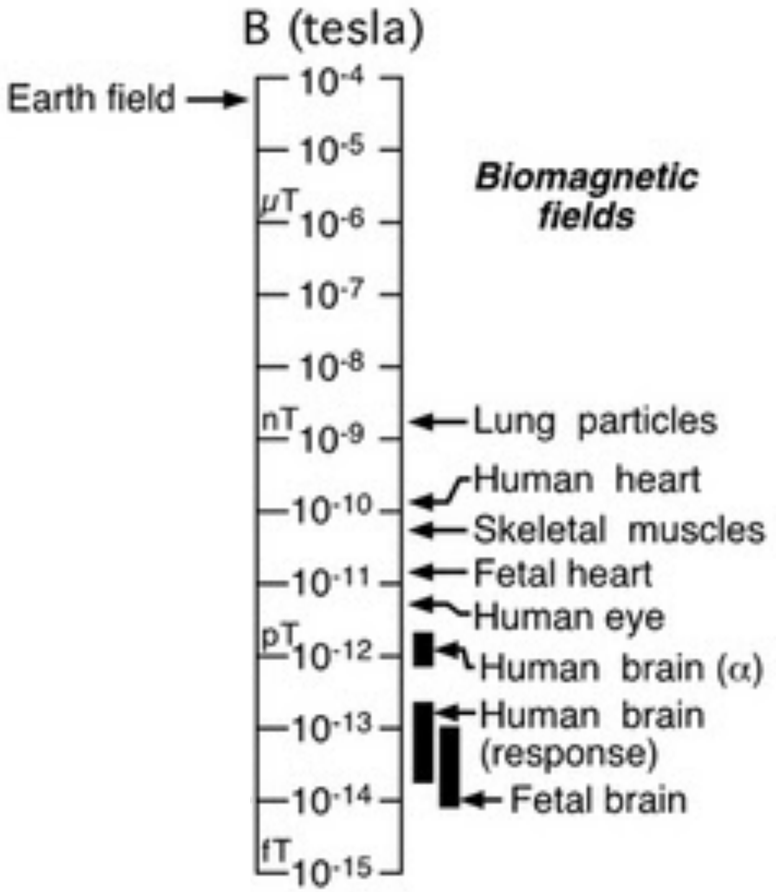
Note: the grid points are near the surface.

Estimate a time series for each grid point.

Brain Activity

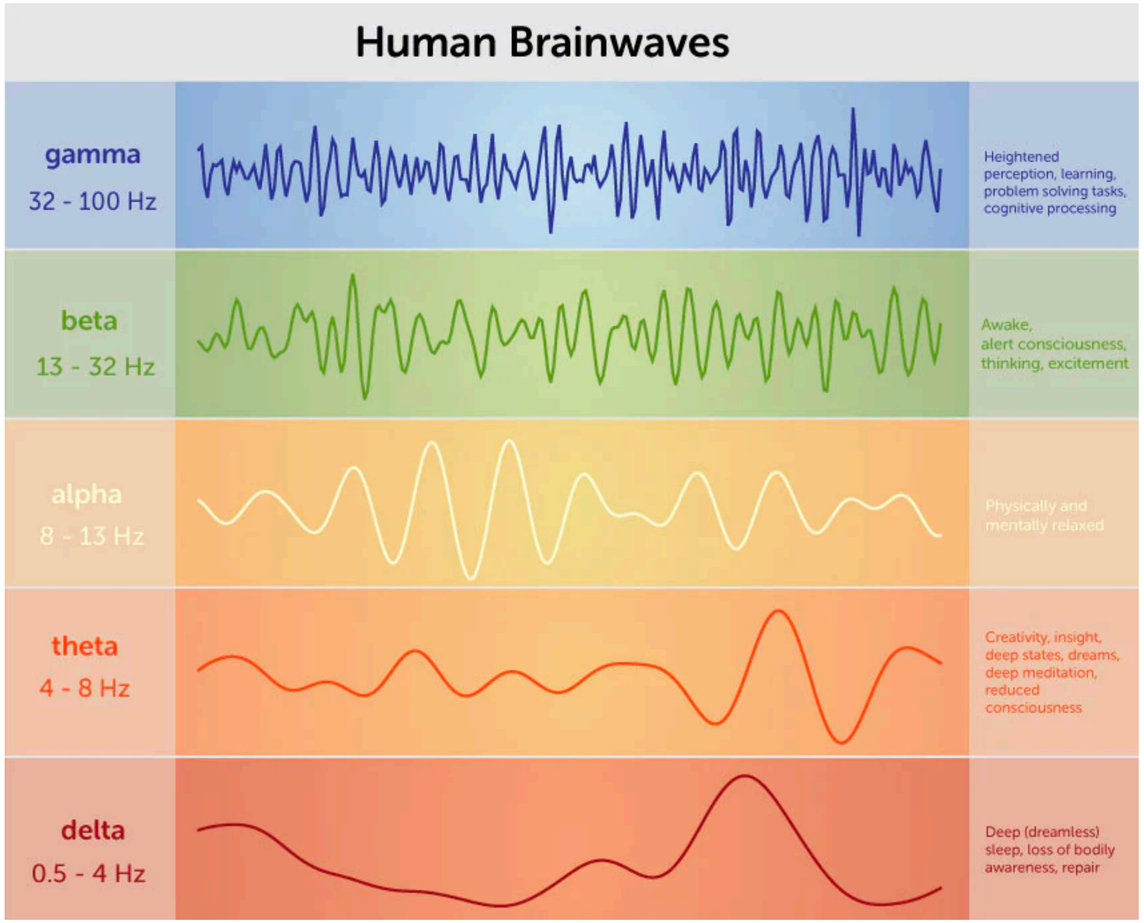
- The MEG signal is from populations of neurons:

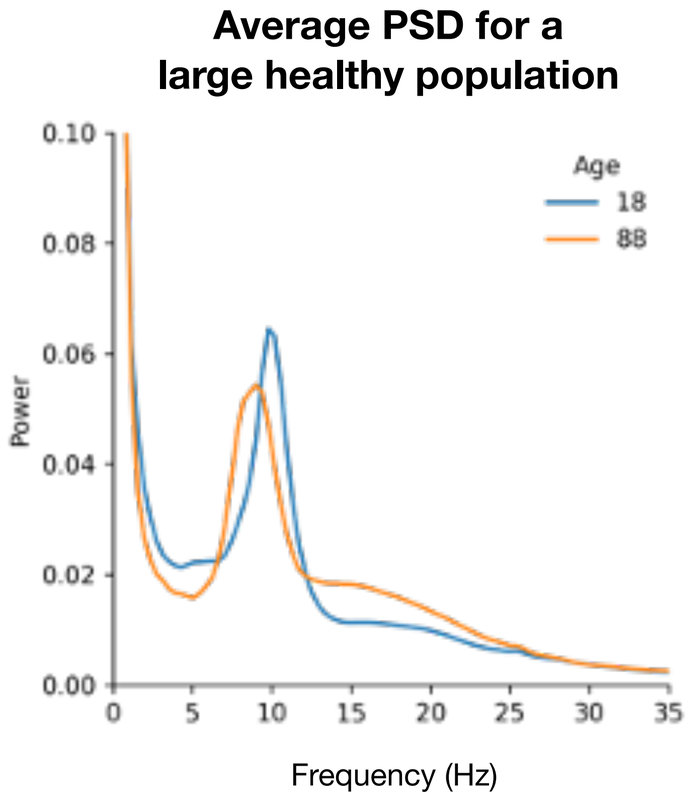




Brain Activity

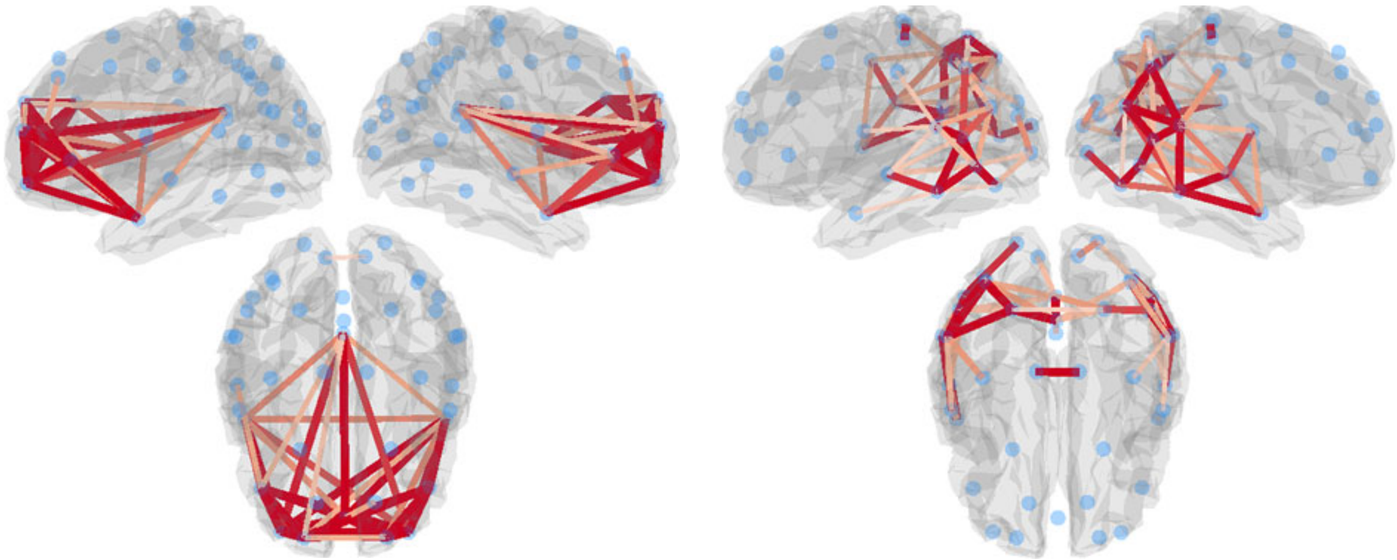
- Oscillations emerge from neuronal populations:





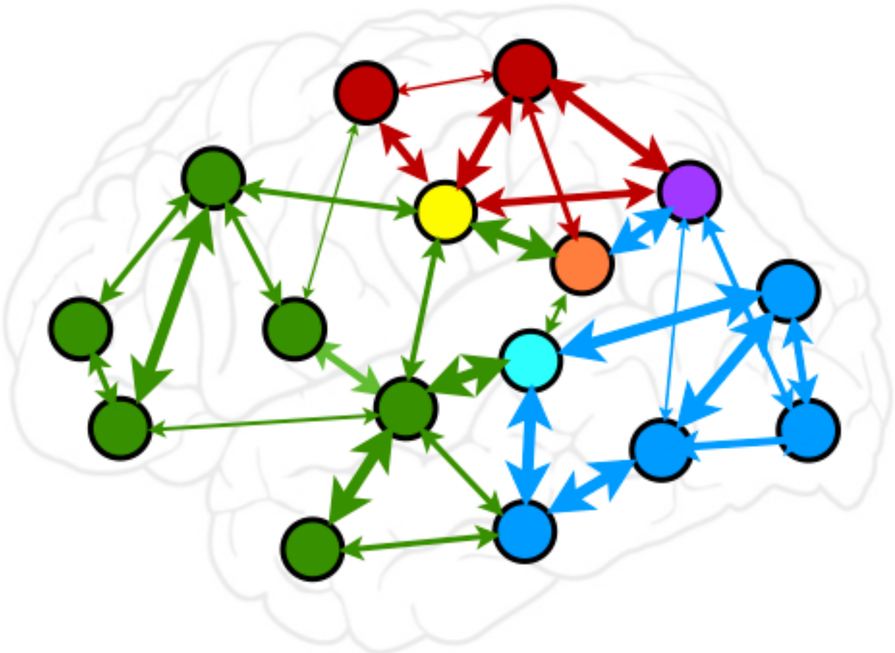
Brain Activity

- How do different regions communicate?
  - Popular theory: via the synchronisation of oscillations.



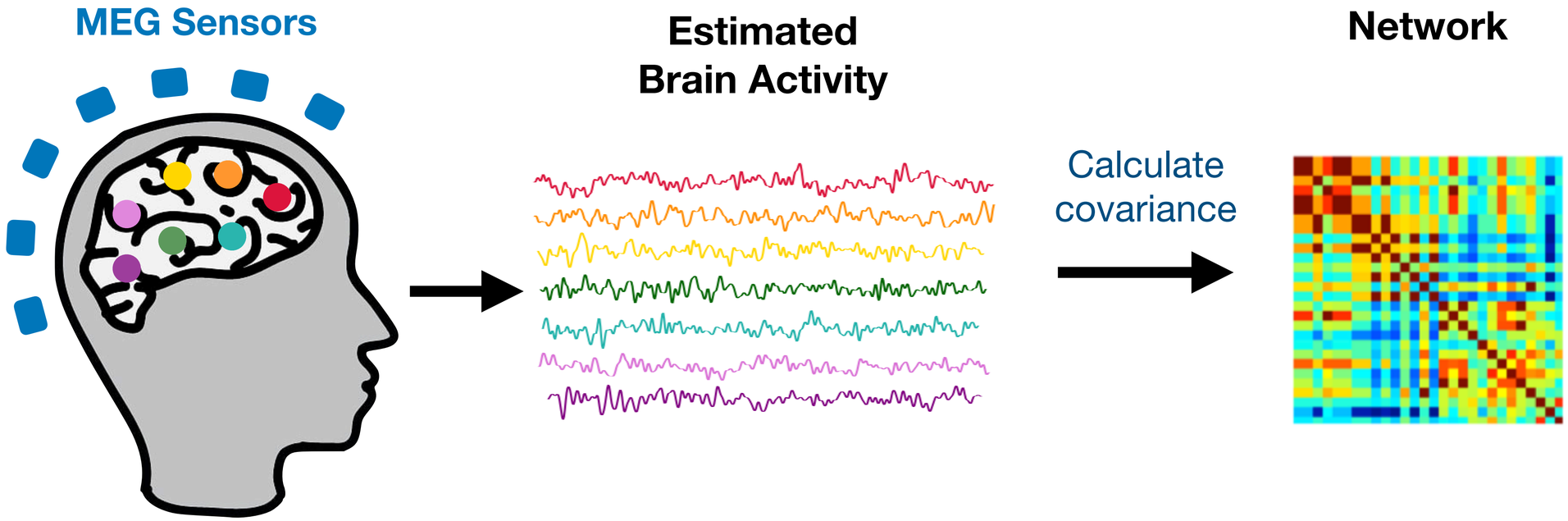
Brain Networks

- Widely believed that the brain performs cognition via distributed brain networks.
  - Historically, analysis has focused on single regions.
- I work on developing novel methods for identifying dynamic brain networks.
  - Unsupervised learning.



Brain Networks

- How do you model brain networks?

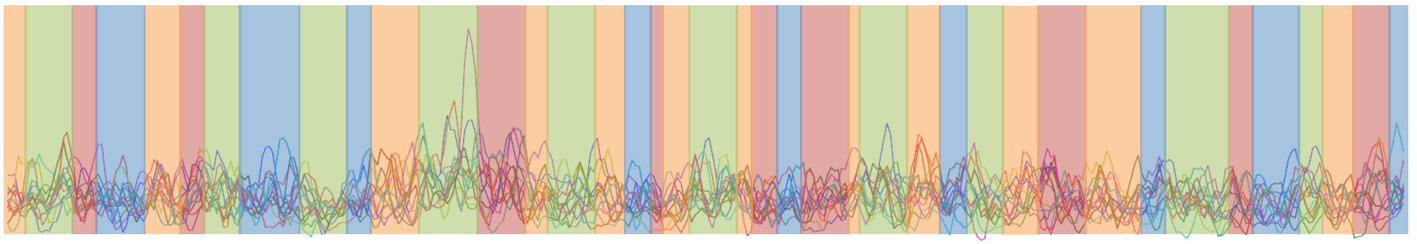


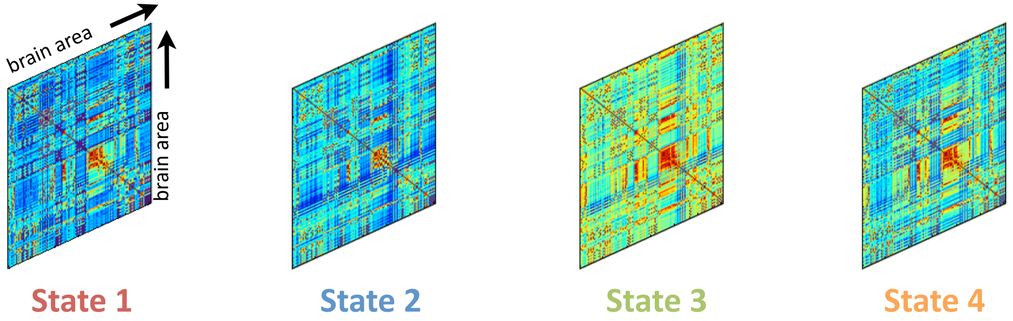
Brain Networks Dynamics

- How do you model dynamic brain networks?

- **Hidden Markov Model:**
  - $x_t \sim \mathcal{N}(0, C_t)$
    - $C_t = C_k, \quad k \in \{1,..,K\}$
  - Finds repeated patterns of covariances.

Observed Time Series and Inferred States

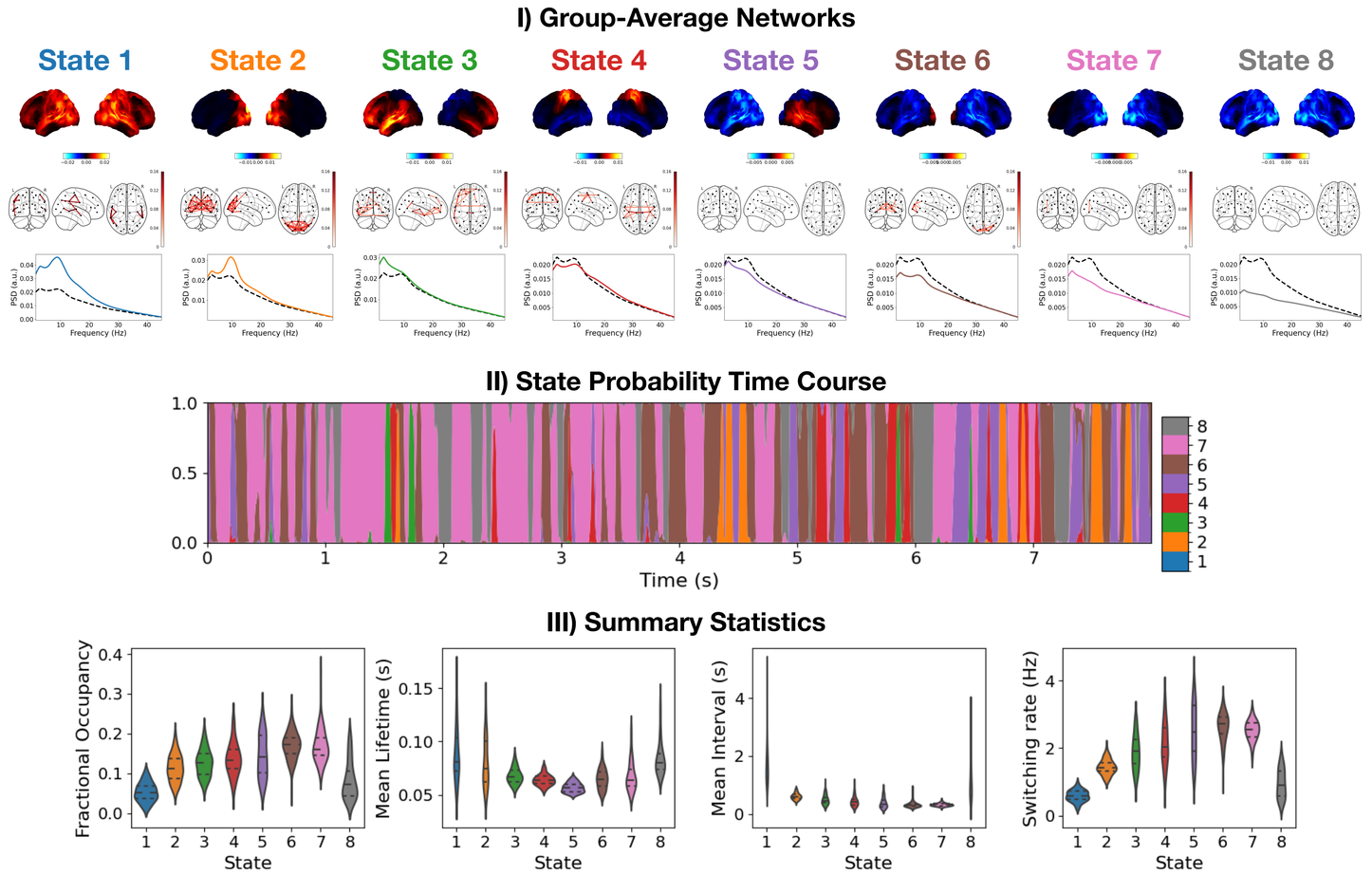




Each state represents a transient brain network

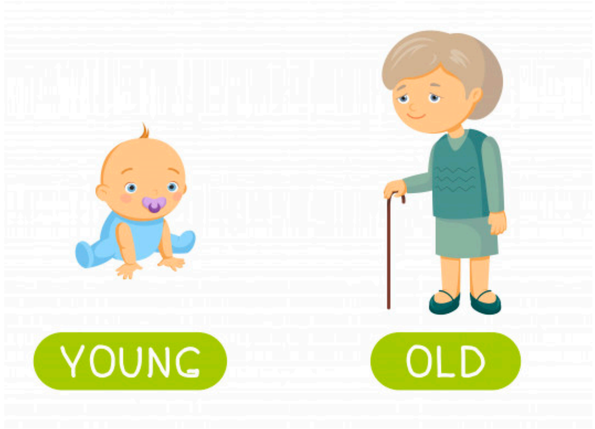
Brain Networks Dynamics

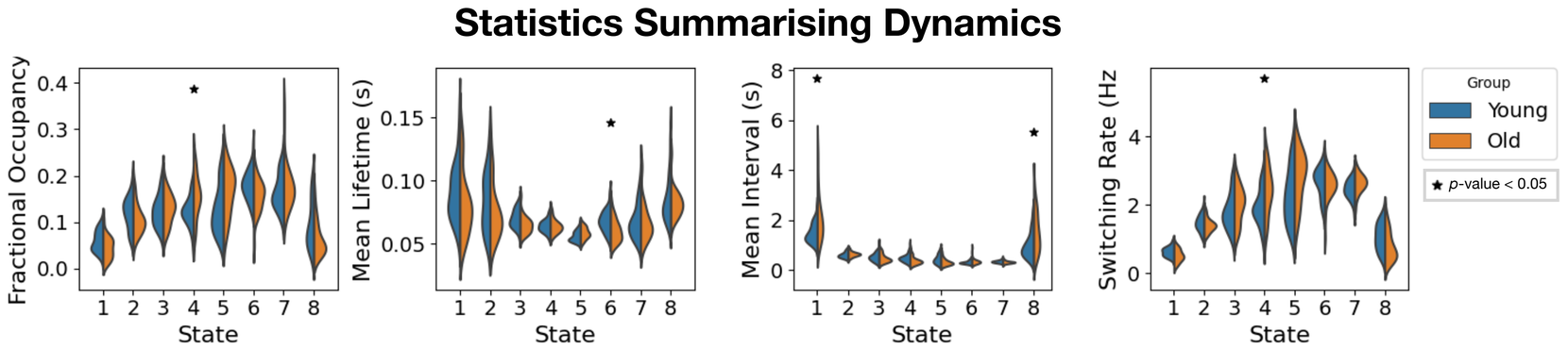
- These are very fast networks (~100 ms):

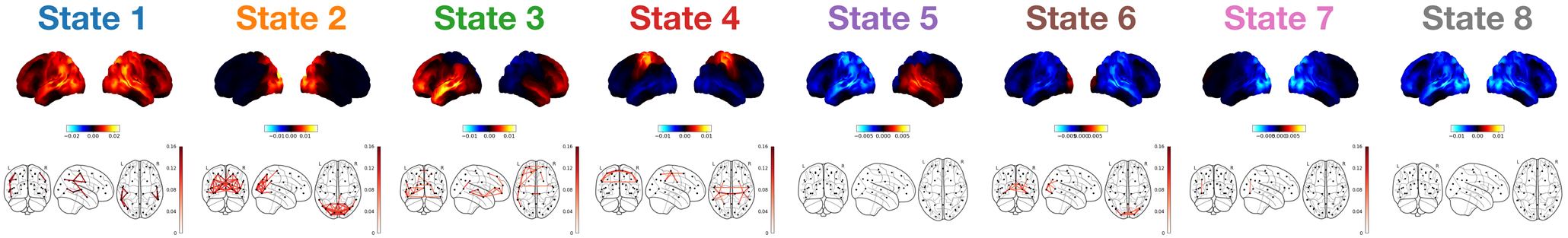


Brain Networks Dynamics

- What can you do with a dynamic brain network perspective?
  - Characterise individuals. E.g.

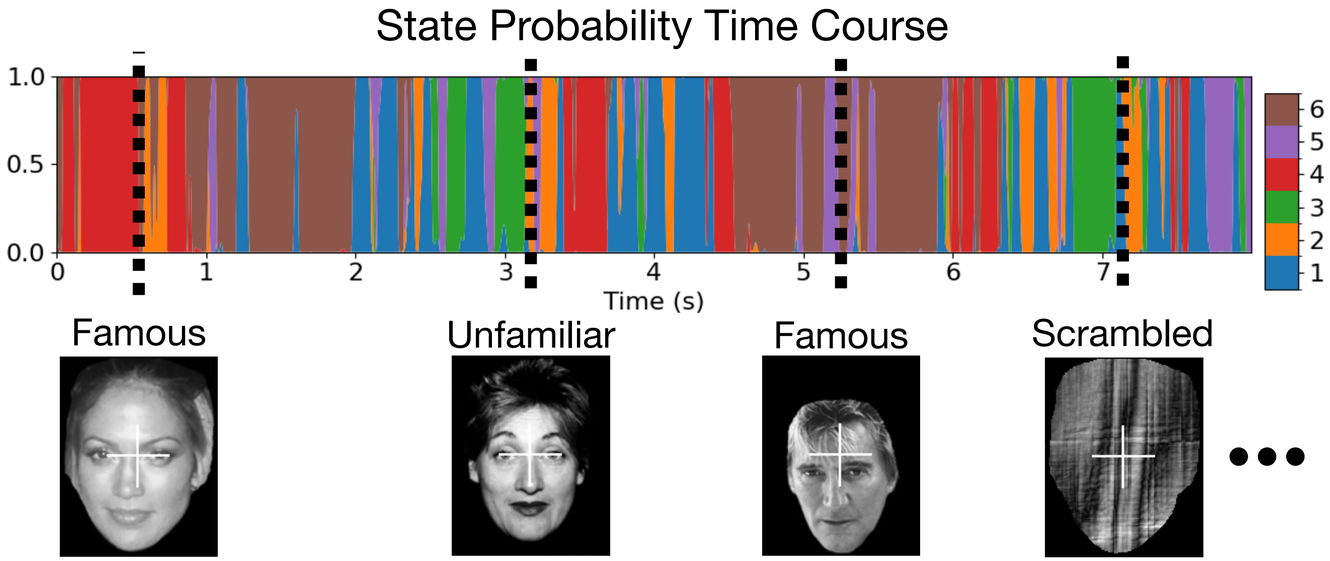


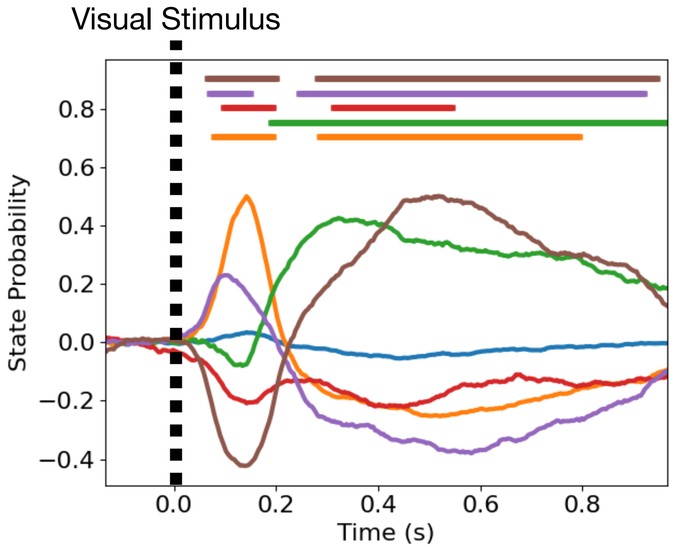


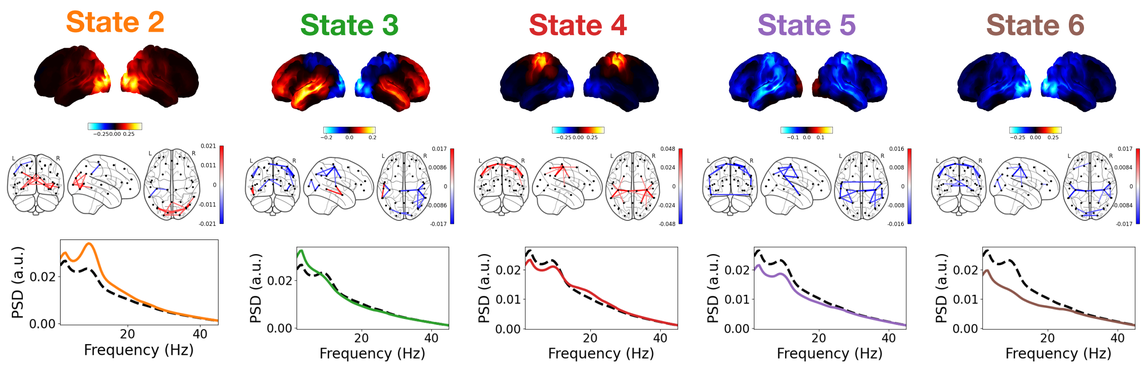


Brain Networks Dynamics

- What can you do with a dynamic brain network perspective?
  - See what's happening in response to a task:







Conclusions

- The skills I developed during my DPhil were very transferable.
- I found the transition to a new field to actually be a lot of fun.
- My day to day isn’t actually that different:
  - Coding scripts to analyse time series data.
- (I’d encourage anyone nearing the end of their DPhil to have a look around.)