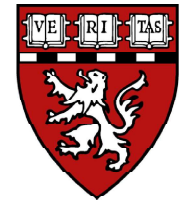


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Predicting neurosurgical outcomes in focal epilepsy patients using computational modelling

Nishant Sinha,

Justin Dauwels, Marcus Kaiser,
Sydney Cash, M. Brandon Westover,
Yujiang Wang, Peter N. Taylor

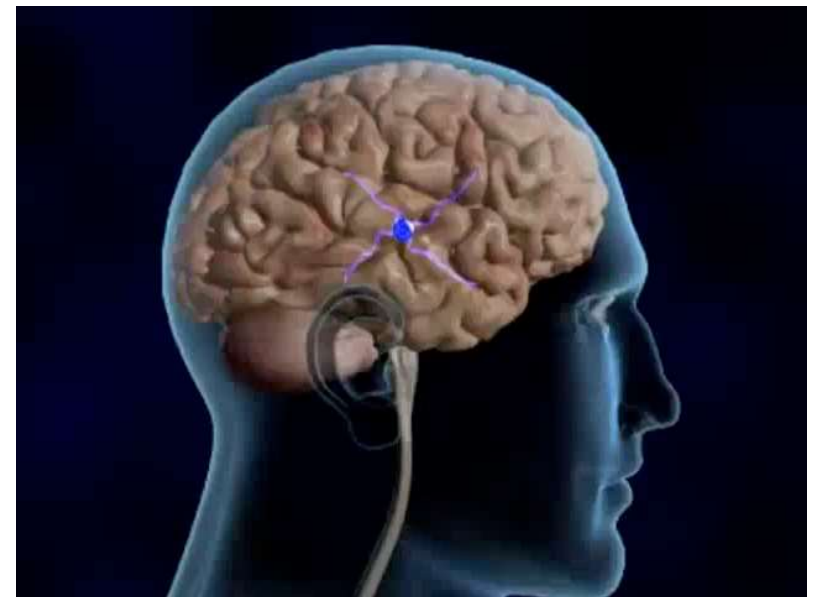
e-mail: n.sinha2@newcastle.ac.uk

Introduction

- **Epilepsy** is a neurological disorder characterised by recurrent **unprovoked seizures**.
- Approx. **50 million** people have epilepsy worldwide.
- For around 30% cases, seizures become intractable i.e. **poorly controlled by the anti epileptic drugs**.

Focal epilepsy

- Seizure onset can be **localised** to a particular brain region.
- **Surgery** is a viable option to control intractable focal onset seizures.

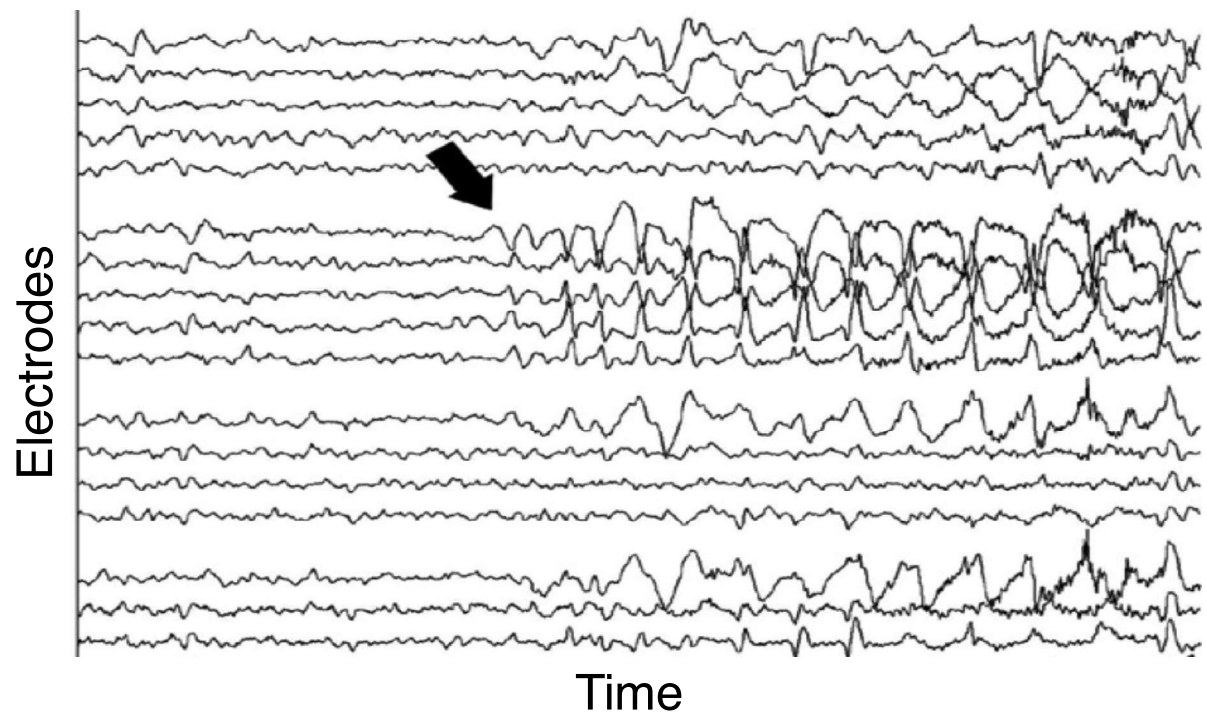
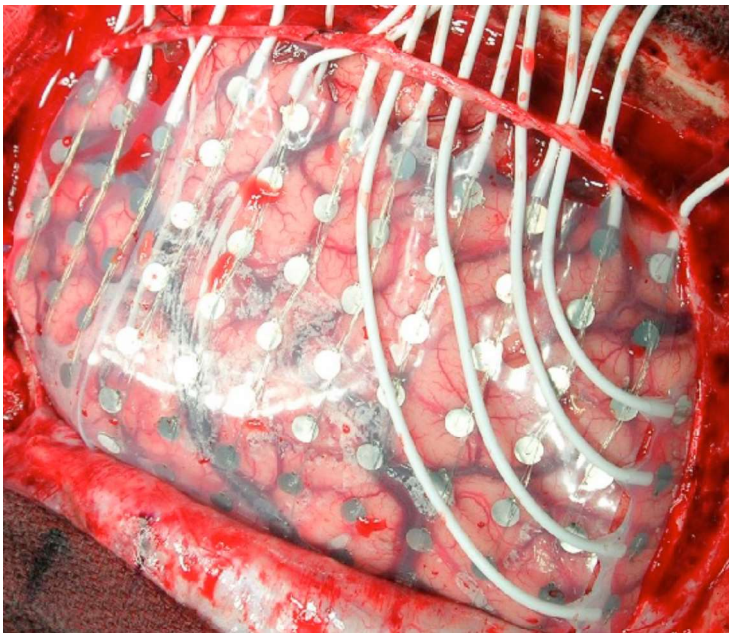


<https://www.youtube.com/watch?v=wV6eclai42Q>

Introduction

Main objectives in pre-surgical evaluation

- **Accurate delineation** of seizure onset and propagation area.
- Avoiding **eloquent cortex** i.e. crucial brain tissues (like language, motor)
- Often, among other brain imaging methods, electrodes are placed directly on the cortical surface for precise mapping of resection site.



Introduction

In a typical clinical setup,

- Seizure markers are determined by **visual inspection**
- **Multiple seizures** are allowed to occur for precise mapping
- **Prolonged invasive** recording, up to 7 to 10 days in some patients.

Seizure reoccurs after surgery

- Success rate in temporal lobe epilepsy approx. 60%.
- Epileptogenic lesion (dysplasia, hippocampal sclerosis) success rate is high.
- Success rate of surgery is poor in
 - MRI Negative or Non-Lesional epilepsy
 - Seizure originates in the extratemporal regions

Introduction

In a typical clinical setup,

- Seizure markers are determined by visual inspection
- Multiple seizures are allowed
- Prolonged invasive recording, up to 7 to 10 days in some patients

Can we predict the location of epileptogenic tissues any faster/better?

Seizure reoccurs after surgery

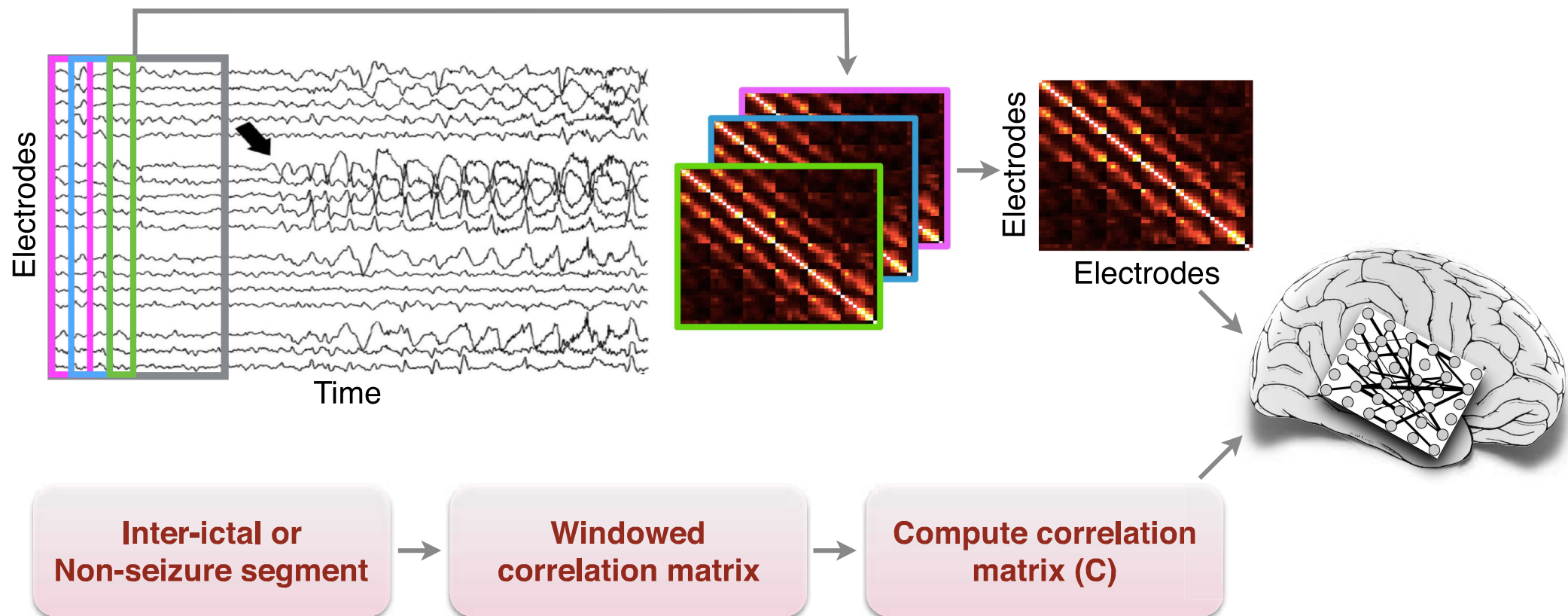
- Success rate in temporal lobe epilepsy approx. 60%
- Epileptogenic lesion (amygdala, hippocampus, etc.)
- Success rate of surgery
- MRI Negative or Non-Lesional epilepsy
- Seizure originates in the extratemporal regions

Can we predict the outcome of surgery to better inform clinicians and patients?

Method

Functional connectivity

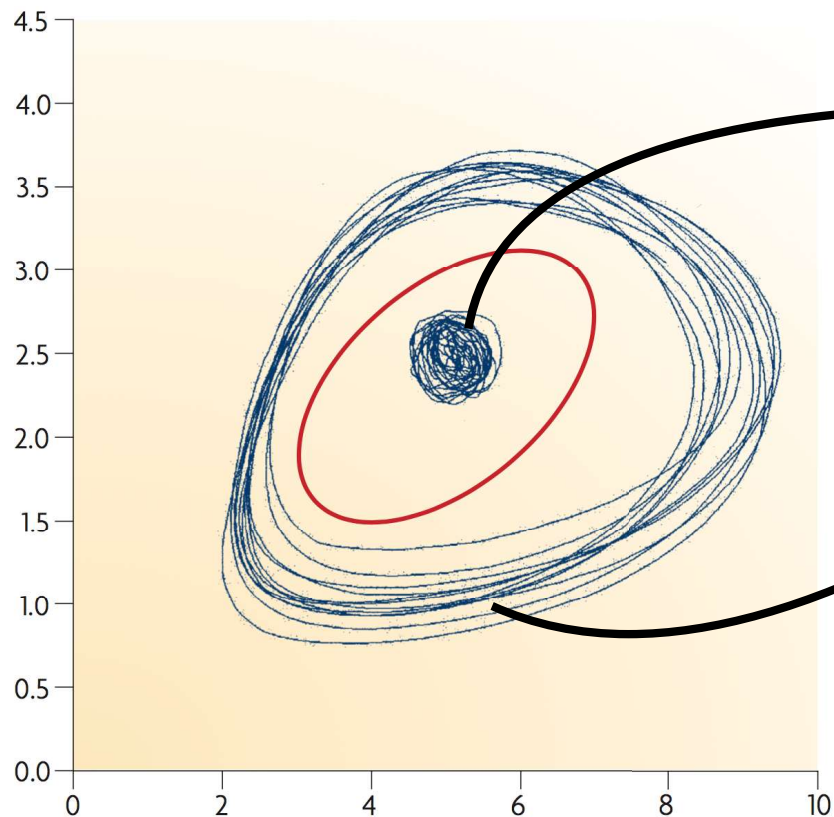
- Compute average cross-correlation from pre-processed **inter-ictal or non-seizure** ECoG segments (1s duration, 50% overlap)
- **Patient-specific** functional interaction between brain areas under each electrode.



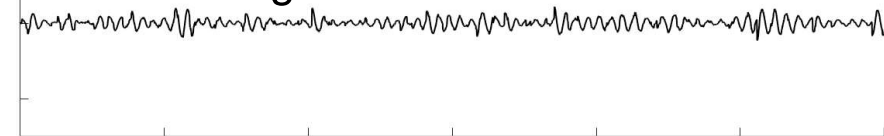
Method

Computational Model

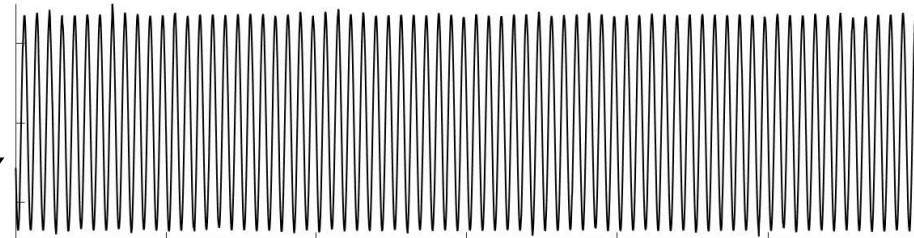
- Non-linear differential equations that place a node in a bistable regime (Lopes da Silva et al., 2003, Epilepsia).
- Dynamics at each node can exhibit transition between the two states.



Dynamics at fixed point
analogous to non-seizure state



Dynamics at limit cycle
analogous to seizure state



Transition between
non-seizure & seizure state

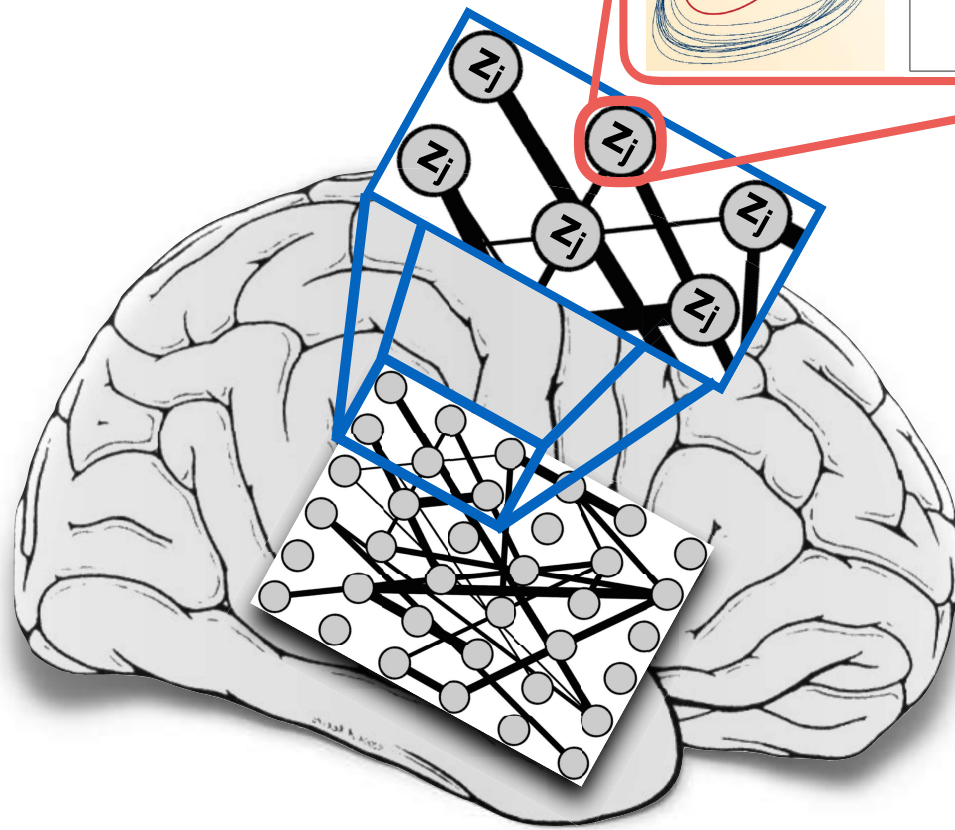
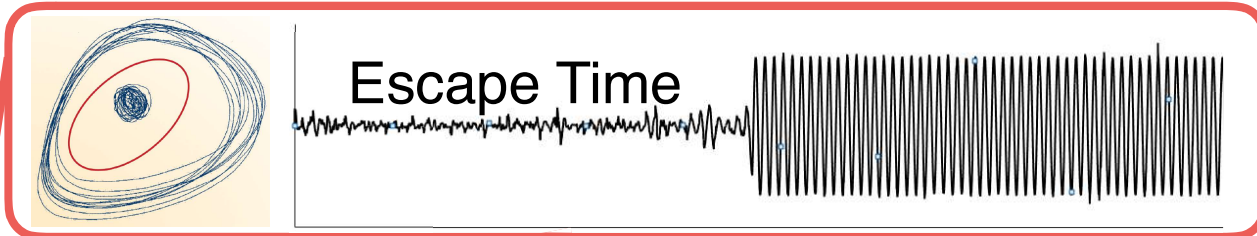


Fig: Bistable model
(Lytton et al., 2008, Nature Rev. Neurosc.)

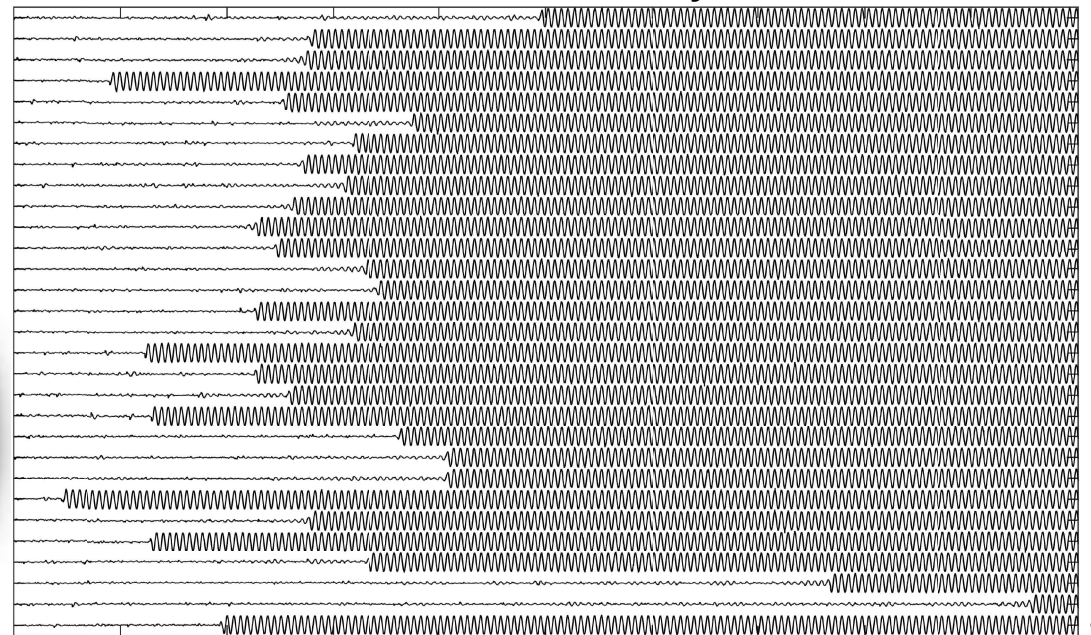
Method

Computational Model + Patient Specific Connectivity

- Consider each ECoG electrode as a node in a bistable regime and all nodes are connected by patient specific functional connectivity.
- **Seizure likelihood can be estimated using escape time**

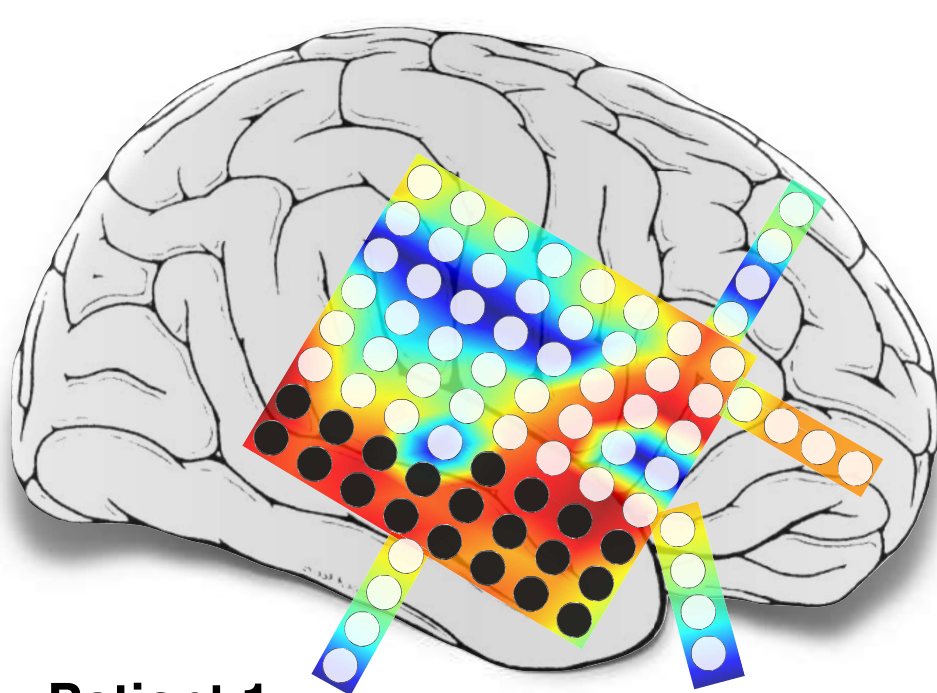


Simulated Network Dynamics

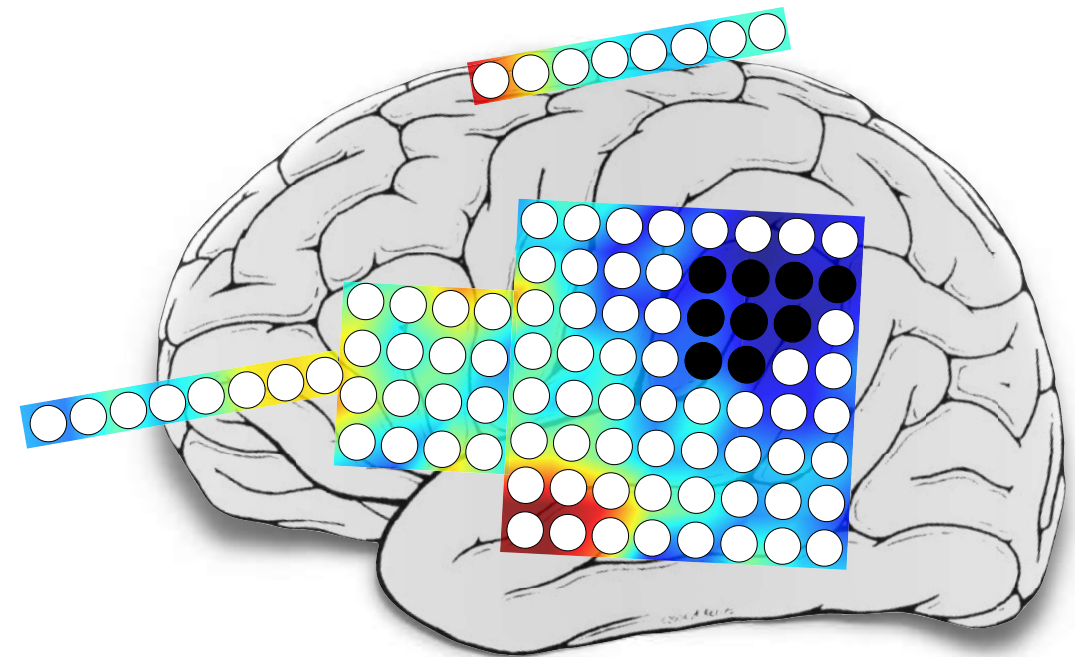


Result: Predicting location of epileptogenic tissues

- Applied this technique **retrospectively** to patients who had focal epilepsy and underwent surgery.
- Seizure likelihood from patient connectivity incorporated in computational model.



Patient 1



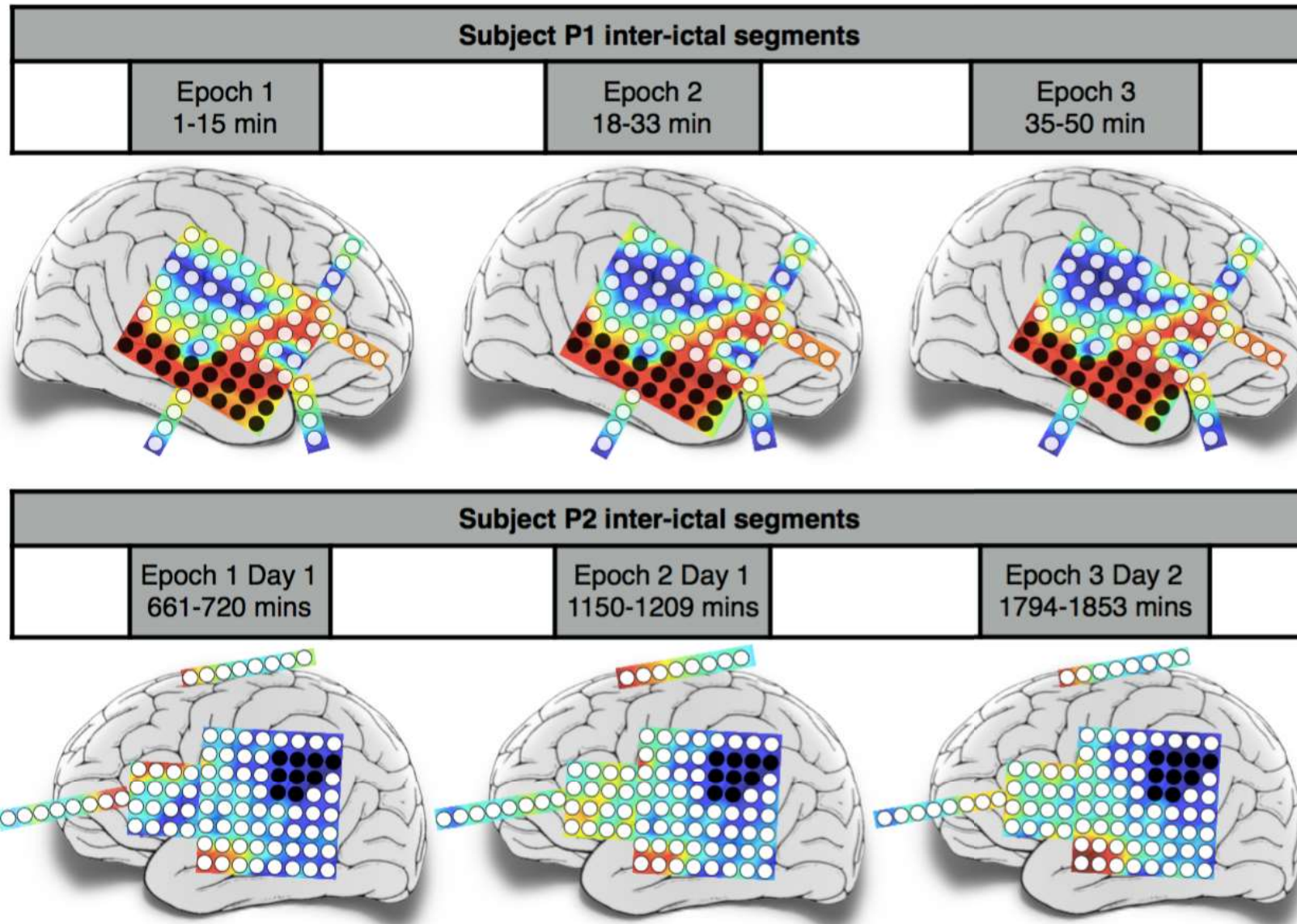
Patient 2

● Location of surgical resection

Low Simulated Seizure likelihood High

Result: Predicting location of epileptogenic tissues

- Consistent for different epochs of different duration.



Result: Predicting location of epileptogenic tissues

- Consistent for different frequency bands.

