Pre-operative Brain Mapping in Neuro-oncology with Graph Theory Analysis of the Functional Connectome

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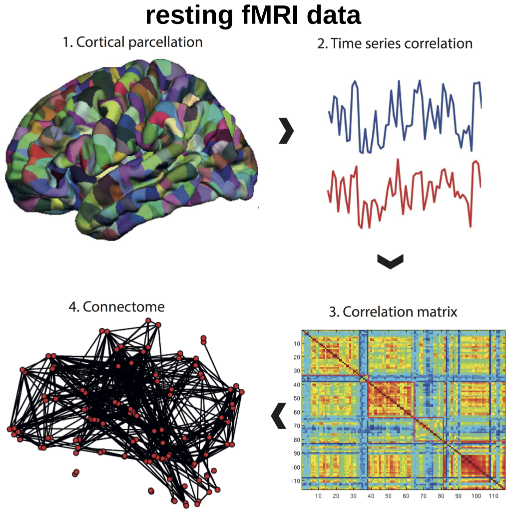
Introduction

Brain mapping has undergone a paradigm shift from functional localization to focusing on complex network connectivity. Central to this has been the search for the connectome or the brains wiring diagram. Modelling the effects of focal lesions using graph theory allows consideration of how important a region is to network function and the effects of its removal. Our aim is to determine the feasibility of applying the connectome to surgical planning in neurosurgery.

Methods

Resting state fMRI at 3T was performed with multi echo independent component analysis pre-operatively on 5 participants with glioblastoma in the right temporal-parietal-occipital region.

Constructing a connectome from resting fMRI data

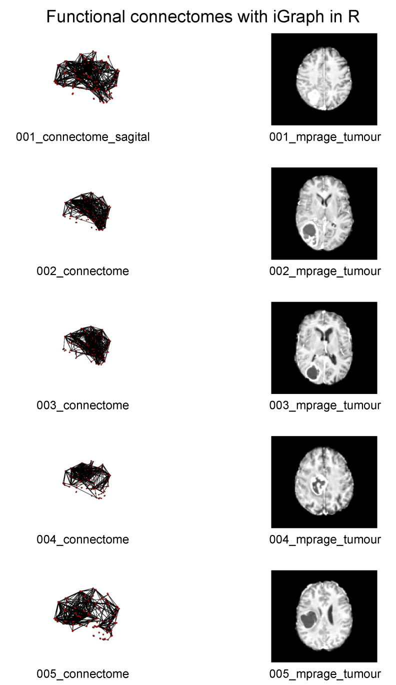


We used an anatomical 116 region template (AAL116), Pearson correlations, and binary thresholding for our matrices.

Results

Our connectome analysis identified ubiquitous small world features, as found in other complex networks, which parsimoniously balances functional localization and network connectivity. Our networks are generally robust to injury but have a core of highly connected and integrated hubs with disproportionate vulnerability. Tumours produced both local and distant effects in terms of reduced connectivity and network fragmentation.

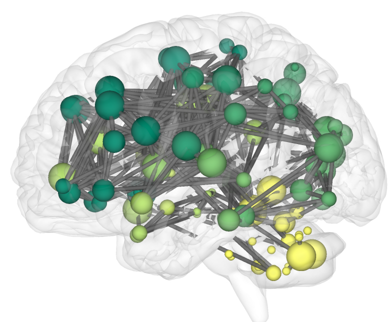
Connectome 'wiring diagrams' and corresponding anatomical images



Conclusions

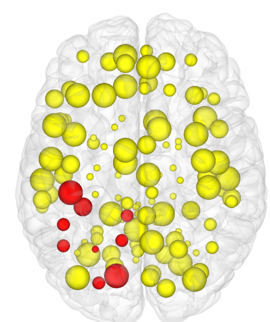
Connectome analysis is a novel and promising approach to pre-operative surgical planning. Mapping of hubs, robustness, and network connectivity offer potential for understanding plasticity and how cognition is affected by and recovers from real lesions.

Connectome on a surface rendering



Node colours represent different anatomical modules and sizes represent the number of connections

Information centrality



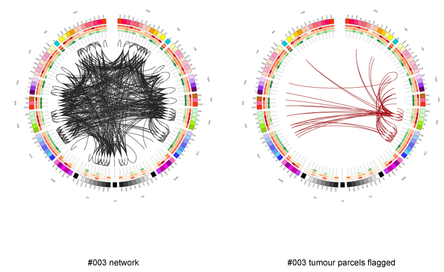
Nodes next to the tumour are highlighted in red. Size represents the effect that removal of a node will have on network efficiency.

Learning Objectives

By the conclusion of this session, participants should be able to:

1) Describe the relevance of the connectome to understanding modern neuroanatomy.
2) Understand how to construct and analyse the connectome from resting state fMRI data using graph theory.
3) Realise how a network based approach of brain mapping focusing on highly central 'hubs' and vulnerable areas can be used to guide surgical resection.
4) Recognise how modelling simulated dynamics on networks can improve our understanding of processes such as seizure propogation, cortical stimulation, or extra-lesional resections.

Circular connectome maps



A complete wiring diagram with areas immediately adjacent to the tumour ("connections at risk") highlighted in red