

# **Network Neurosurgery: Trajectory**

**Michael Sughrue, MD**

# Disclosure

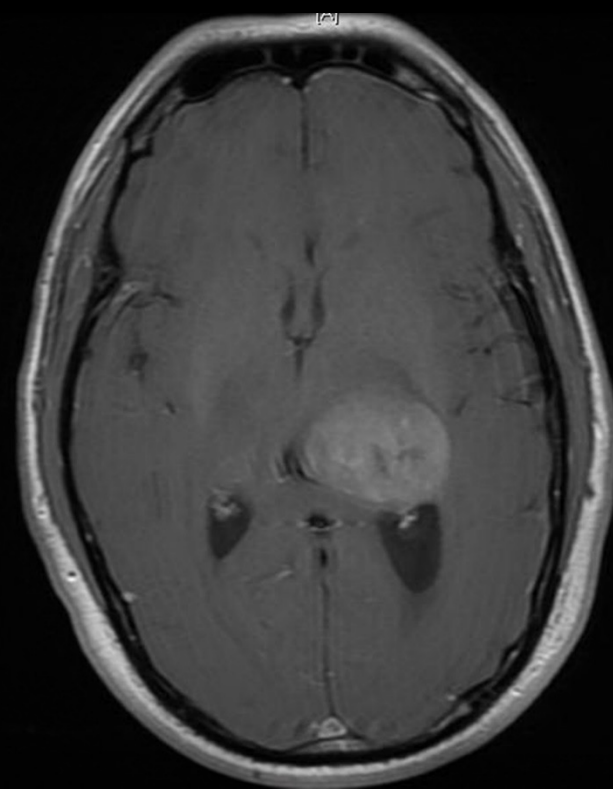
- **Founder and CMO, Omniscient neurotechnology**

# Disconnection vs Trajectory

Disconnection

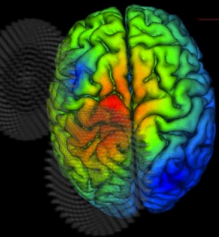
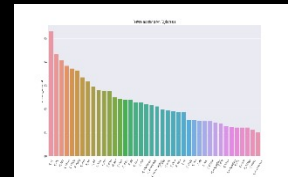
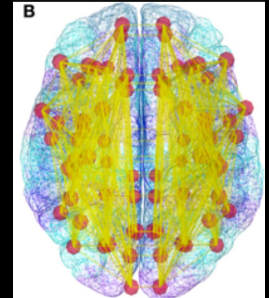
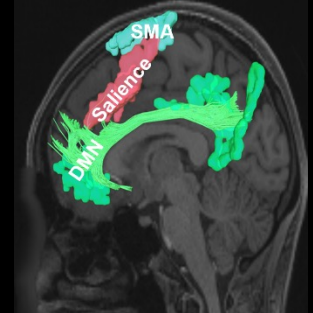


Trajectory



# Paths towards reducing cognitive footprint

1. Preserve the core of networks whenever possible
2. Consider the full brain ramifications of the action
3. Move our thinking towards individual circuits
4. Consider the possibility that we can change the connectome

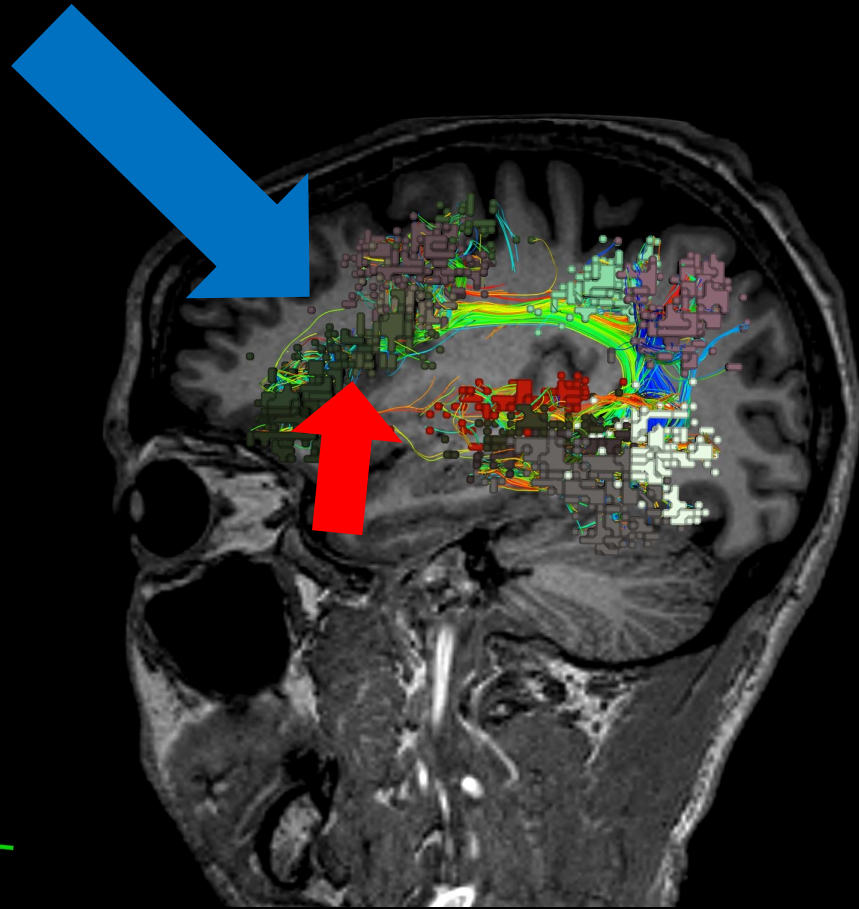




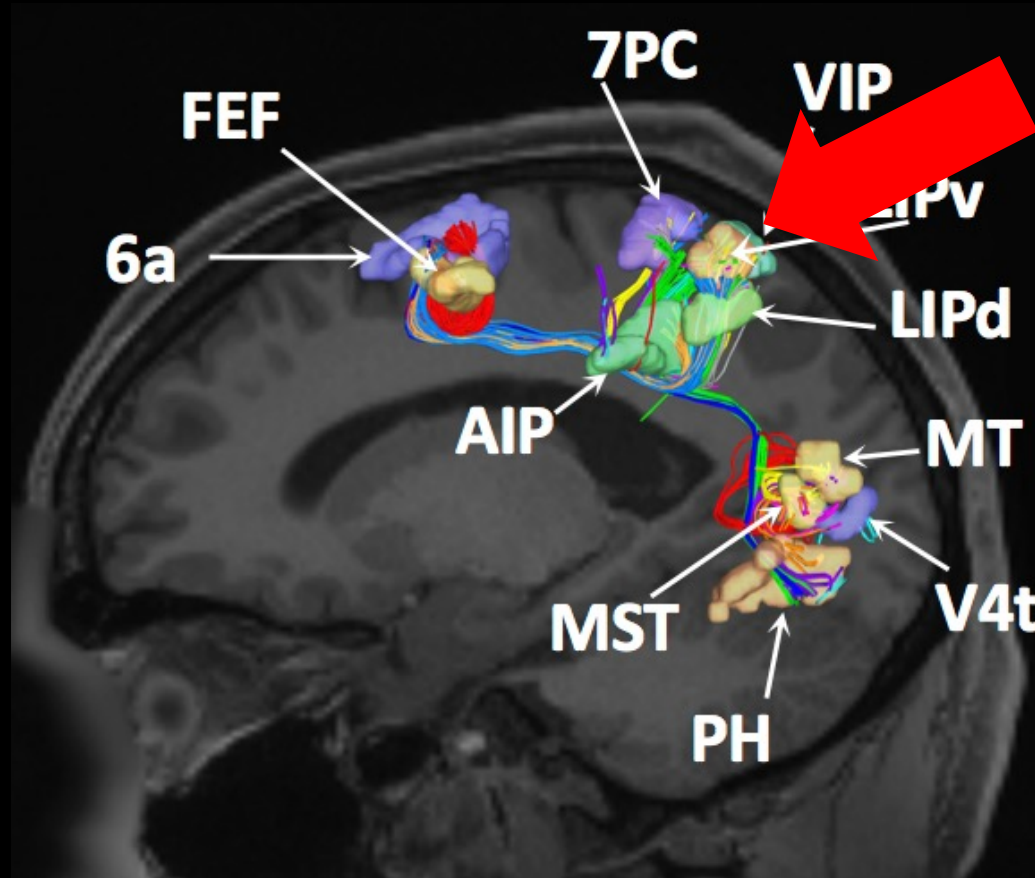
# **Network Principles of a good trajectories**

- 1. No patient cares about white matter, they care about function, Networks are function**
- 2. 2mm of cutting through a network is worse than 2cm of cutting a non-network**
- 3. Don't transgress a hub on the way in**
- 4. Work downward, not backward as much as possible**

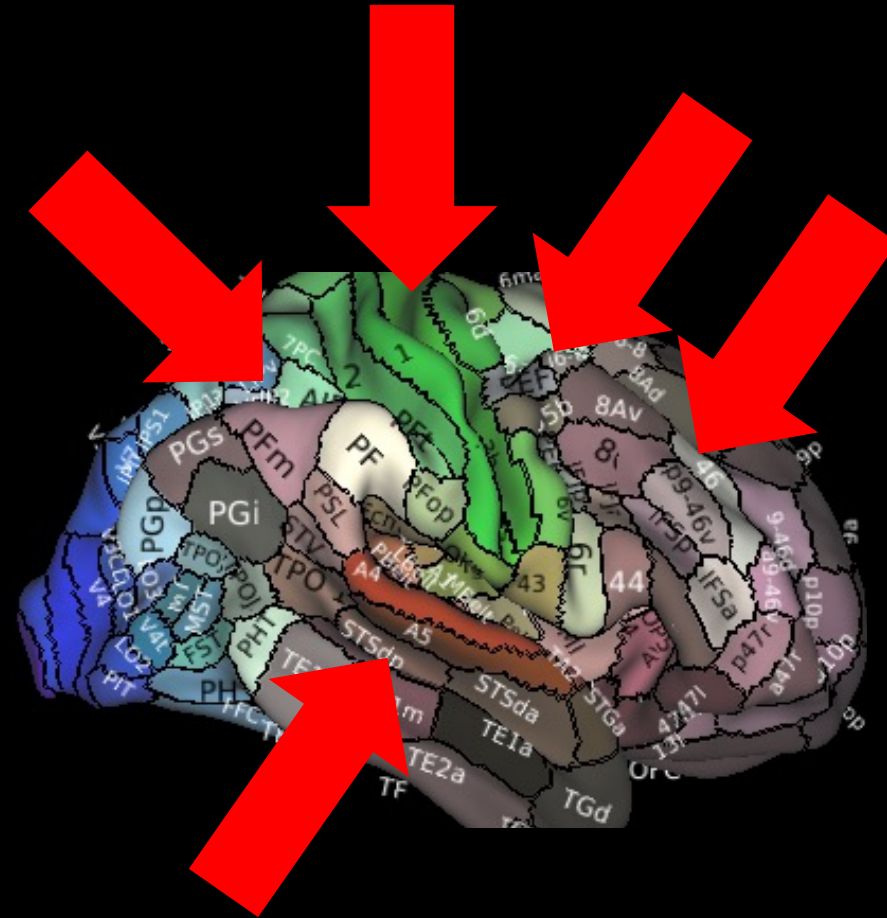
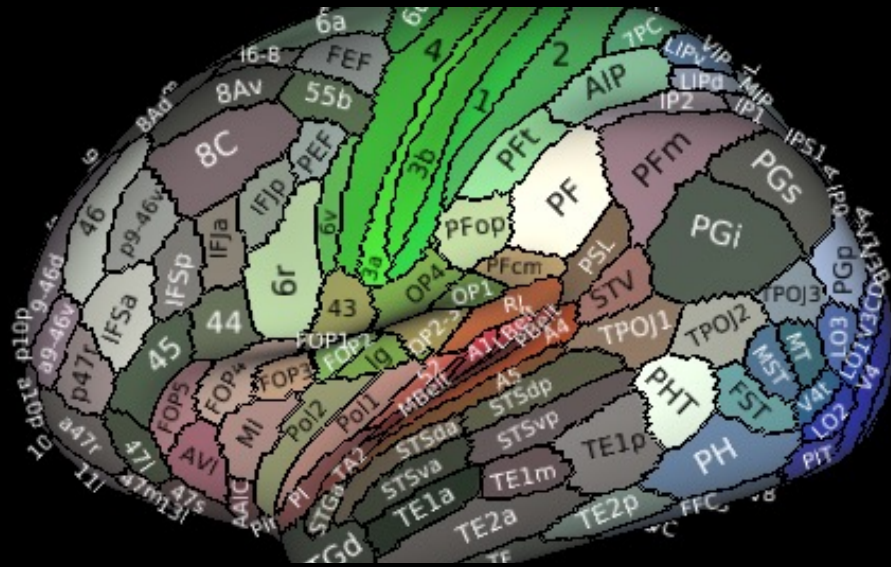
# Shorter isn't always better



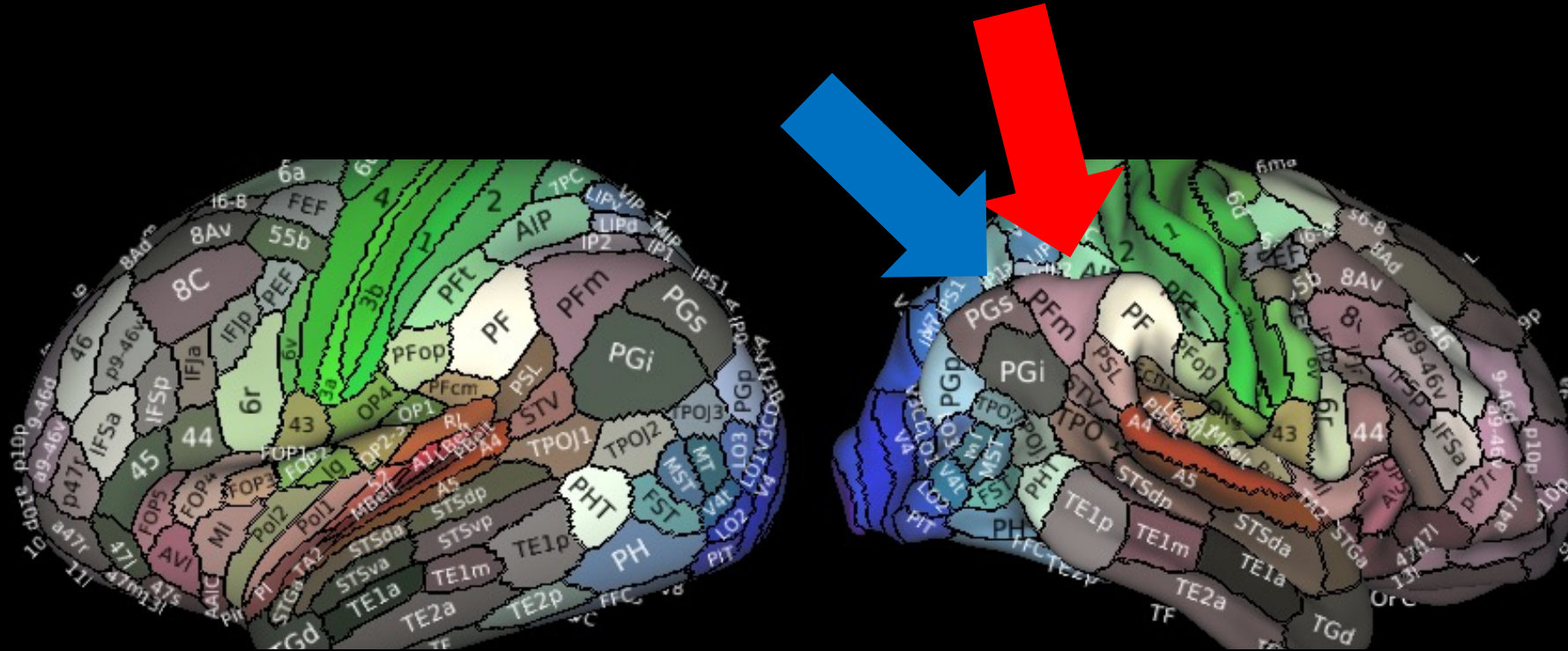
# Sulci are only sometimes better than gyri



# Sulci are only sometimes better than gyri



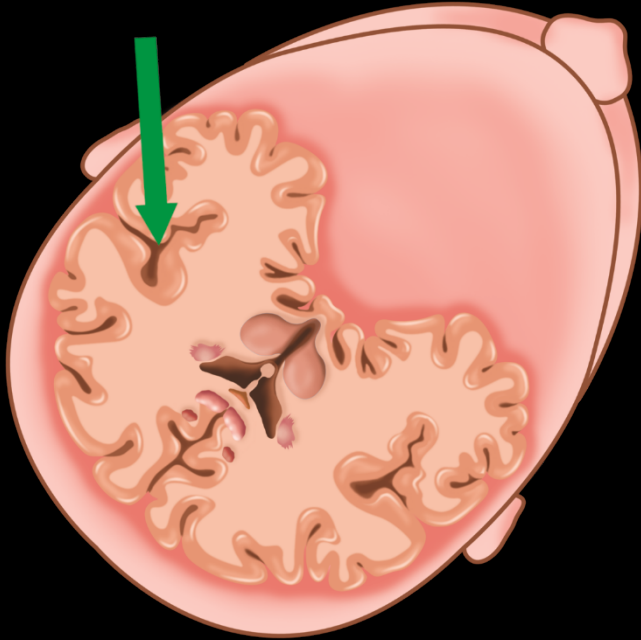
# Sulci are only sometimes better than gyri



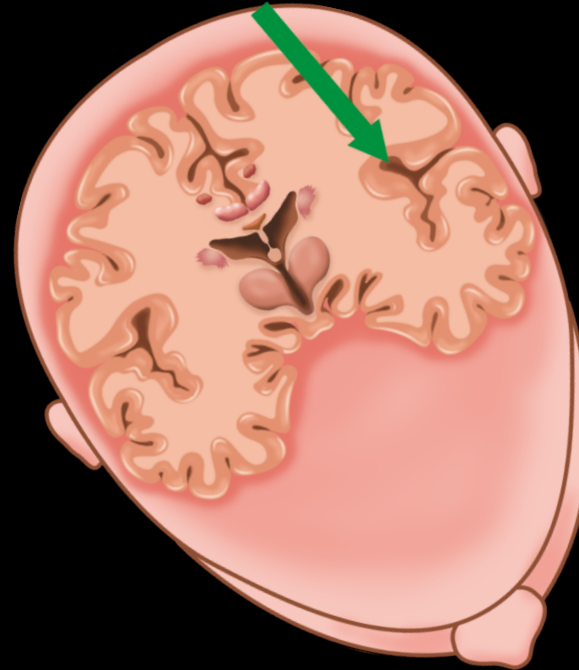


# Work downward, If possible

## Hard



## Easy



**Heroic efforts to avoid cutting brain, are often met with unheroic postop scans**

- Disorientation**
- Awkward angles**
- Unclear boundaries**
- Major blindspots**

**Brain surgery is hard, don't make it harder**  
**Use network anatomy to not cut bad brain**

# Hubs: why we should avoid them



# Cognition is a mixing of networks

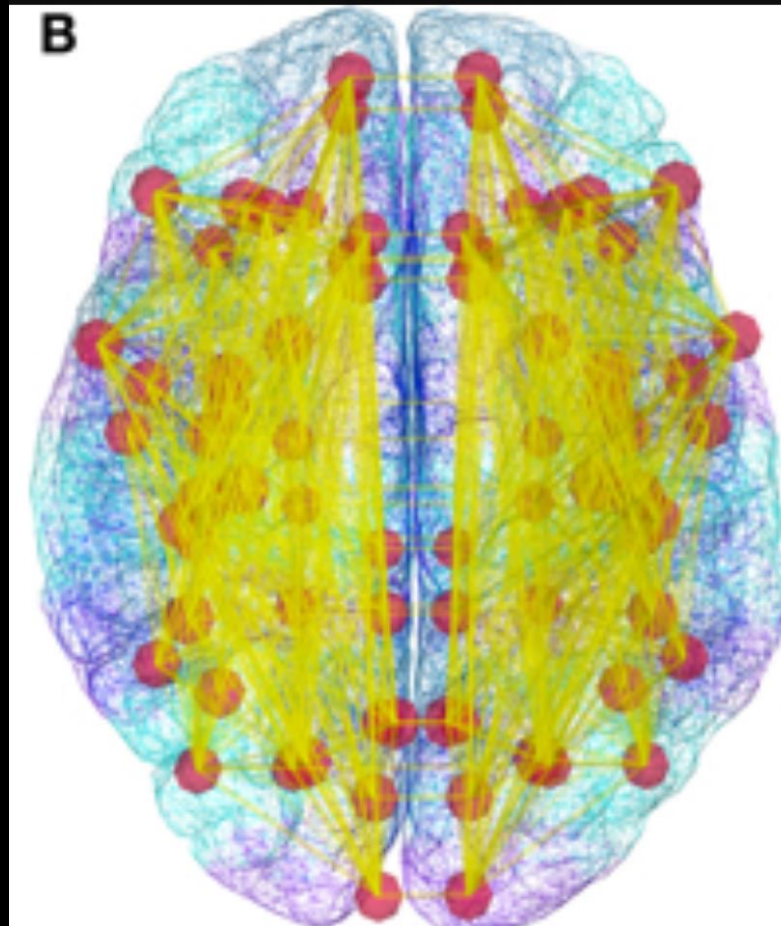
- **Math**

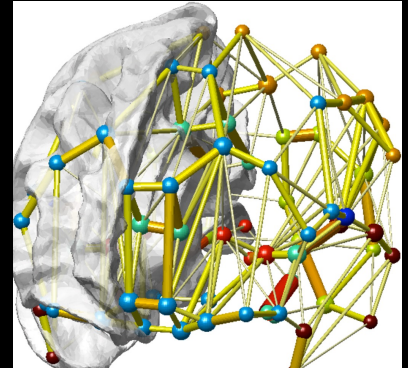
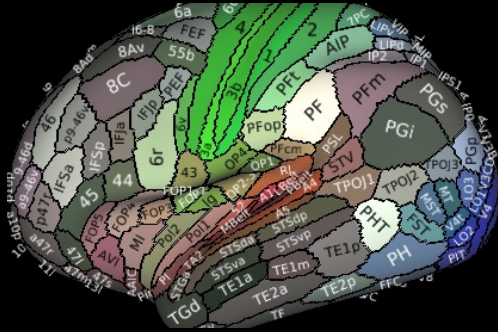
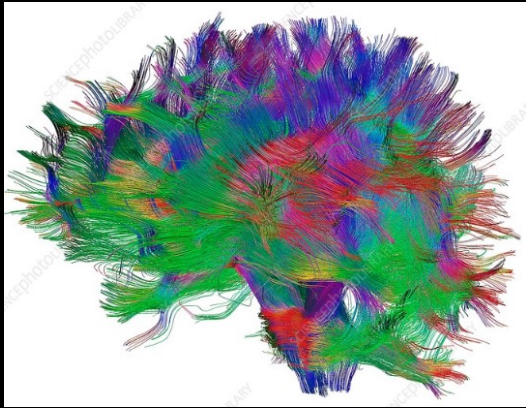
- **Visual**
- **Semantic system**
- **Motor**
- **DAN**
- **The white matter which links it**

## Math core

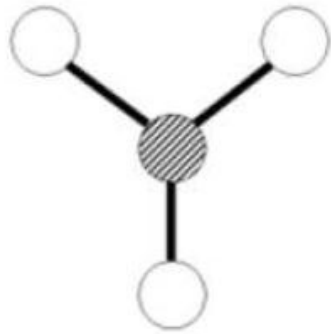


# Graph Theory

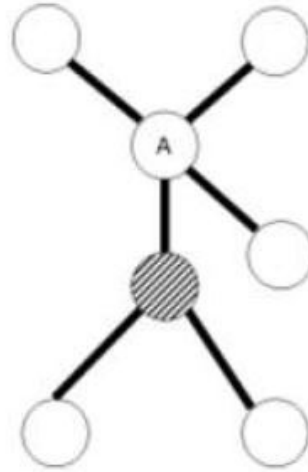




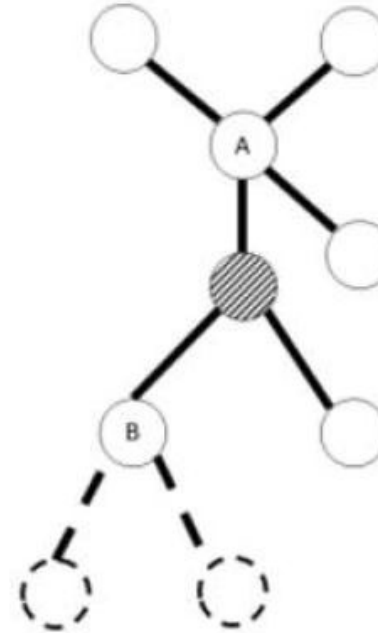
# Centrality measures



Degree




Eigenvector centrality



PageRank centrality

# What does “Eloquence” Really mean?



ROIs PR	
V1	1.5
V2	4
6r	9
TGd	9
V3	11
4	12.5
RSC	14
V3A	16
2	17.5
8C	21



## Unexpected hubness: a proof-of-concept study of the human connectome using pagerank centrality and implications for intracerebral neurosurgery

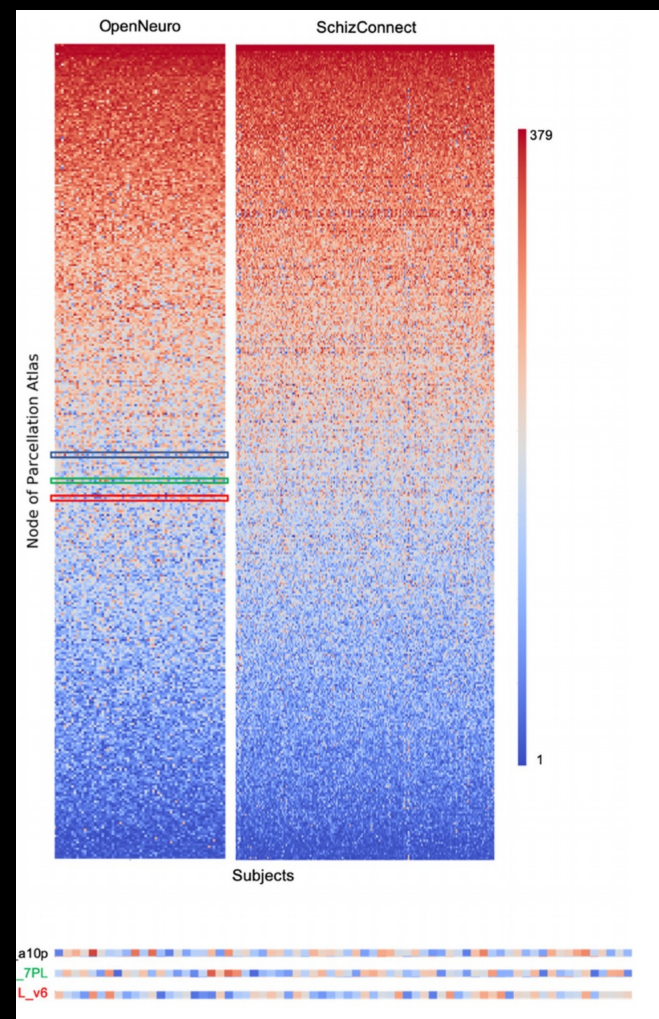
Jacky T. Yeung<sup>1</sup> · Hugh M. Taylor<sup>2</sup> · Isabella M. Young<sup>3</sup> · Peter J. Nicholas<sup>2</sup> · Stéphane Doyen<sup>2</sup> · Michael E. Sughrue<sup>1,2</sup>

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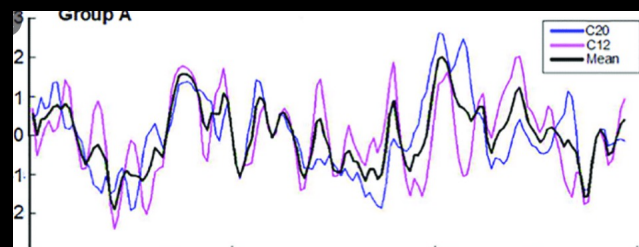
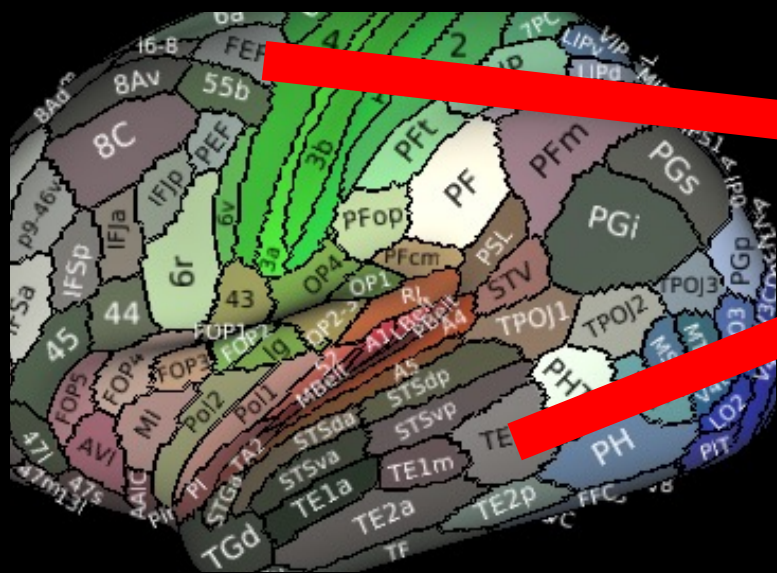
Most connected

Least connected



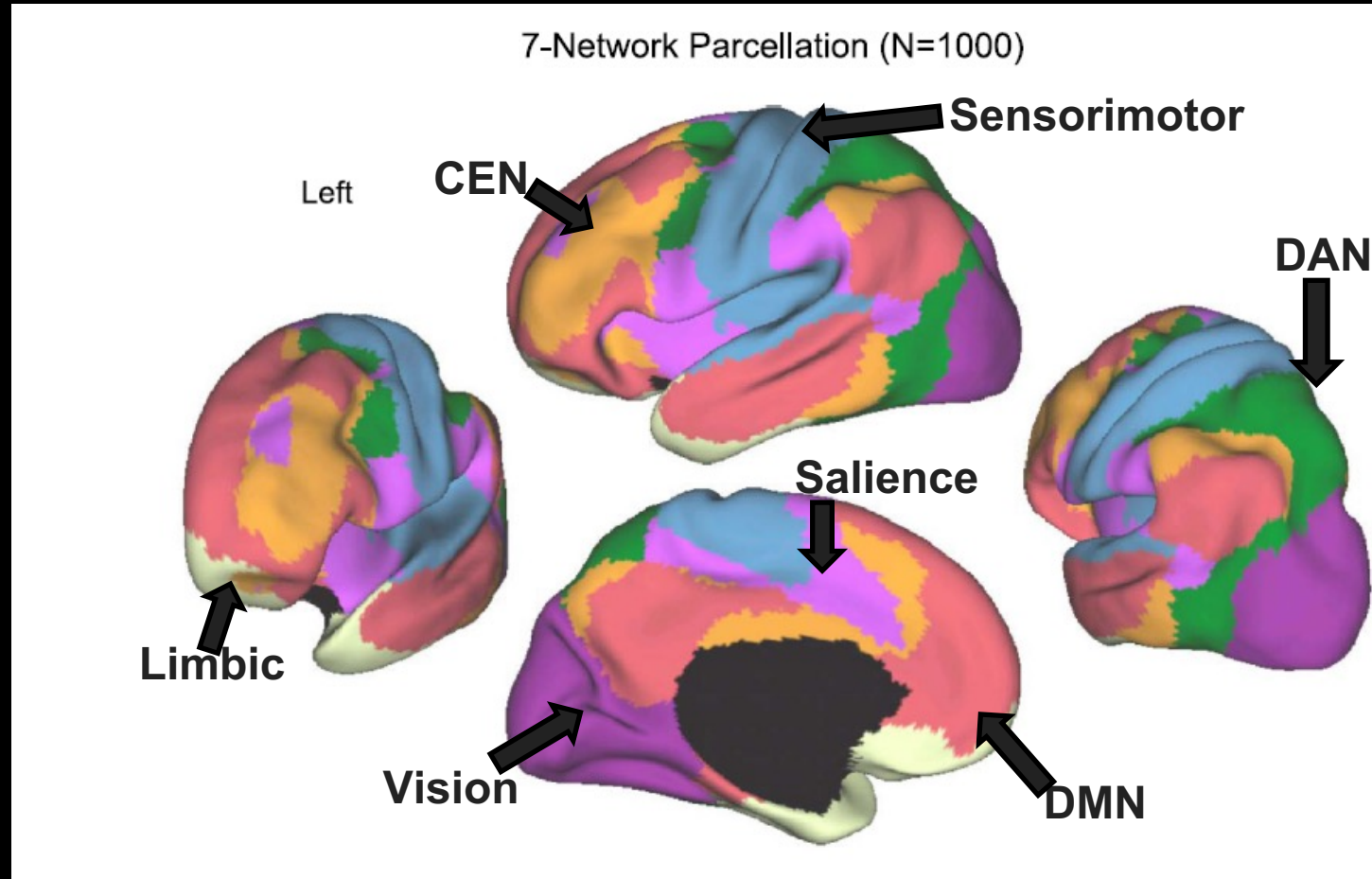
# The Main Networks

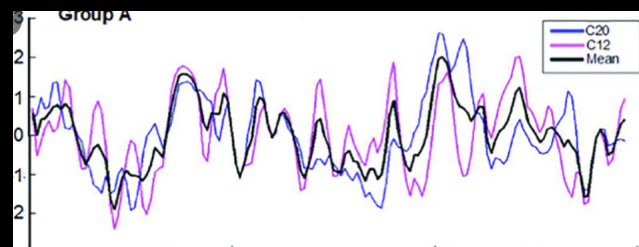
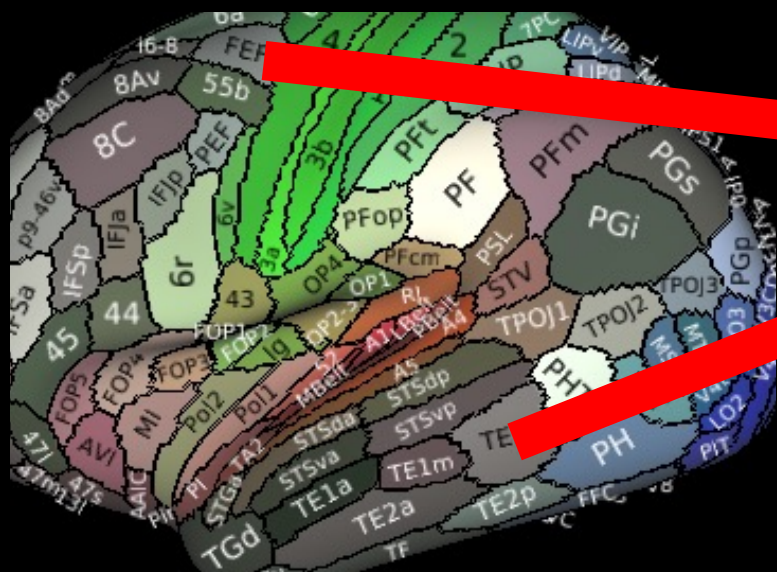




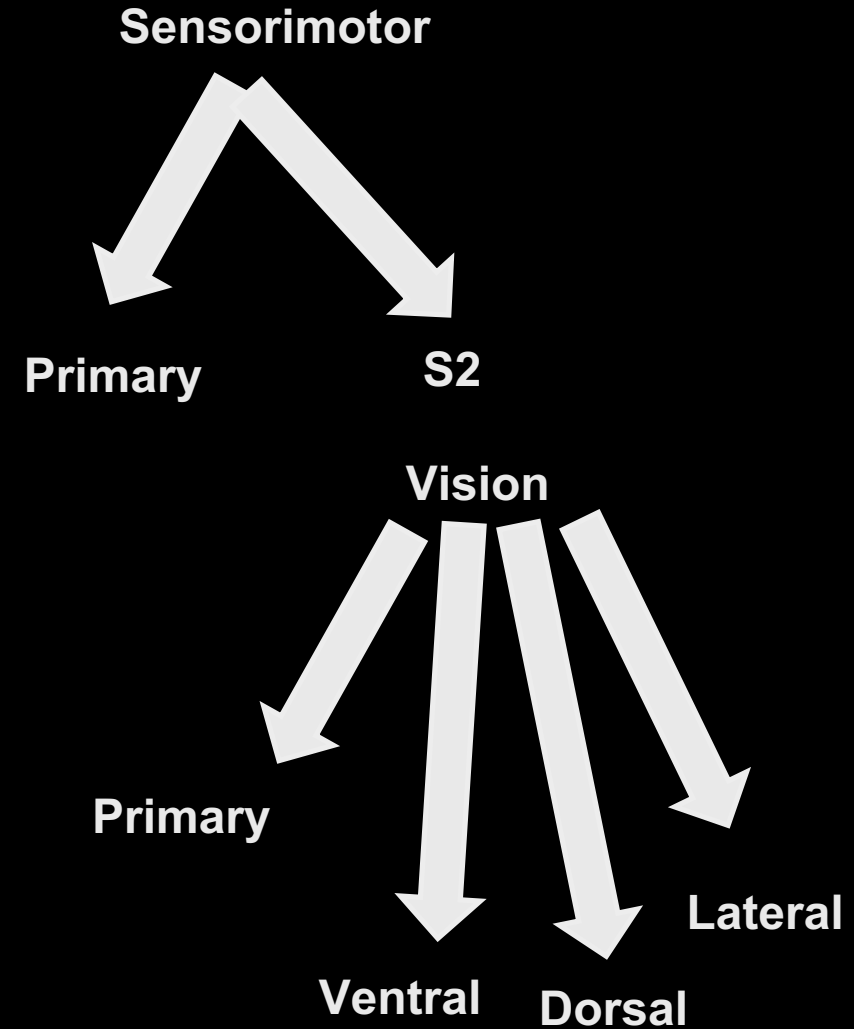
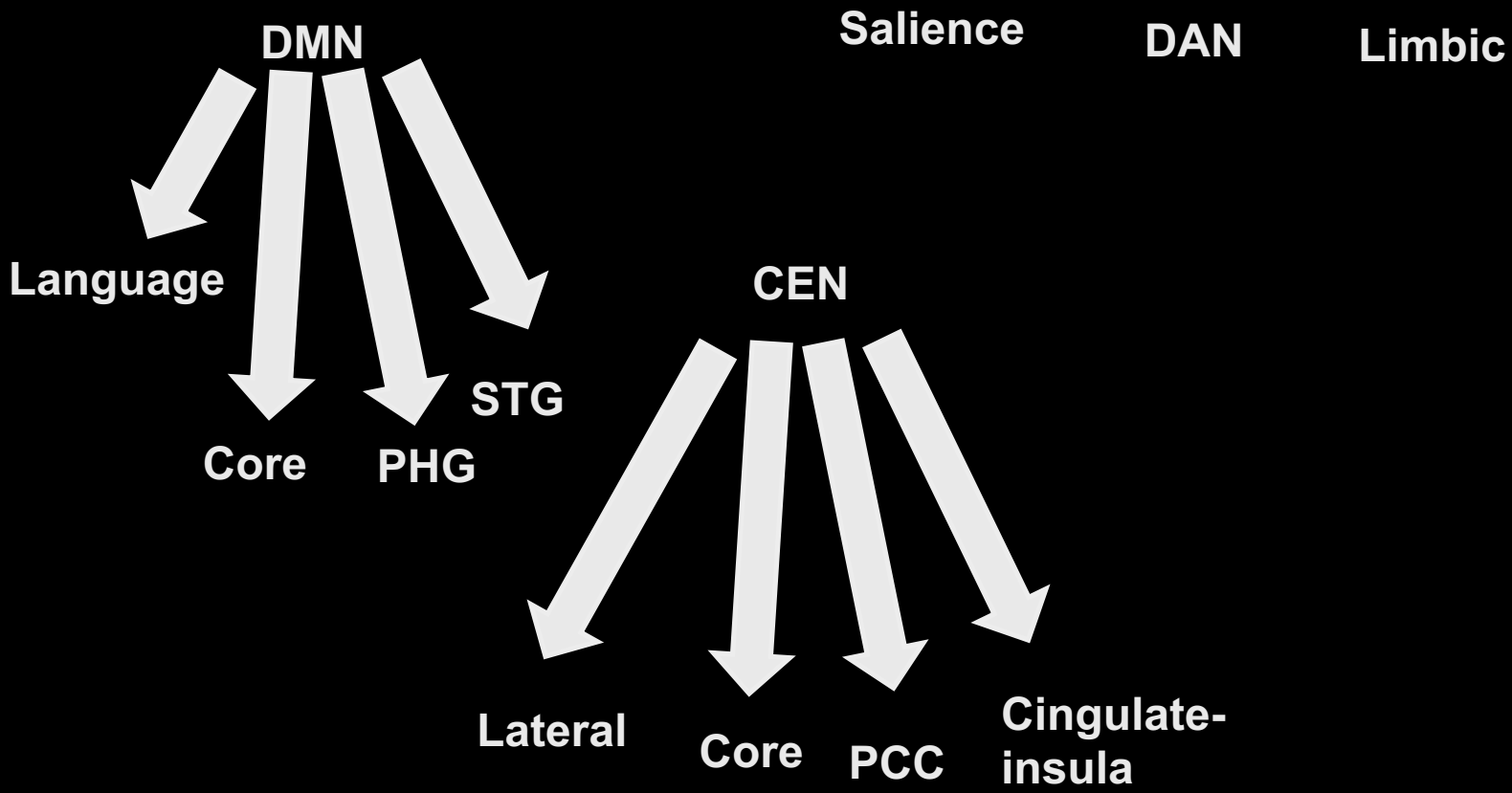


# 7 Main network



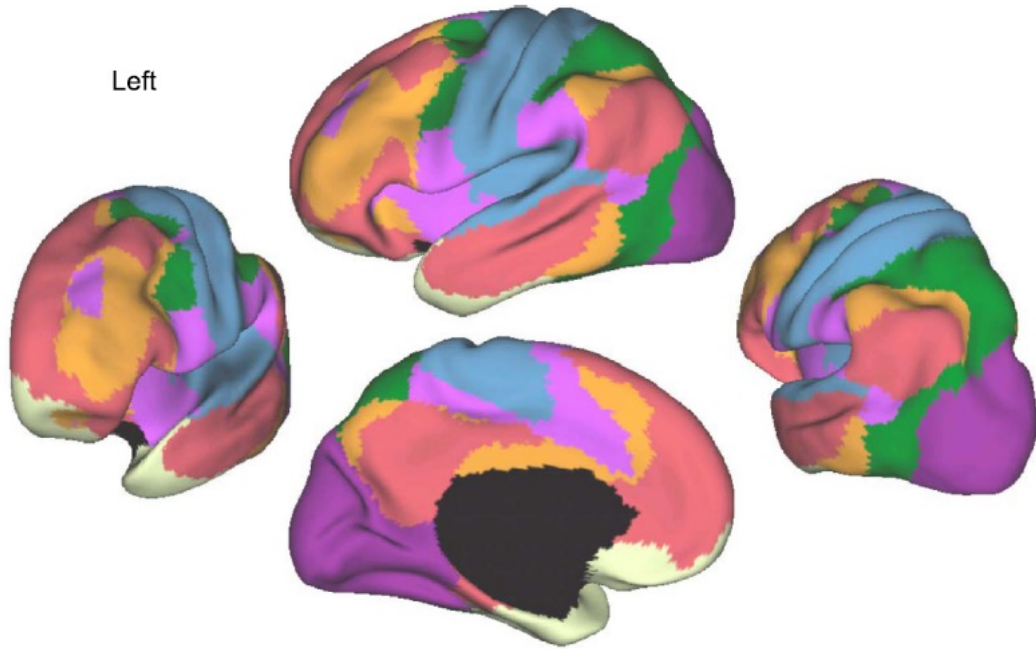


# Network Can be divided



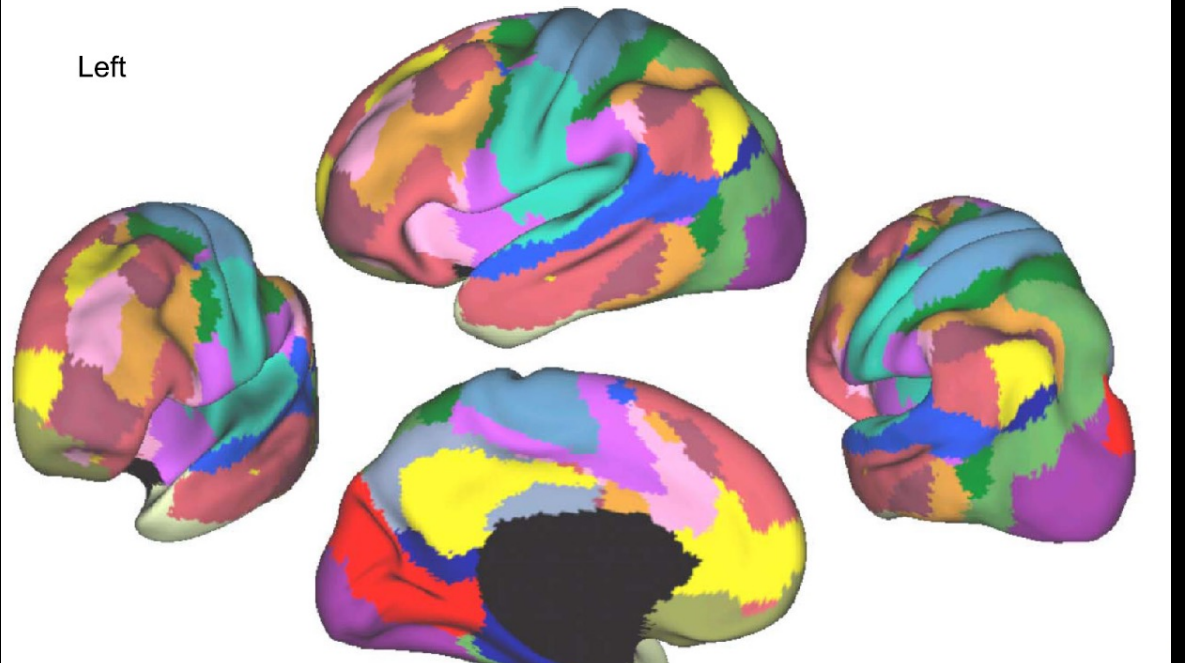
# 7 network

Left



# 17 network

Left

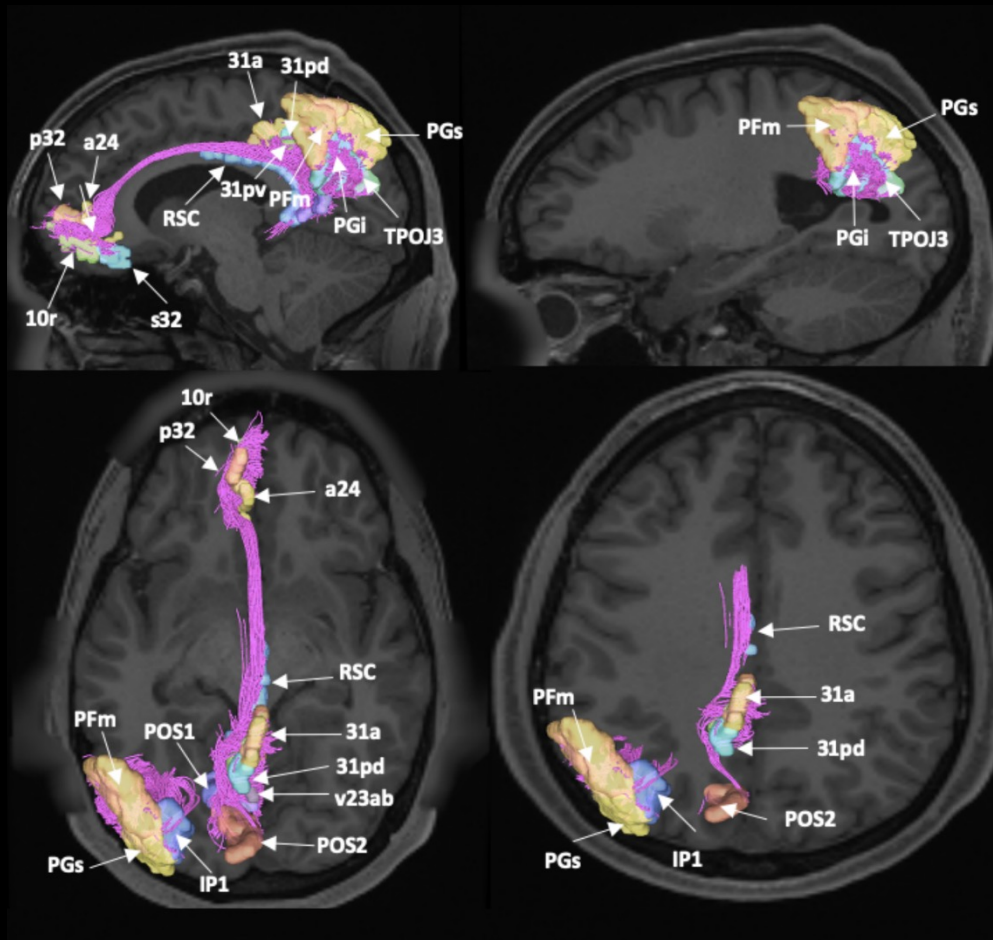


# Mixed networks

- Multiple demand
- Ventral attention network (right only)

# Making network decisions

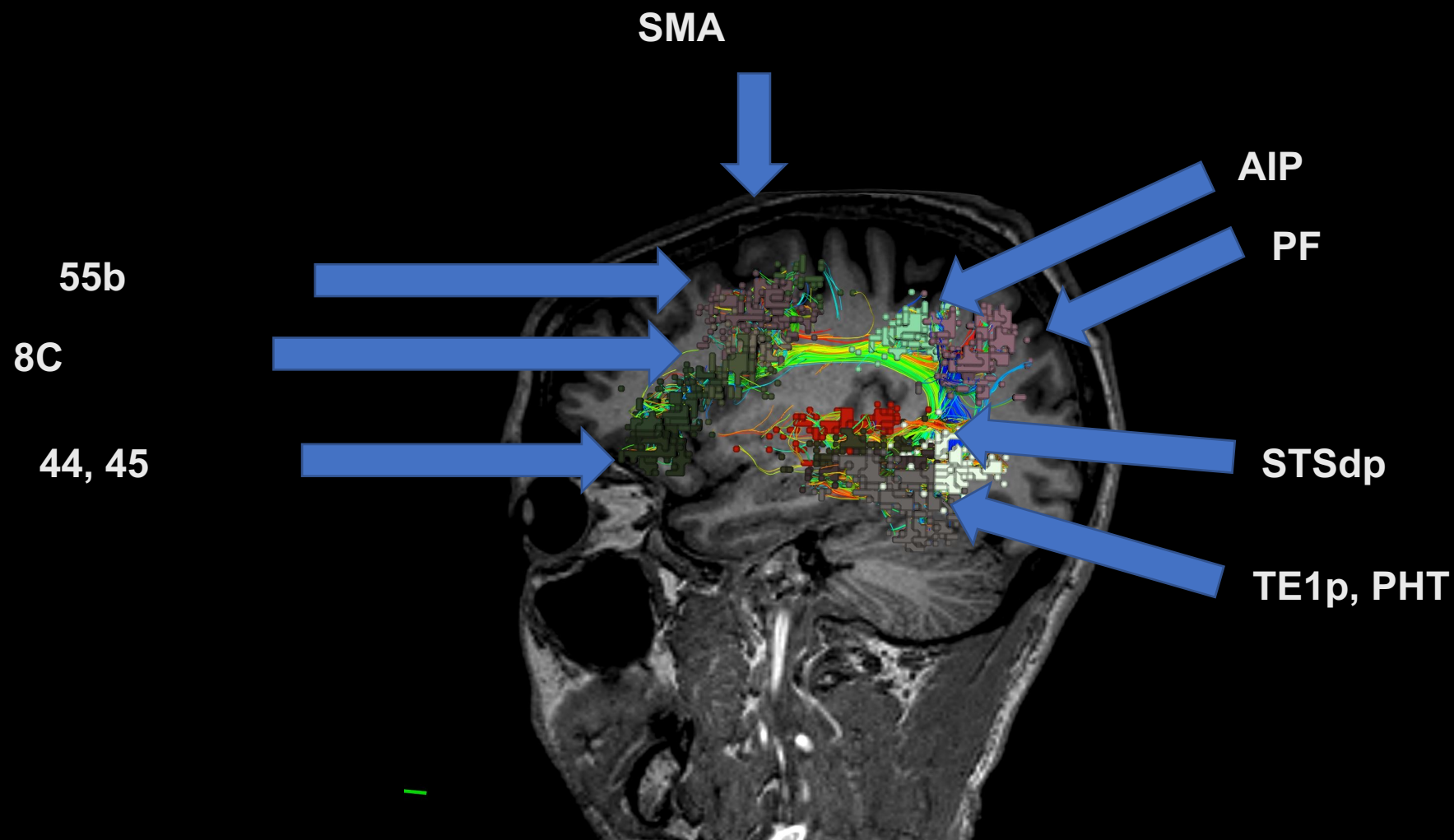
- Focus on the core
- Is it a good trade?
- Is it salvageable?



## DMN

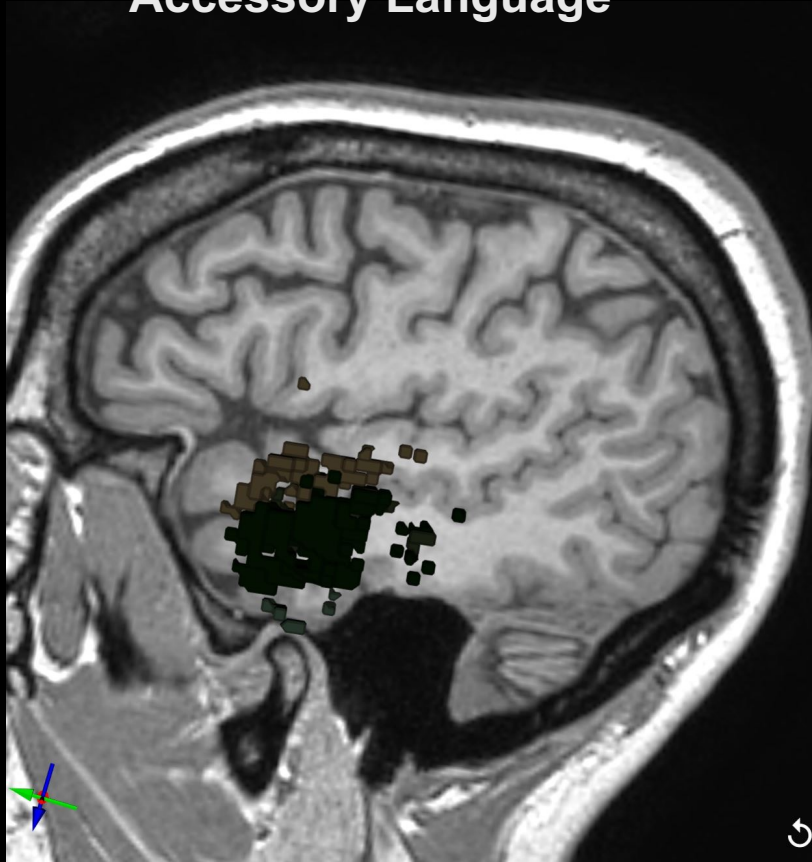
- Theory of Mind
- Internal thought
- Imagination
- Most mental illnesses
- Much, much more

# Language System- Speech



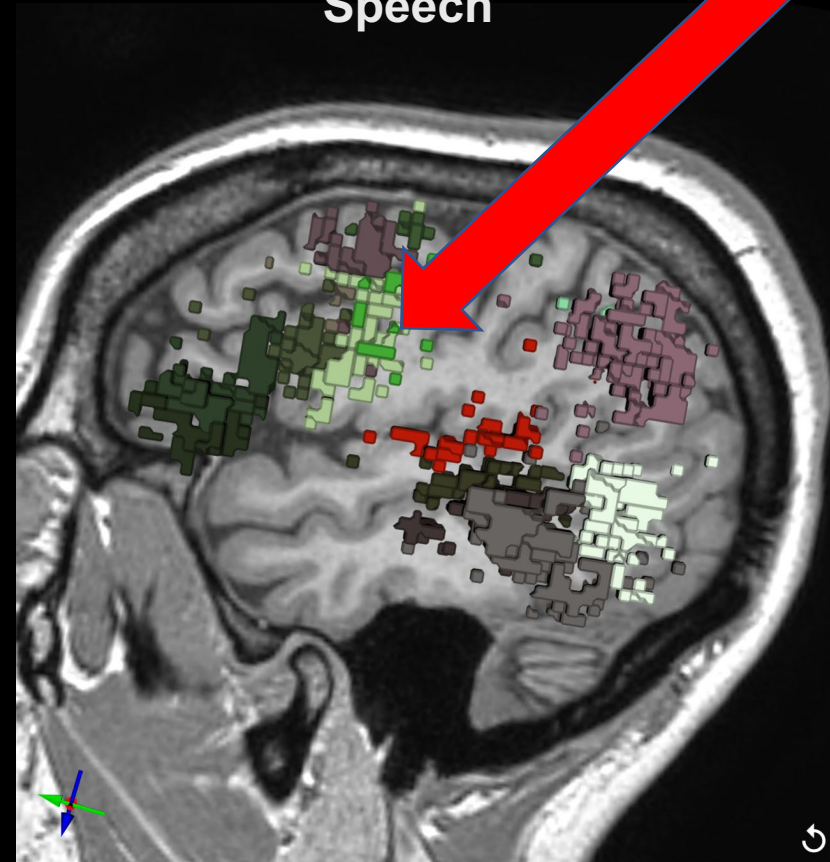


Accessory Language



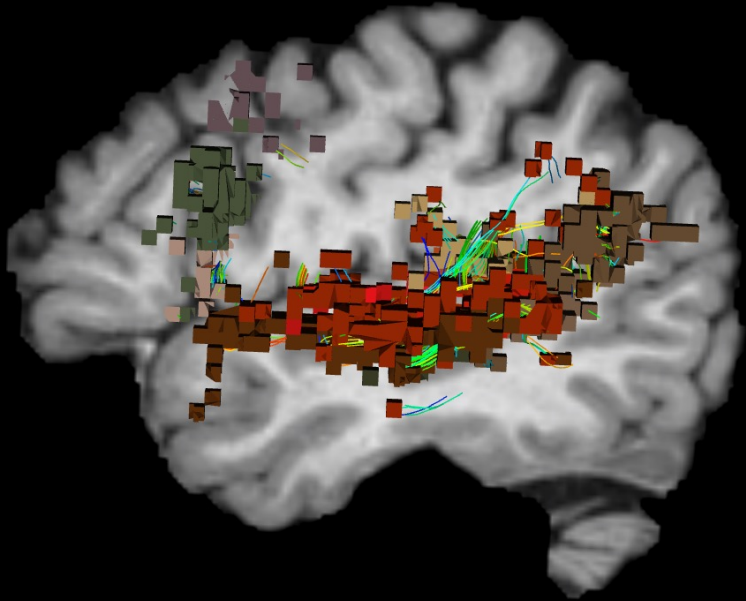
Verbal memory

Speech



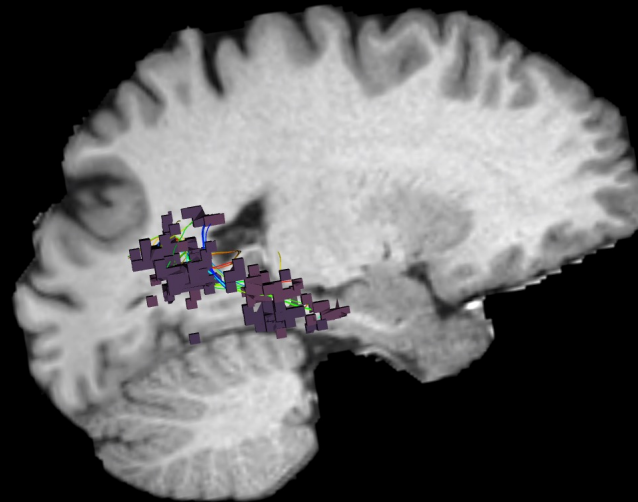
Speech Arrest

**Auditory**



**Auditory Processing**

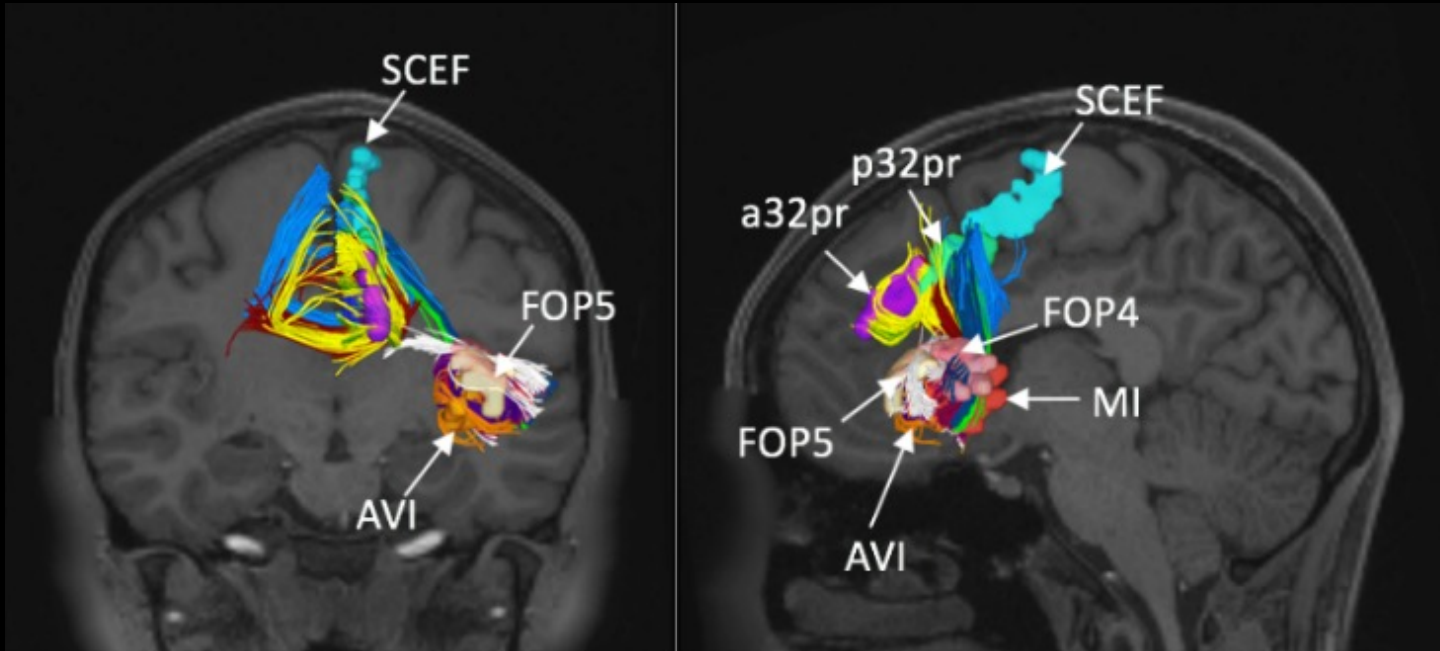
**PHG**

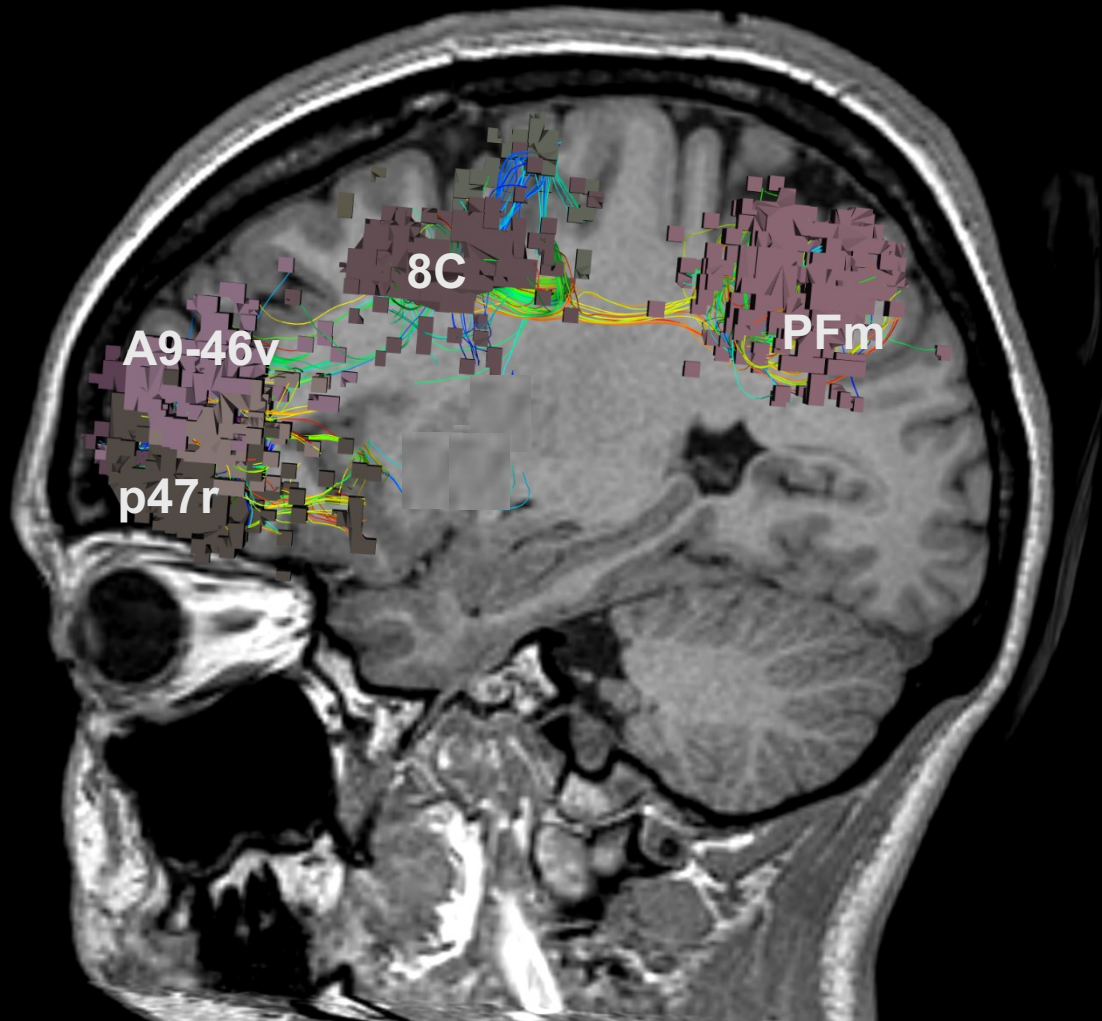


**Episodic Memory**

# Salience

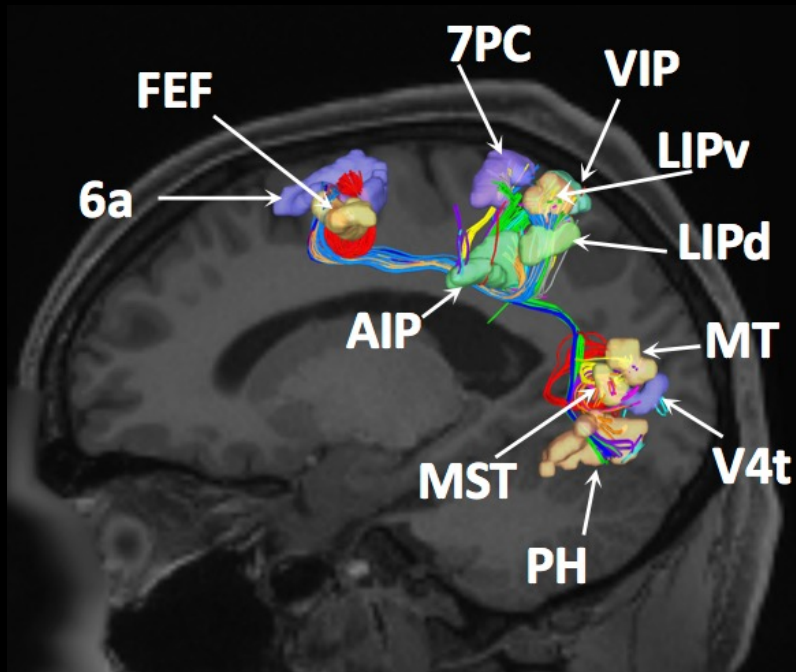
- Coordinating Response to Stimuli
- Pain
- Emotional regulation





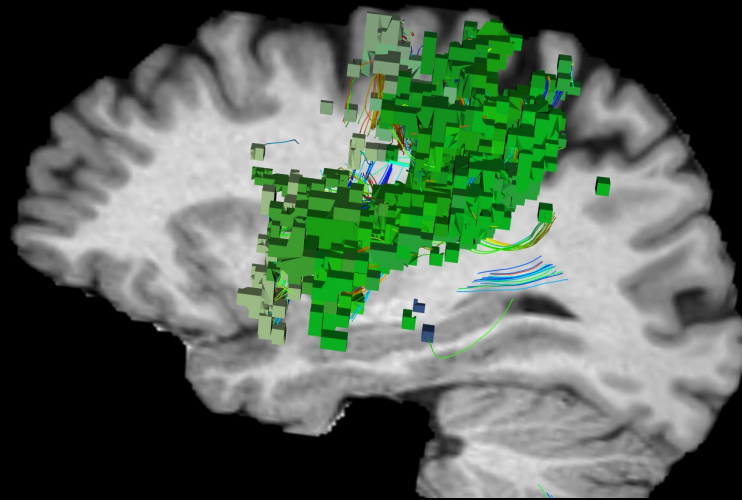
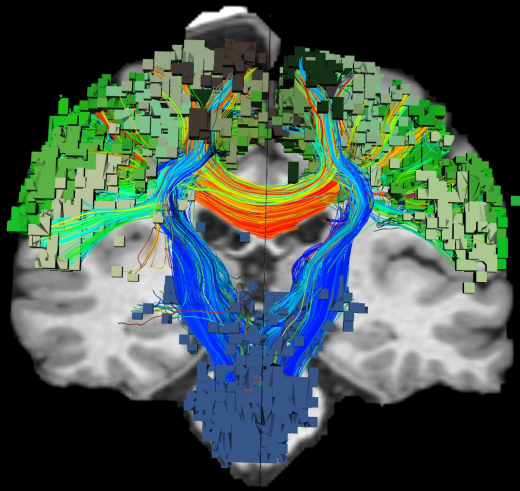
## CEN

- Working memory
- Executive function



## DAN

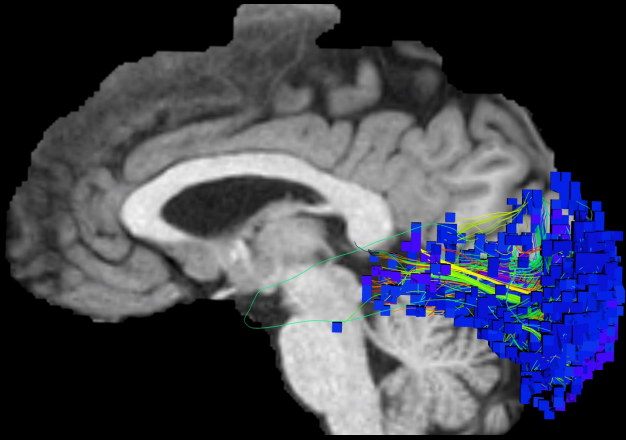
- Sustained Directed attention
- VAN=Change in attention due to sensory input



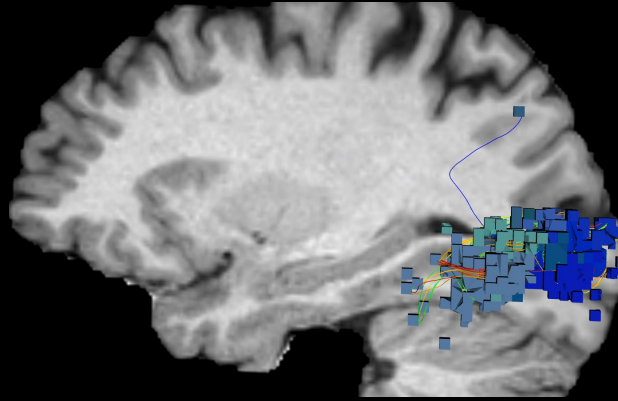
## Sensorimotor

- Primary Motor
- Primary Sensory
- SMA
- Ventral Premotor
- Dorsal Premotor
- Cingulate Motor

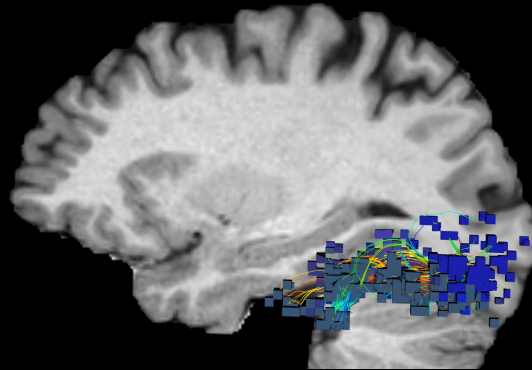




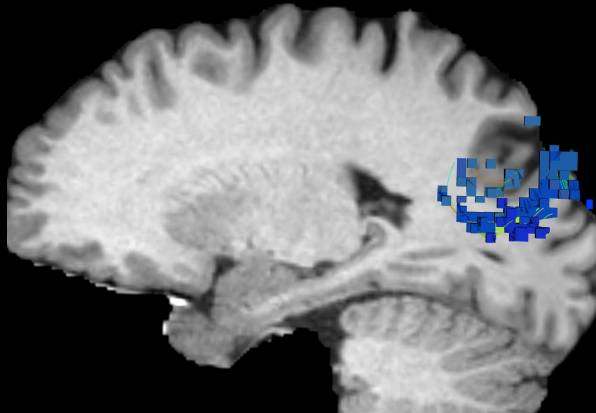
**Primary**



**Lateral**



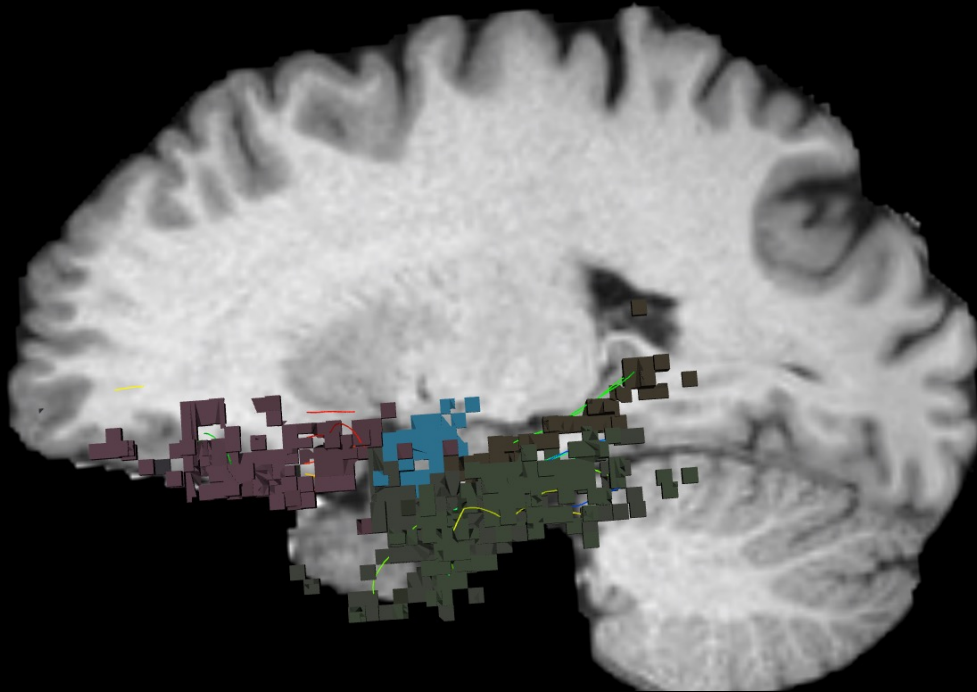
**Ventral**



**Dorsal**

## **Vision**

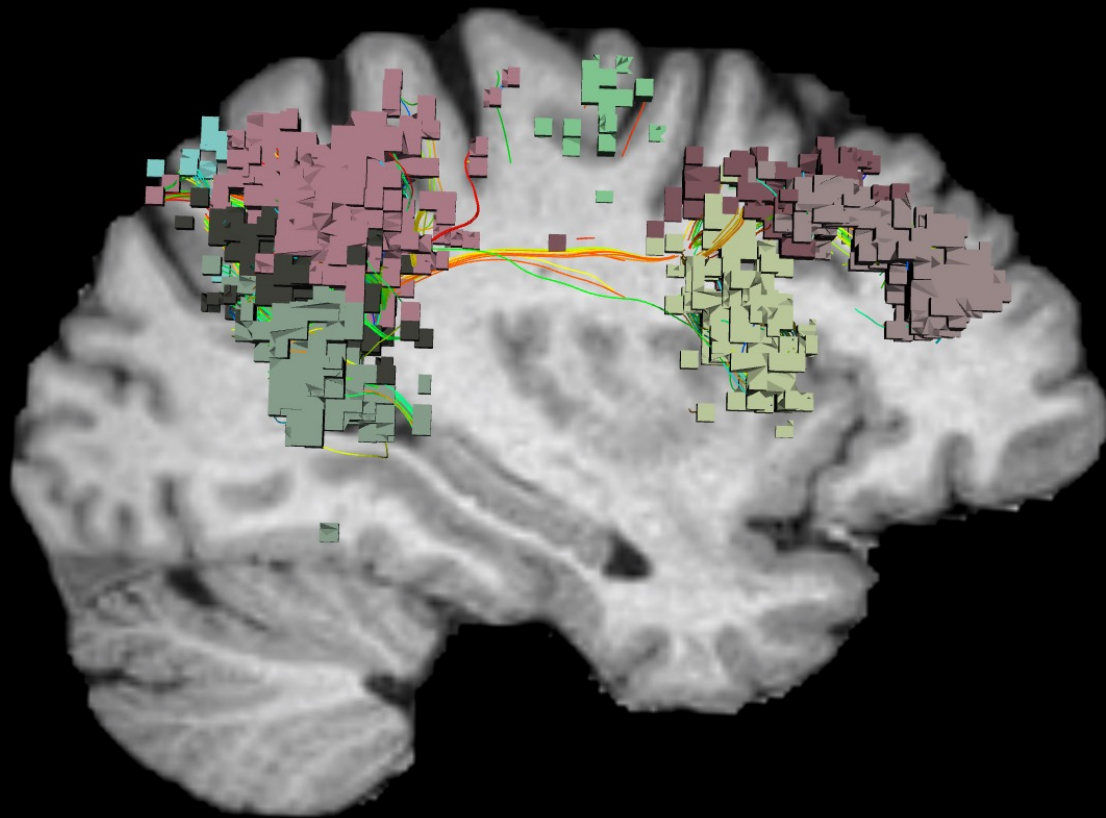
- **Primary Motor**
- **Lateral (higher order)**
- **Ventral (“what”)**
- **Dorsal (“where”)**



## Limbic

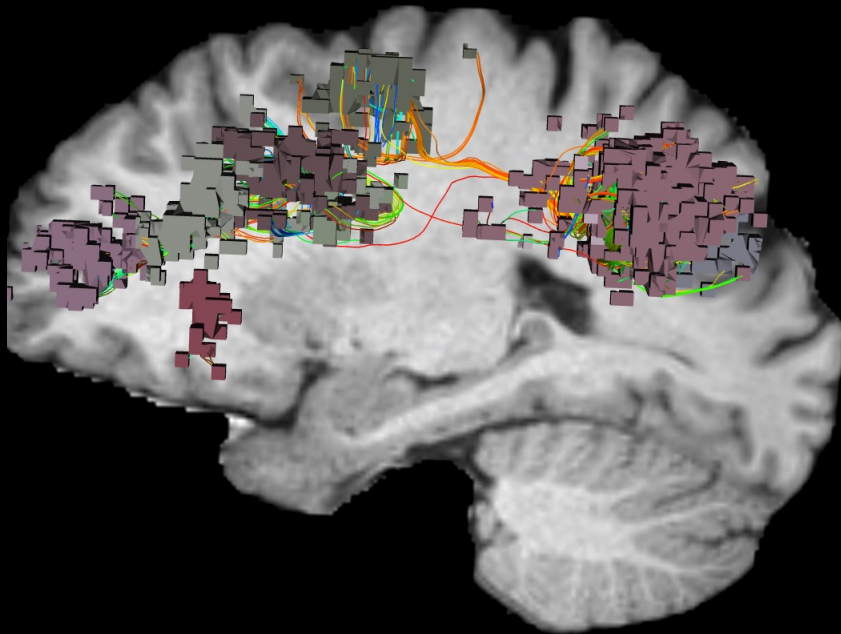
- Medial Temporal
- Orbitofrontal
- Subcallosal Cingulate





## VAN

- Right Sided Only
- Likely Neglect network



## Multiple Demand

- **Mixed Network**
- **Injury Drops IQ**

# Ideal Trajectory Planning

- **Origin:** Don't enter through somewhere bad
- **Path:** Don't cut through a brain network
- **Target:** Hit lesion on favorable angle