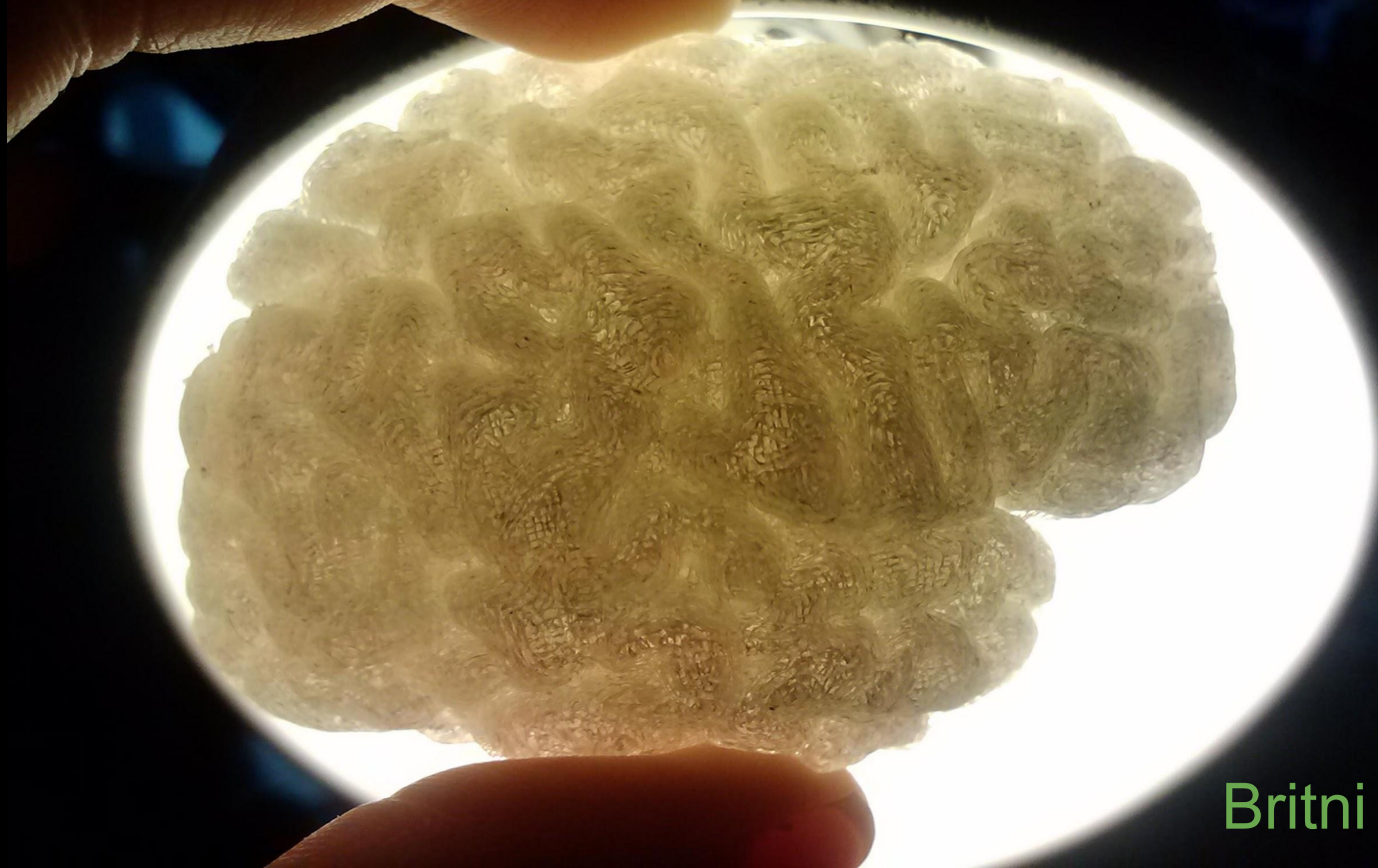
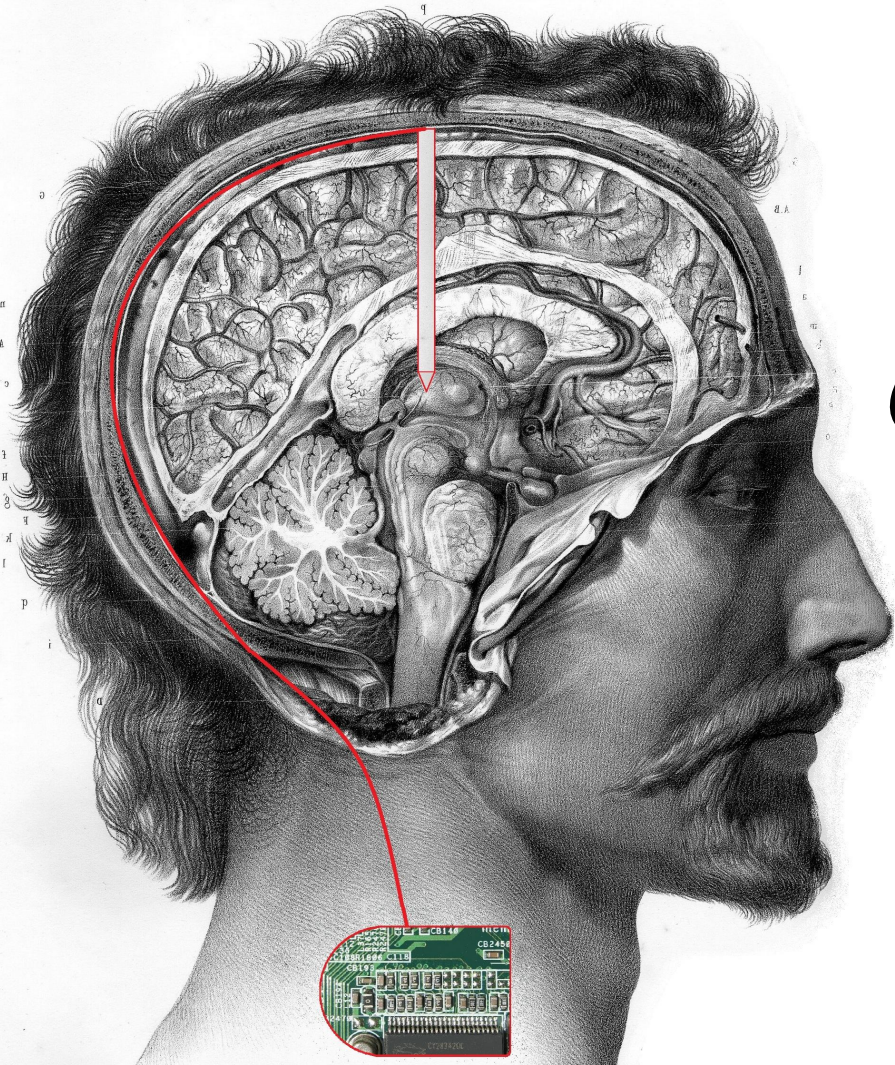


The effects of electrical stimulation on the human brain



Britni Crocker



Parkinson's
Essential Tremor

Addiction

Chronic Pain

OCD

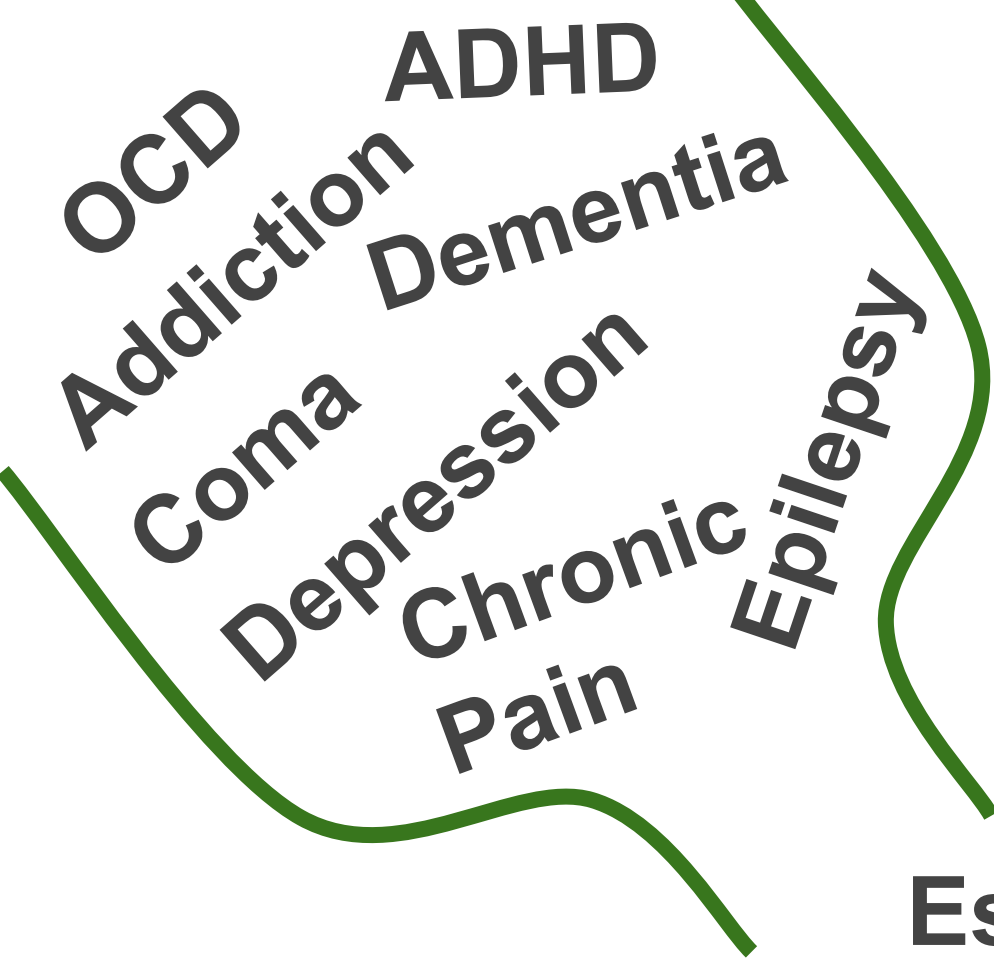
Dementia

ADHD

Epilepsy

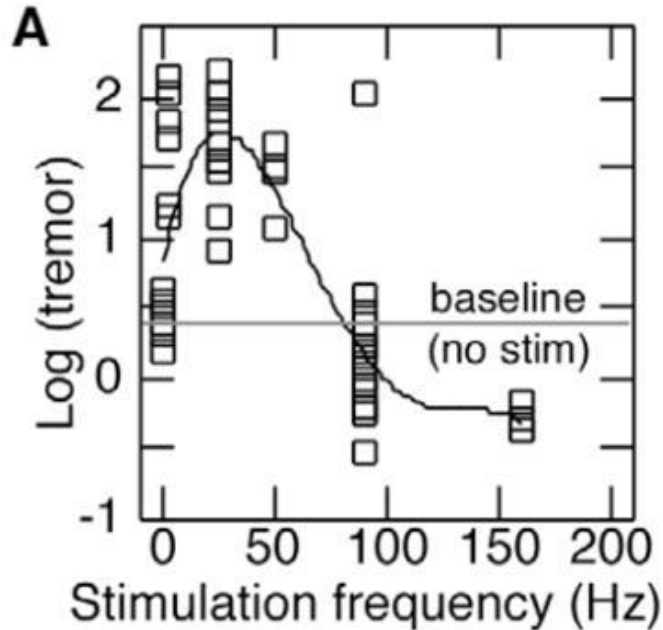
Depression

Coma

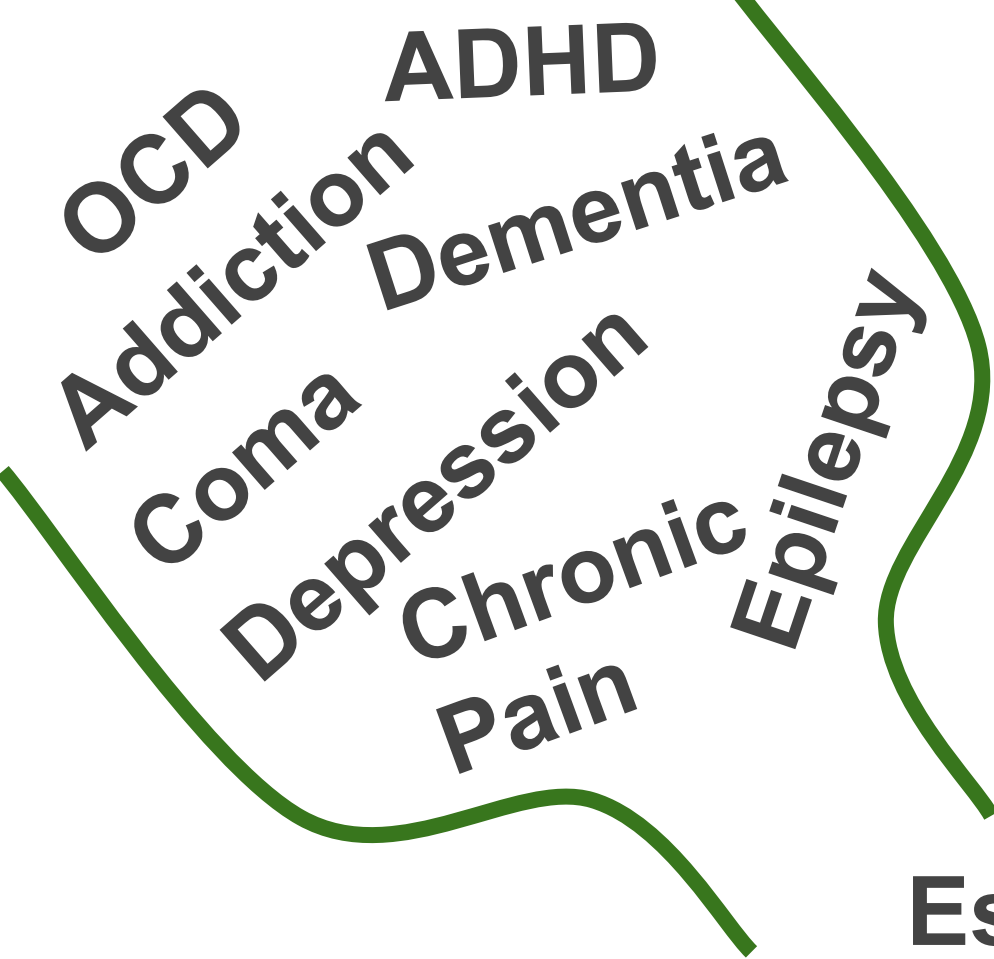


Despite large effort and expense, development of brain stimulation therapy has been slow. **Why?**

**Essential Tremor
Parkinson's**

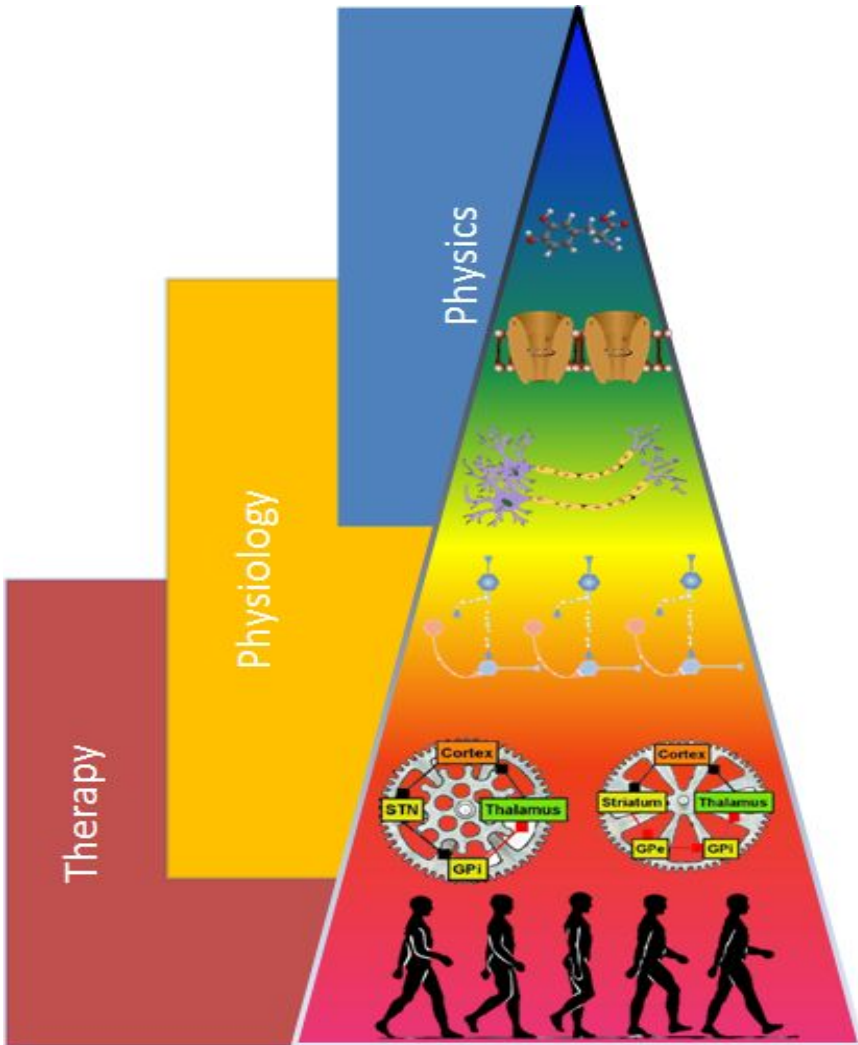


Useful stimulation
parameters discovered
by trial-and-error



Trial-and-error methods are a large bottleneck to discovering effective therapy in such a large parameter space.

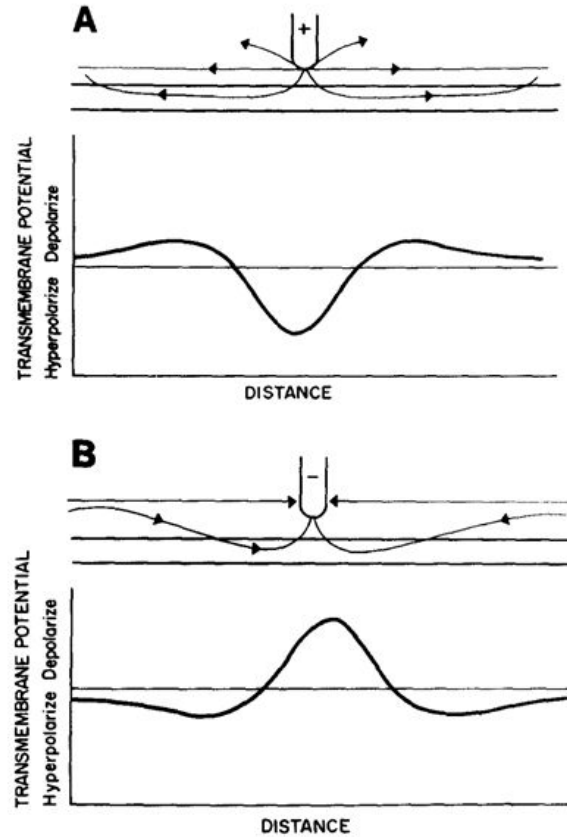
Essential Tremor
Parkinson's



On the **therapeutic side**, understanding effective **stimulation parameters** for alleviating symptoms has largely been accomplished by **trial and error**.

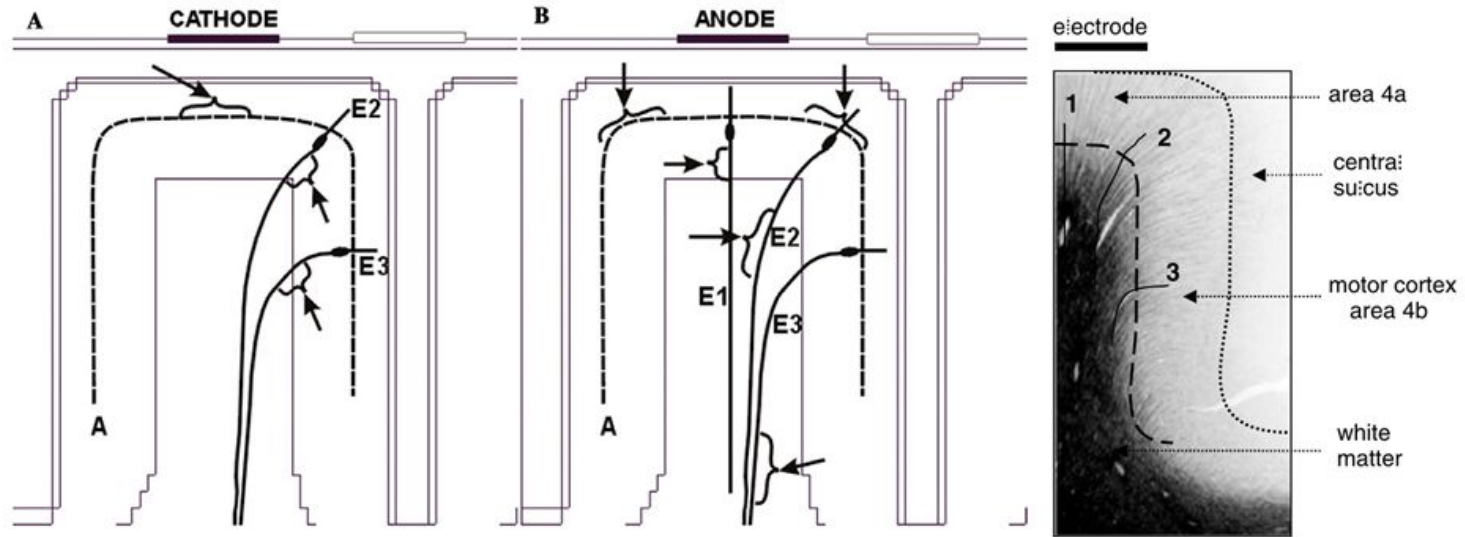
What is our understanding of **brain stimulation** on the **scientific level**?

Electrical stimulation
depolarizes cell
membranes and **activates**
voltage-gated ion
channels in a geometry-
and polarity- dependent
manner

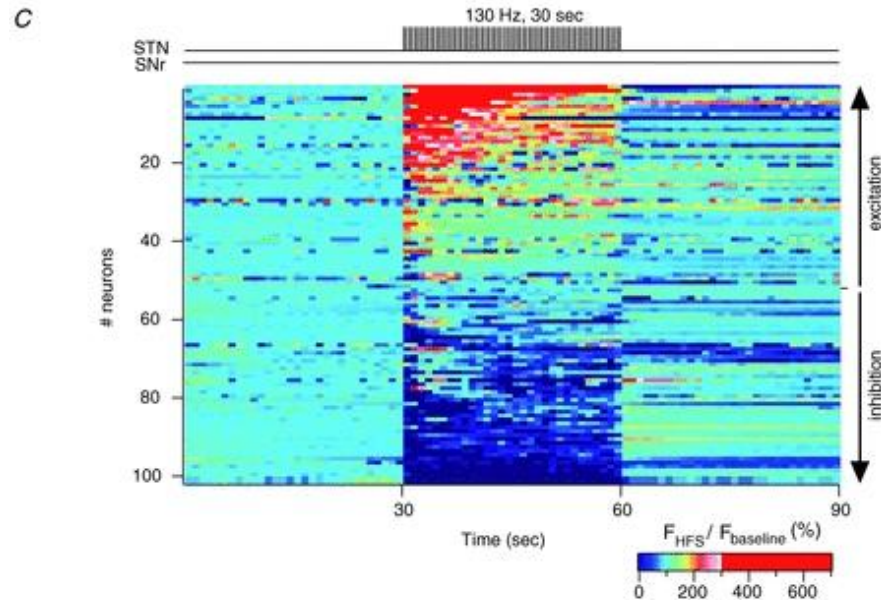
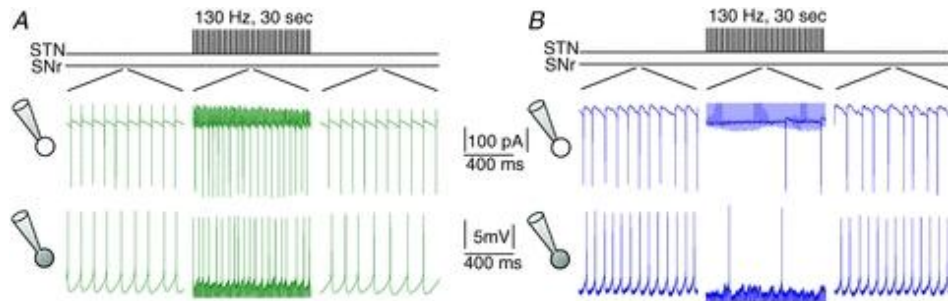


Ranck 1975

Simulation studies predict polarity-dependence of electrical stimulation

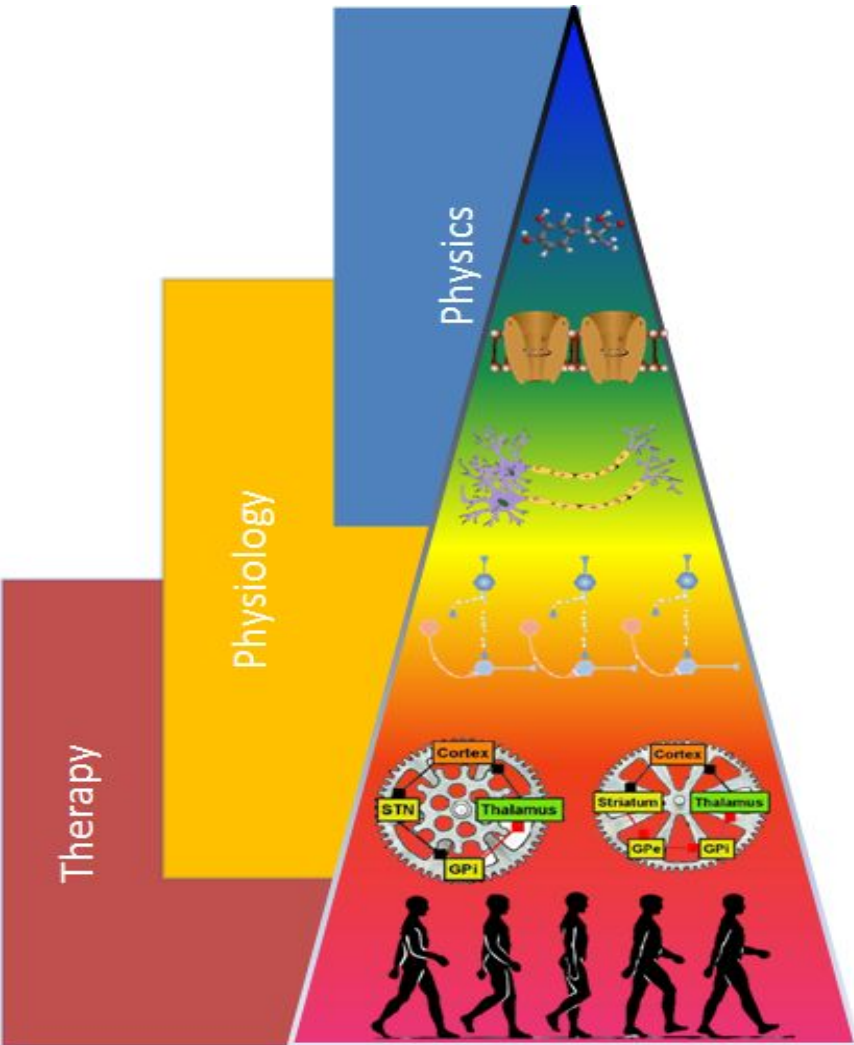


Manola et al. 2007



In rat brain slices, neurons respond to electrical stimulation by:

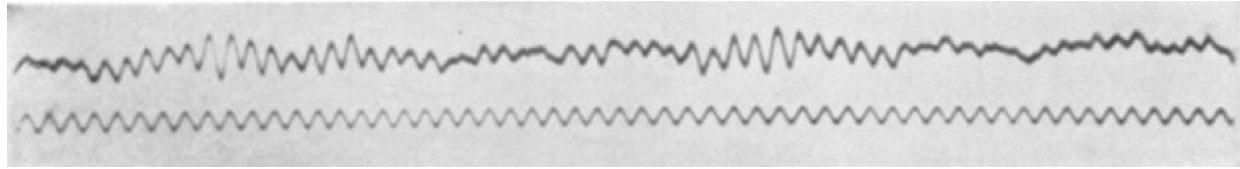
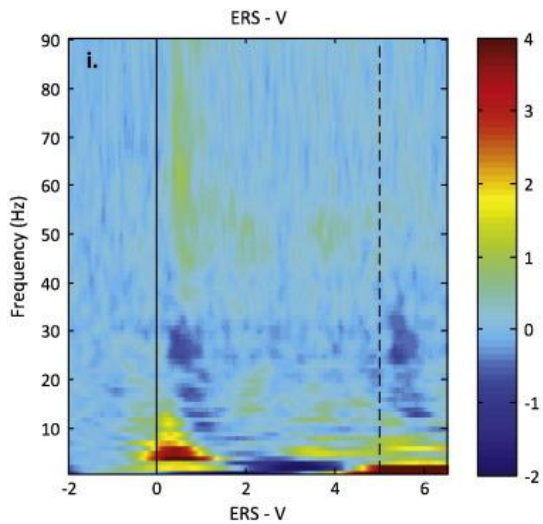
- increasing their firing rate
- decreasing their firing rate
- not changing their firing at all.



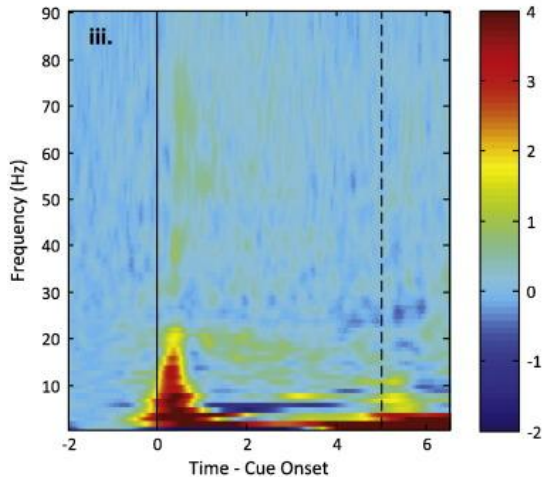
Trial and error methods are inefficient, unprincipled, and slow.

Simulation and stimulation studies are not clinically relevant or easily integrated into our current level of understanding.

We need a principled way of understanding brain stimulation that will be clinically relevant.



Berger 1924



Brain waves are easy to measure and often correlate with both behavior and clinical symptoms.

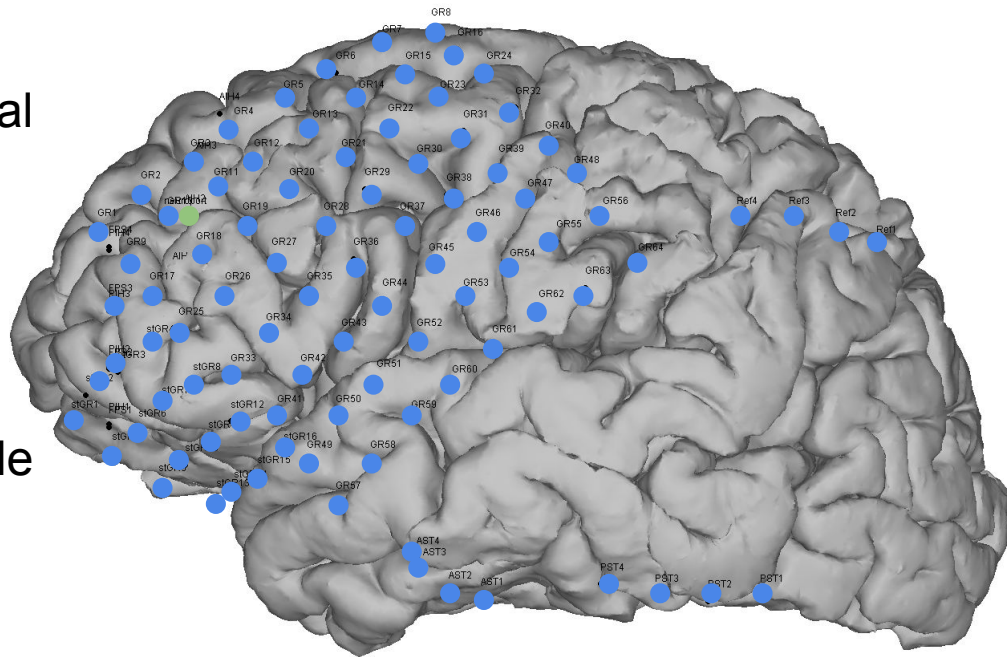
The Setup

Human epilepsy patients with electrodes implanted for clinical purposes

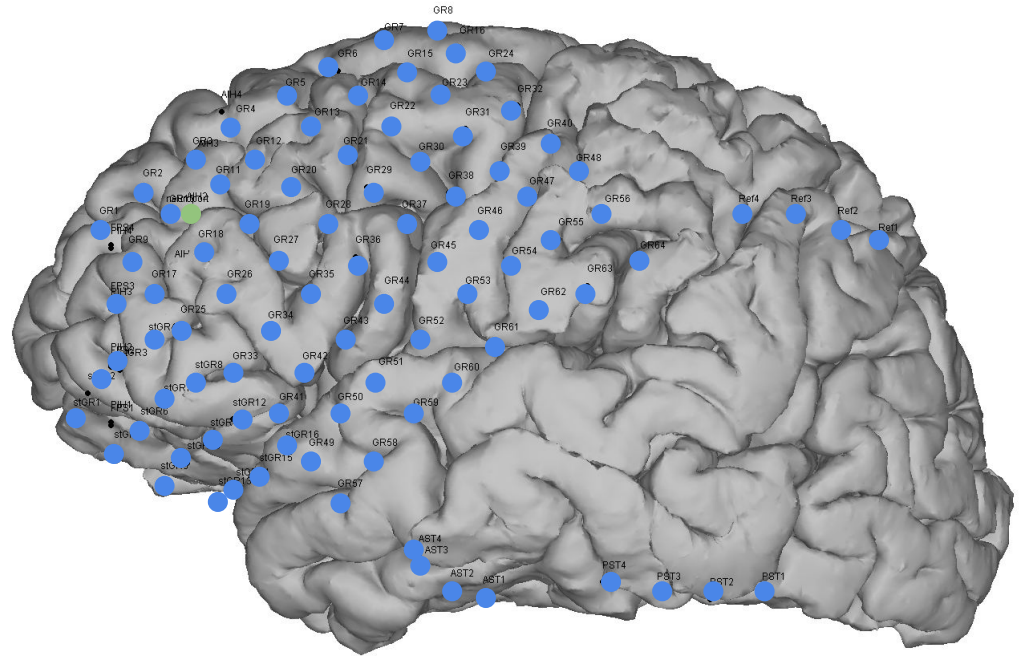
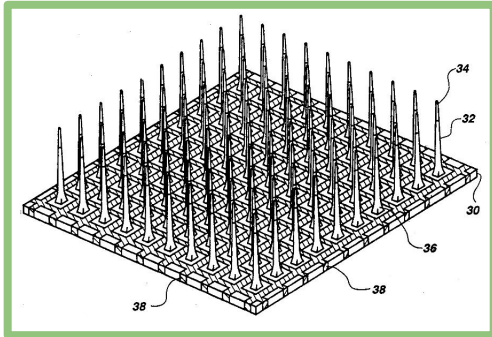
~100 electrodes per patient

Each electrode records continuous data at 2kHz (single precision)

~3GB per hour (or about 500 GB per patient over the entire hospital stay)



Experimental electrodes allow us to collect more precise information about the neuronal response

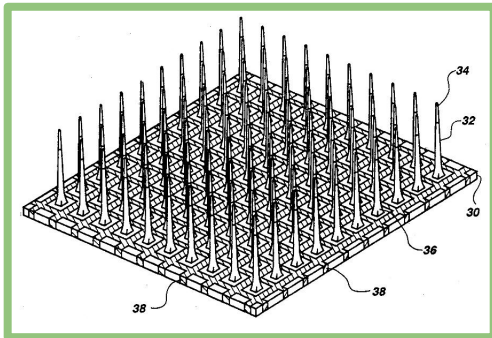


Experimental electrodes allow us to collect more precise information about the neuronal response



Human epilepsy patients with electrodes implanted for clinical **and research** purposes

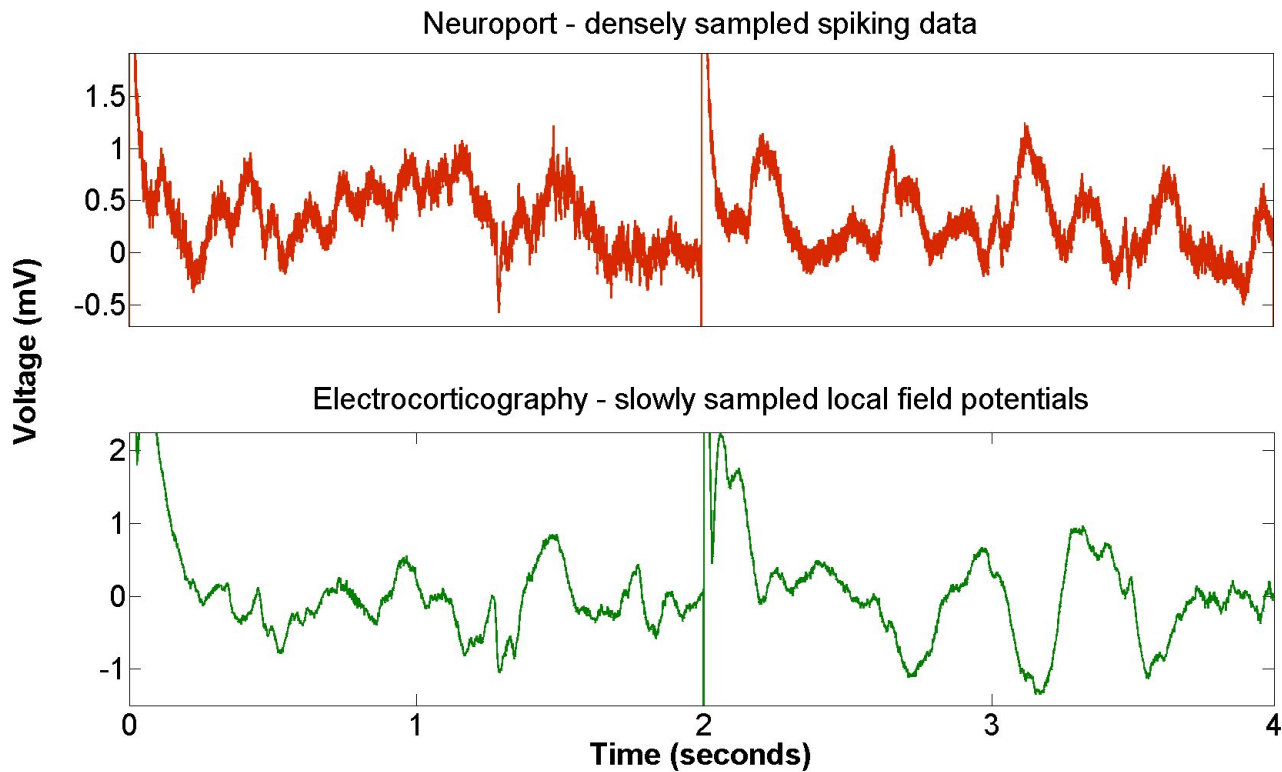
~100 electrodes in a single square centimeter



Each electrode records continuous data at 40 kHz (single precision)

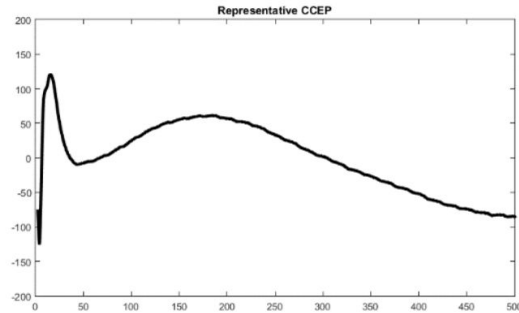
~120 GB per hour (or about 5 TB per patient over the entire hospital stay)

The Setup

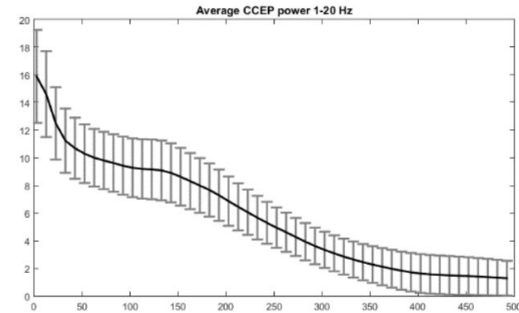


The effects of a single pulse of stimulation are long-lasting

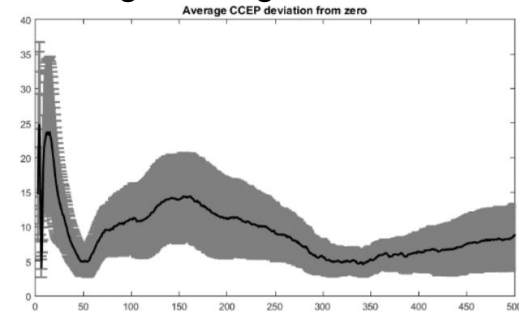
Example: Voltage over time in a channel



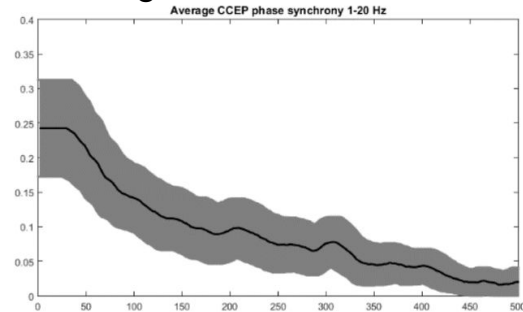
Average Spectral Power over time



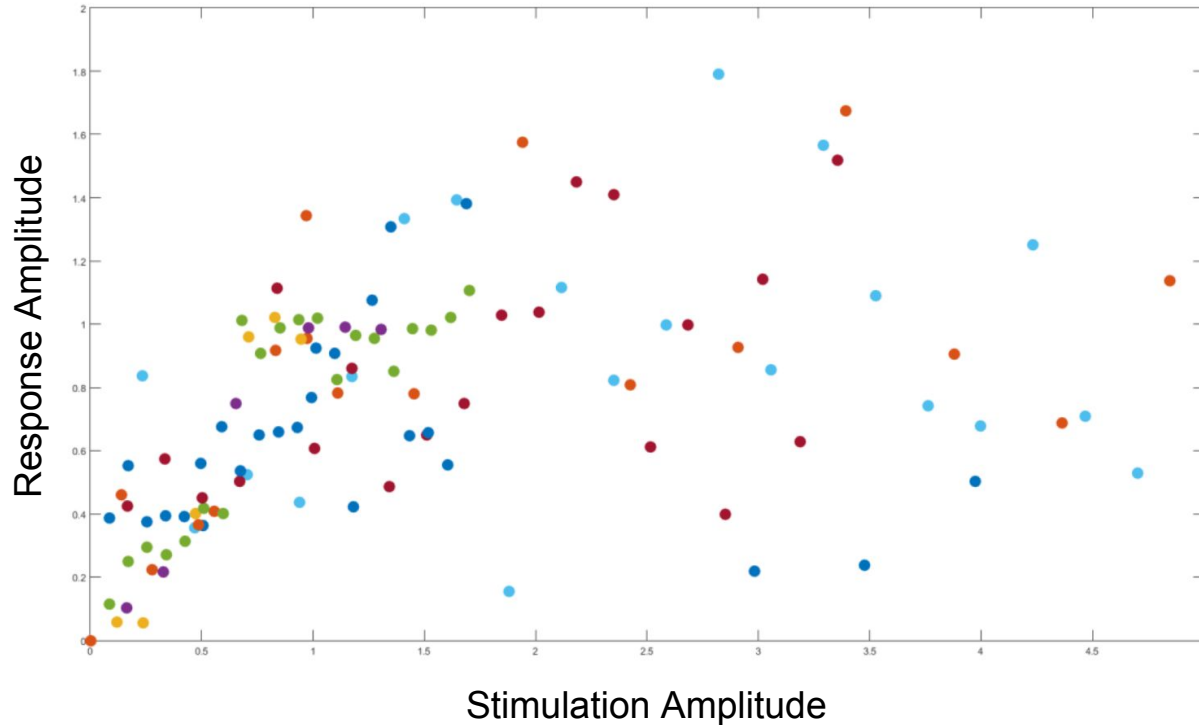
Average Voltage over time



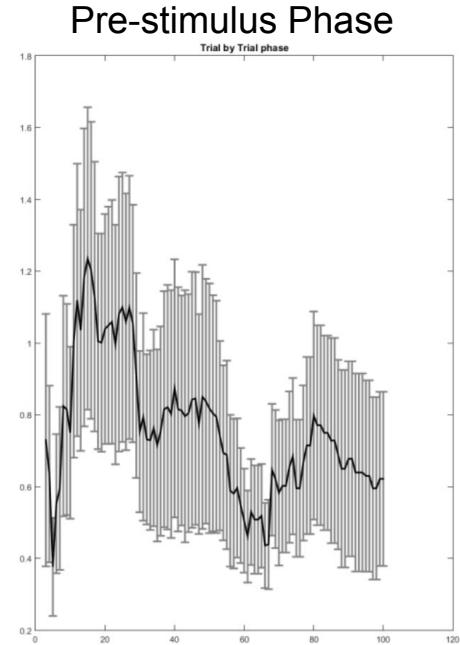
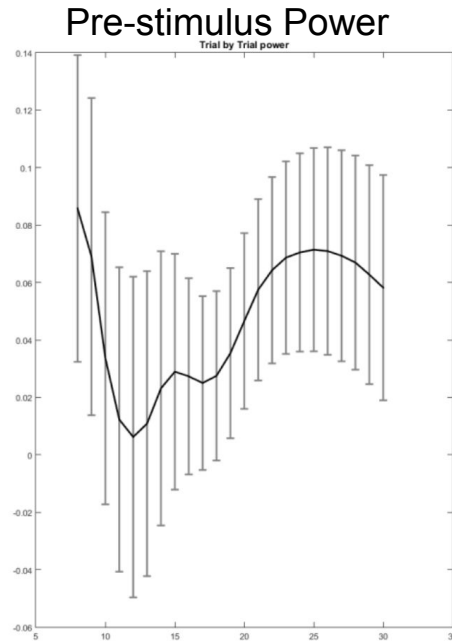
Average Phase Coherence over time



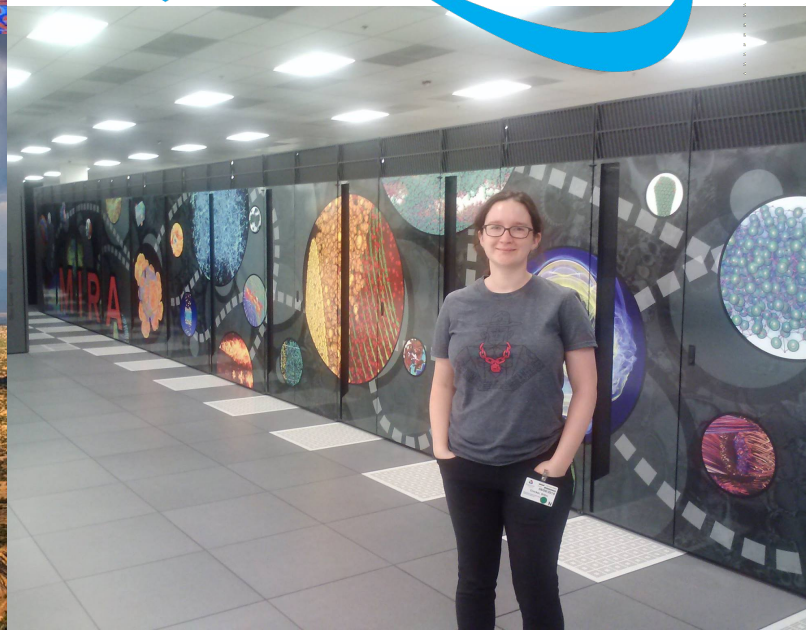
Long-lasting effects scale linearly with stimulation amplitude



Stimulation effects are dynamically dependent on brain state



Frequency (Hz)





Thanks!