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Sensing and stimulating the brain to restore neurological function

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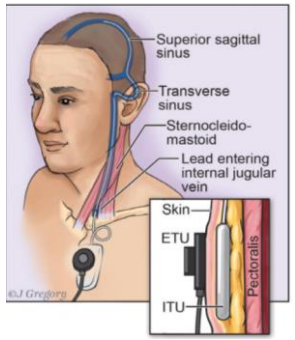
Neuroscience Institute

Topics for Today

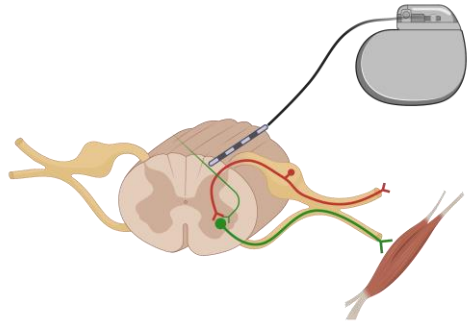
Sensing residual motor signals in people that are paralyzed

Brain-computer interfaces



Amplifying upper extremity motor function after paralysis

Spinal Dorsal Rootlet Stimulation after Stroke



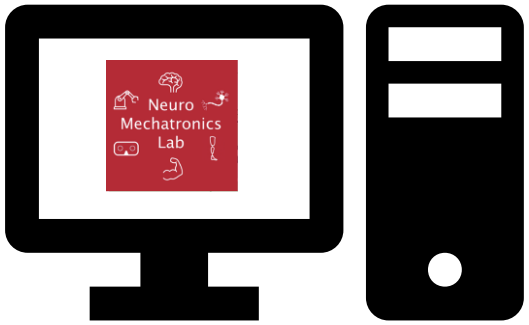
Neurotechnology for sensing motor signals

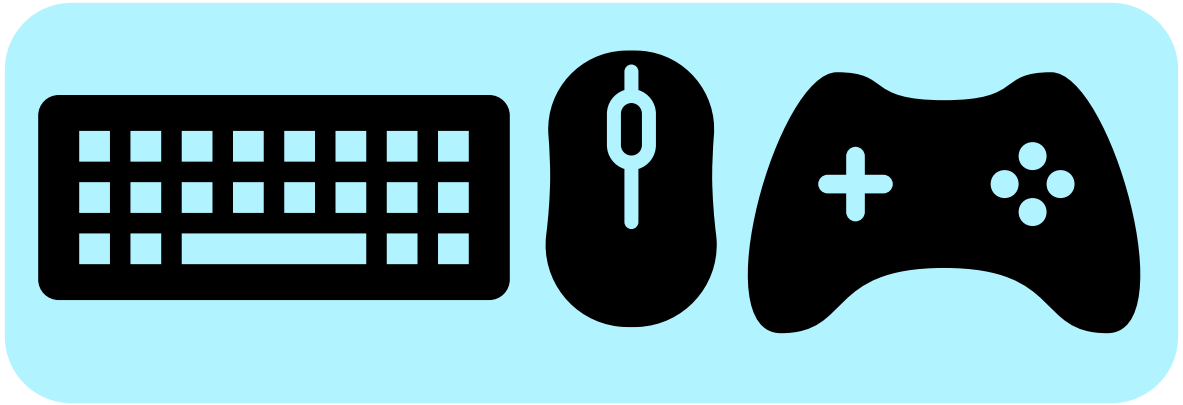
Access to Digital Devices is Crucial for Many Activities of Daily Living

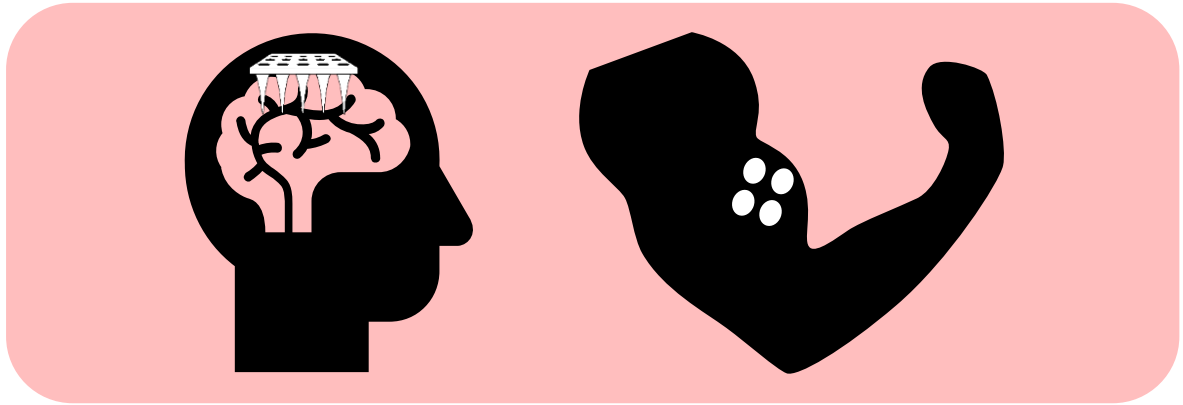
People with tetraplegia require adaptations to use traditional computer input devices

Image credit: Dailyn Despradel

Digital Input Devices







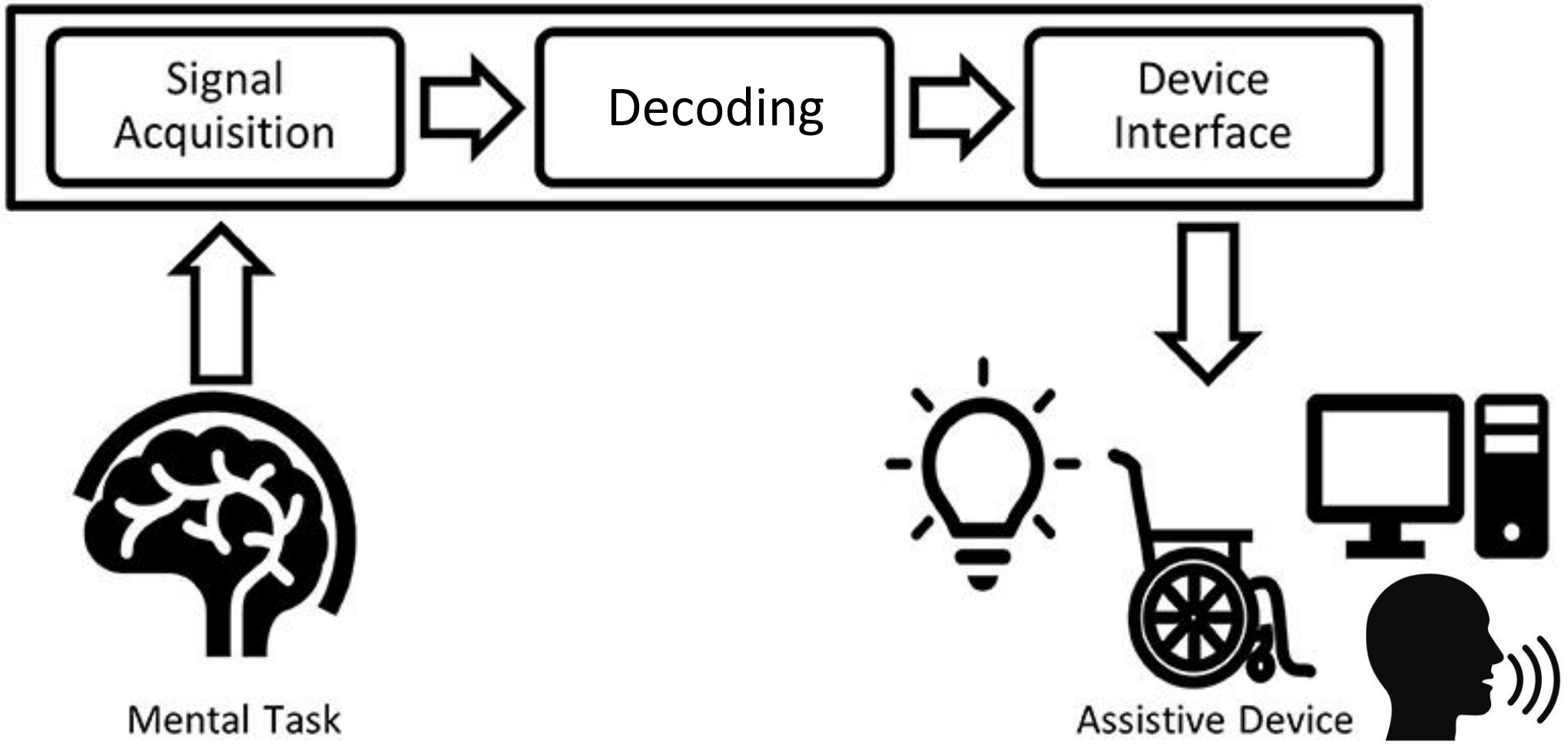
Mechanical Interfaces

Bioelectronic Interfaces

Implantable Brain-Computer Interfaces

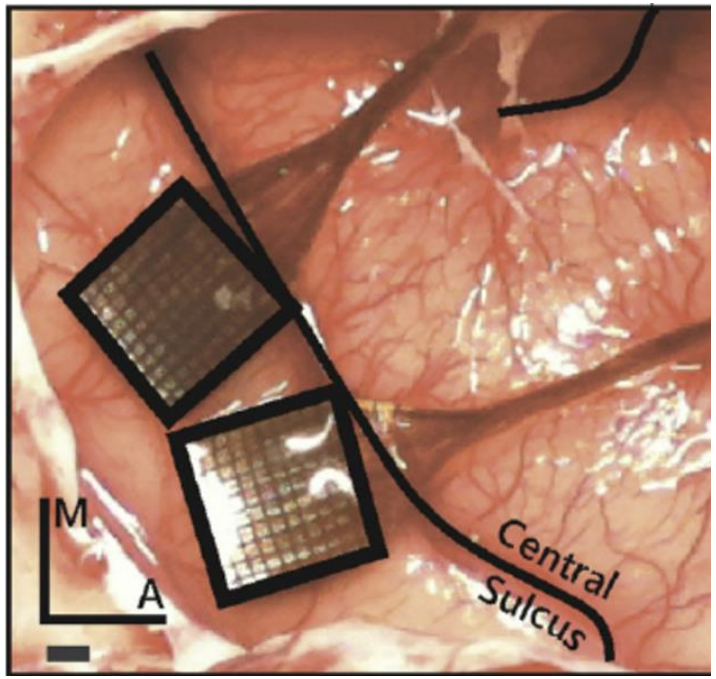
Brain-Computer Interface Concept

Primary motivation is to bypass injury in the nervous system

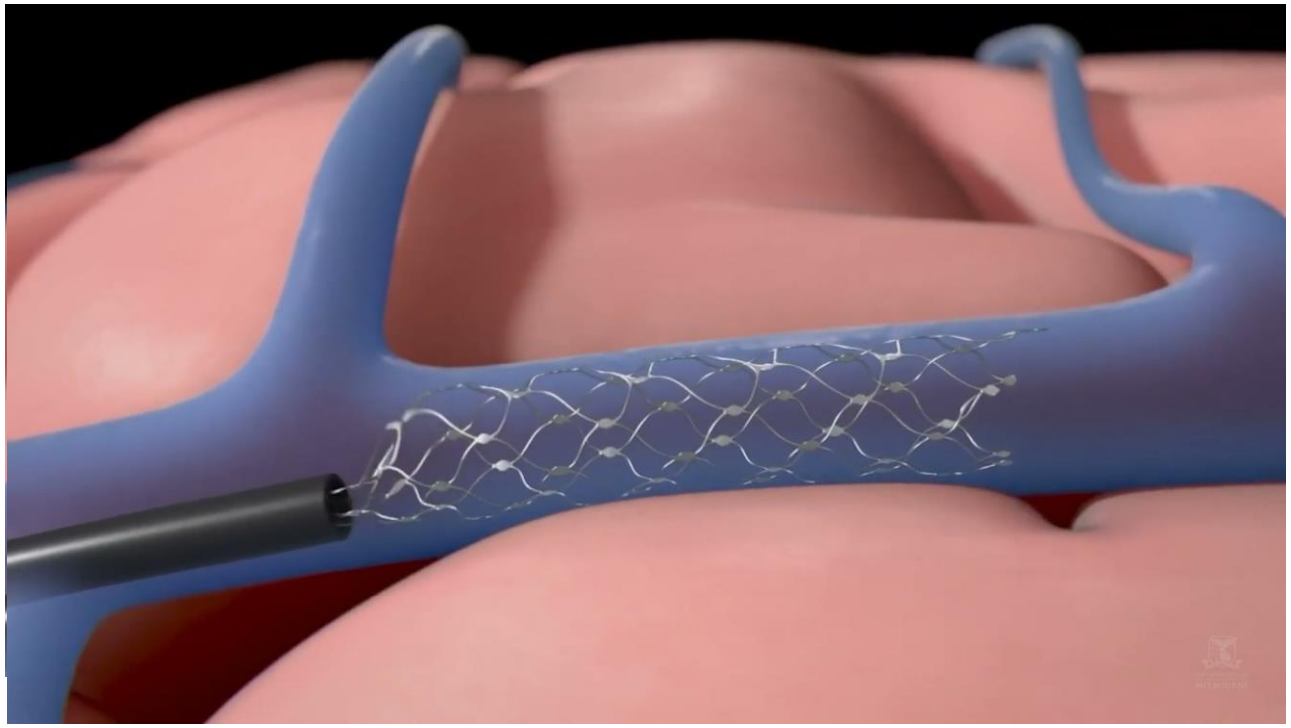


Wiring the Brain for Digital Communication

Intracortical BMI Implants



Endovascular BMI Implants



Funding Source

NIH

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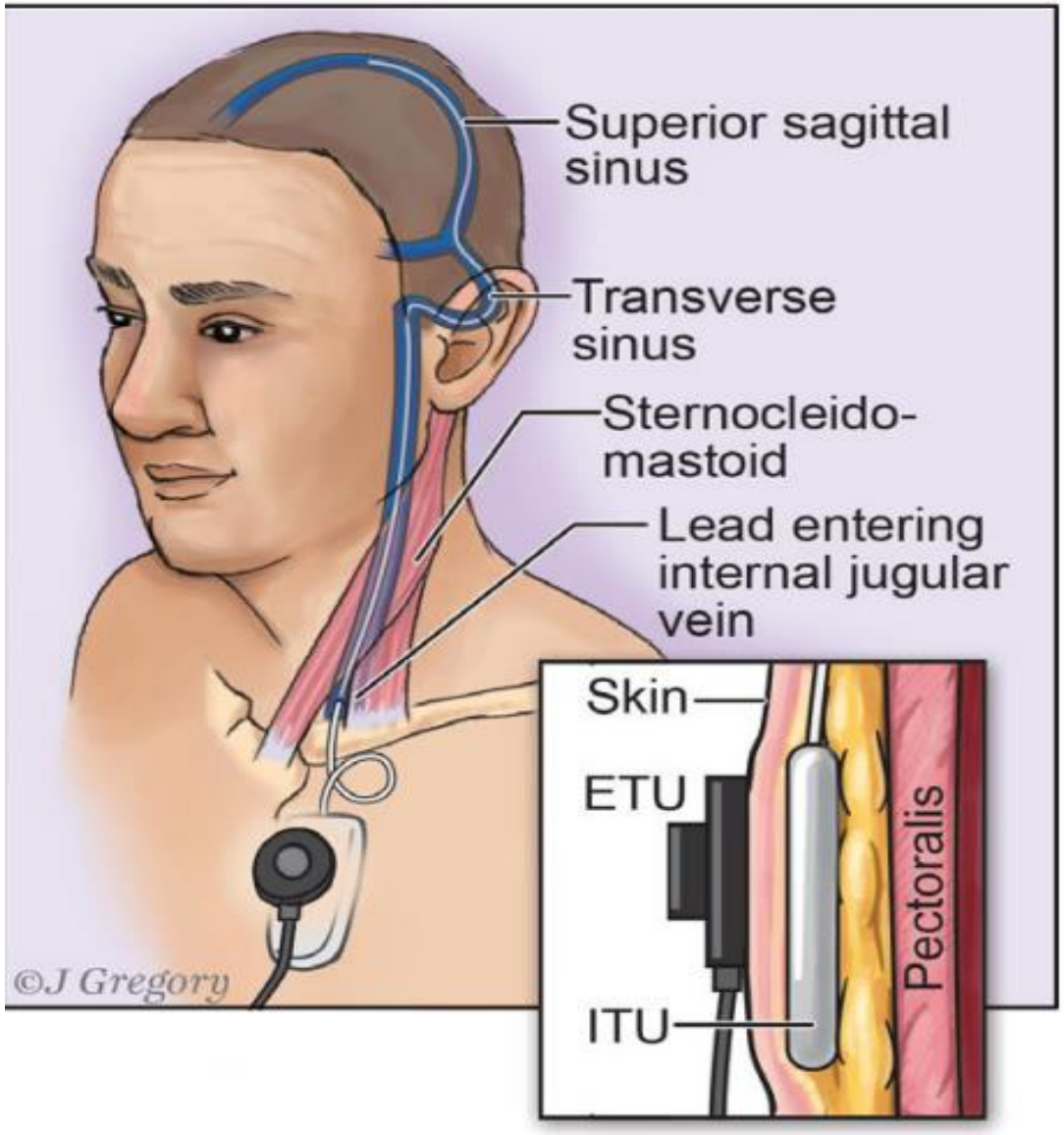
Stentrode BCI System

credit: Synchron

- Nitinol stent scaffold
- 16 x 500 μm diameter platinum electrodes
- Inserted via catheter through jugular vein to the superior sagittal sinus adjacent to motor cortex



Early Feasibility Study Objectives

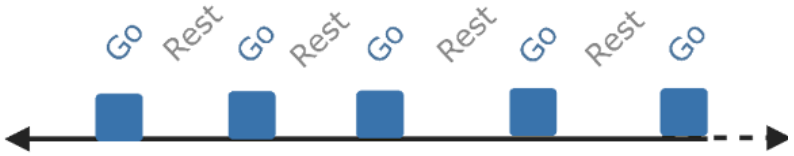
Primary: Evaluate safety of Stentrode BCI in n=6 people with severe paralysis

Secondary: Evaluate signal quality and user function

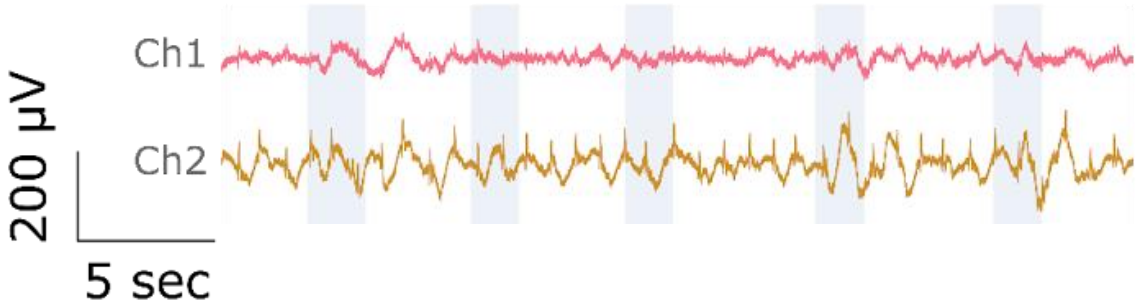
- ❑ Motor signal strength
- ❑ Signal Stability
- ❑ Channelization (degrees of freedom)

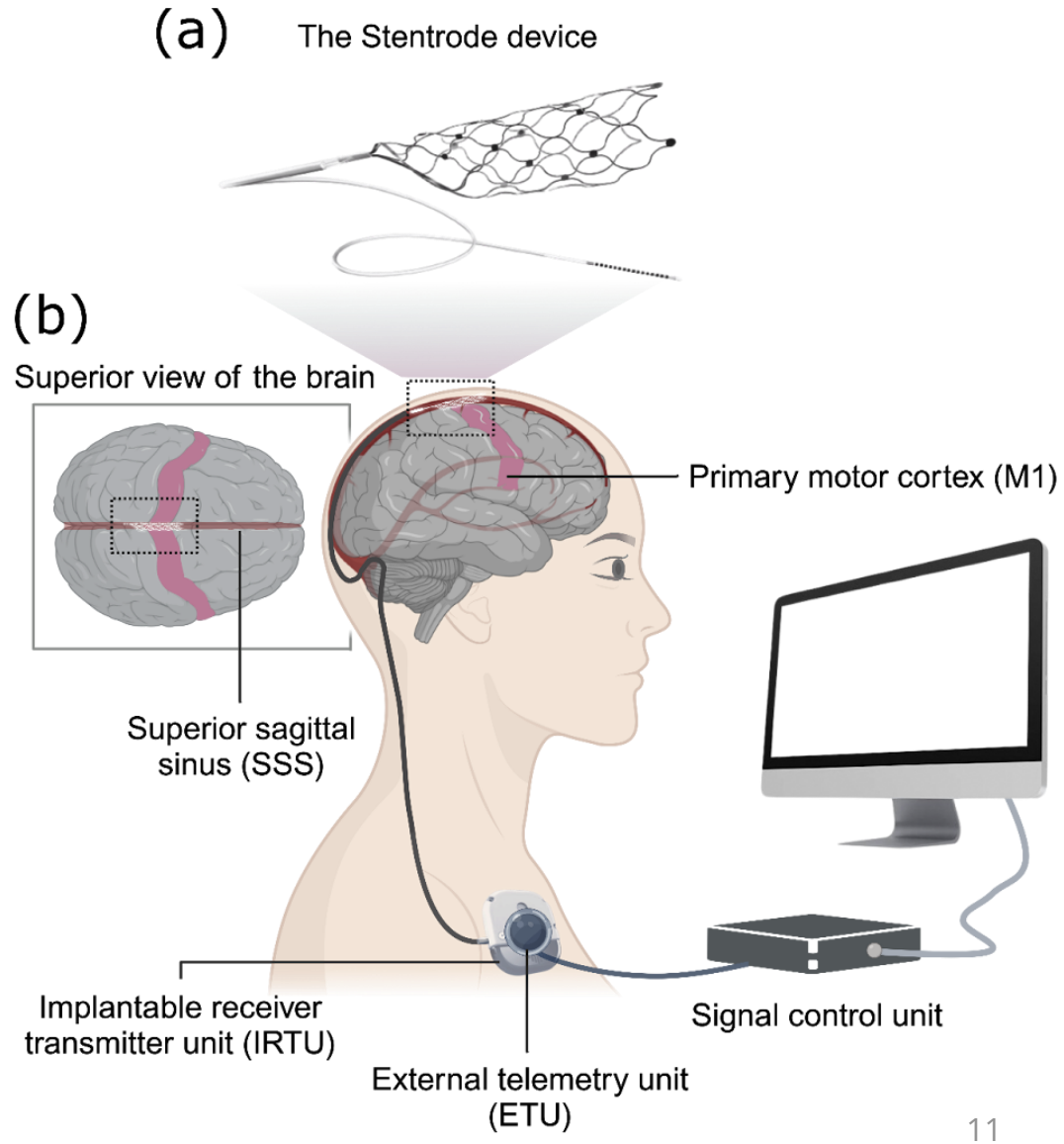
Measuring Motor Signal Strength

- Participant seated in front of computer
- Visual and verbal prompts to cue “attempt moving ankle(s) and hand(s)”
- Prompts alternate between “rest” and “go”

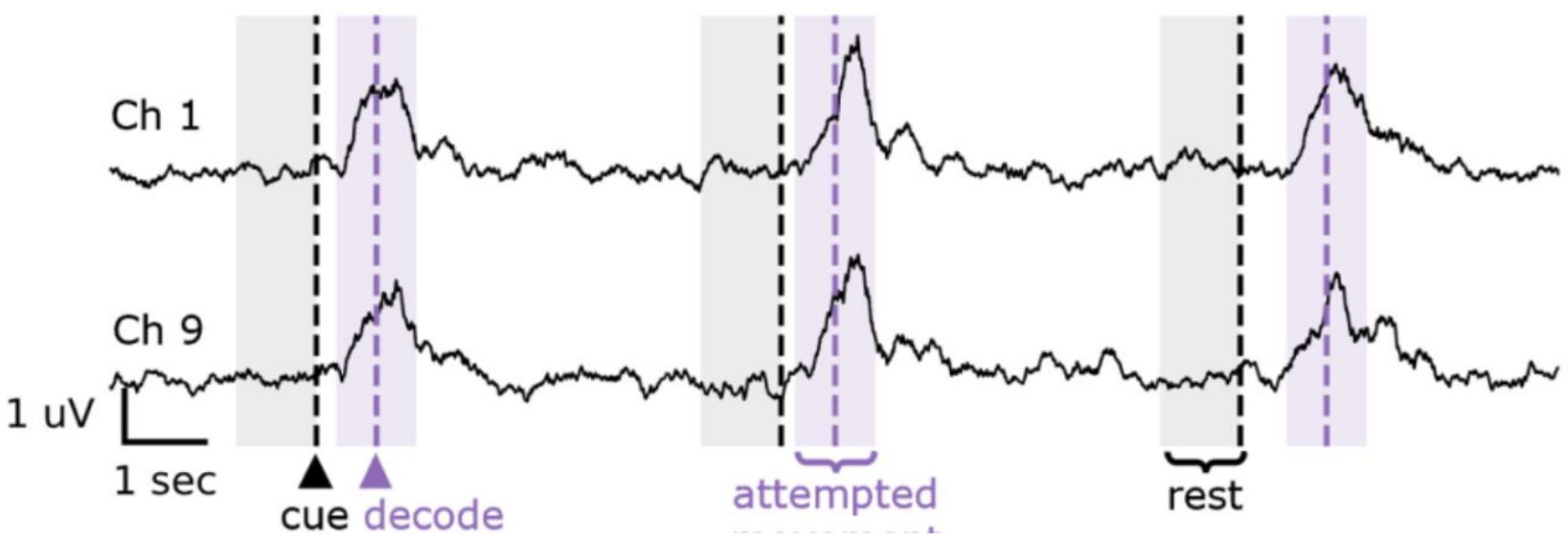


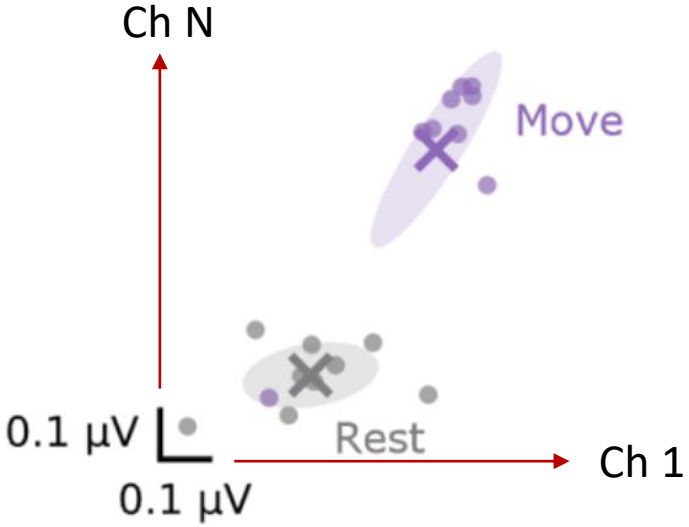
- Examine vascular ECoG (vECoG) signal changes between rest and go intervals



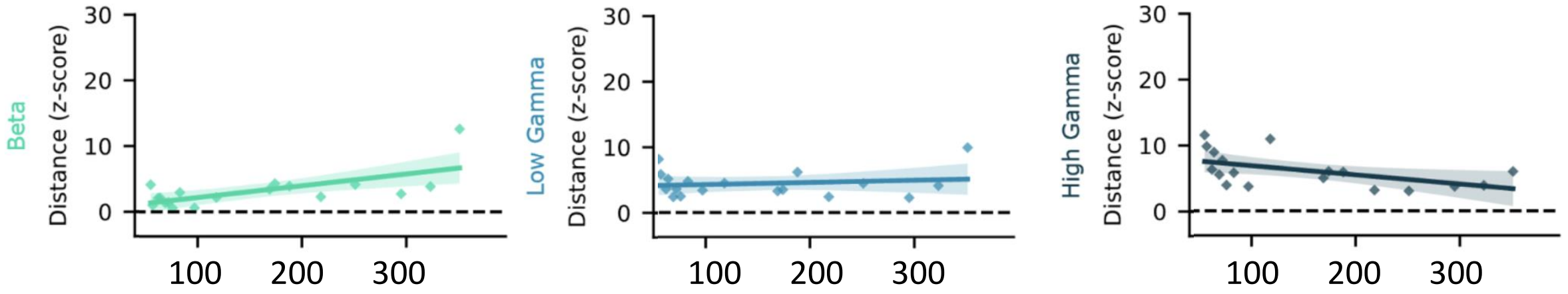


Multichannel Motor Signal Metric

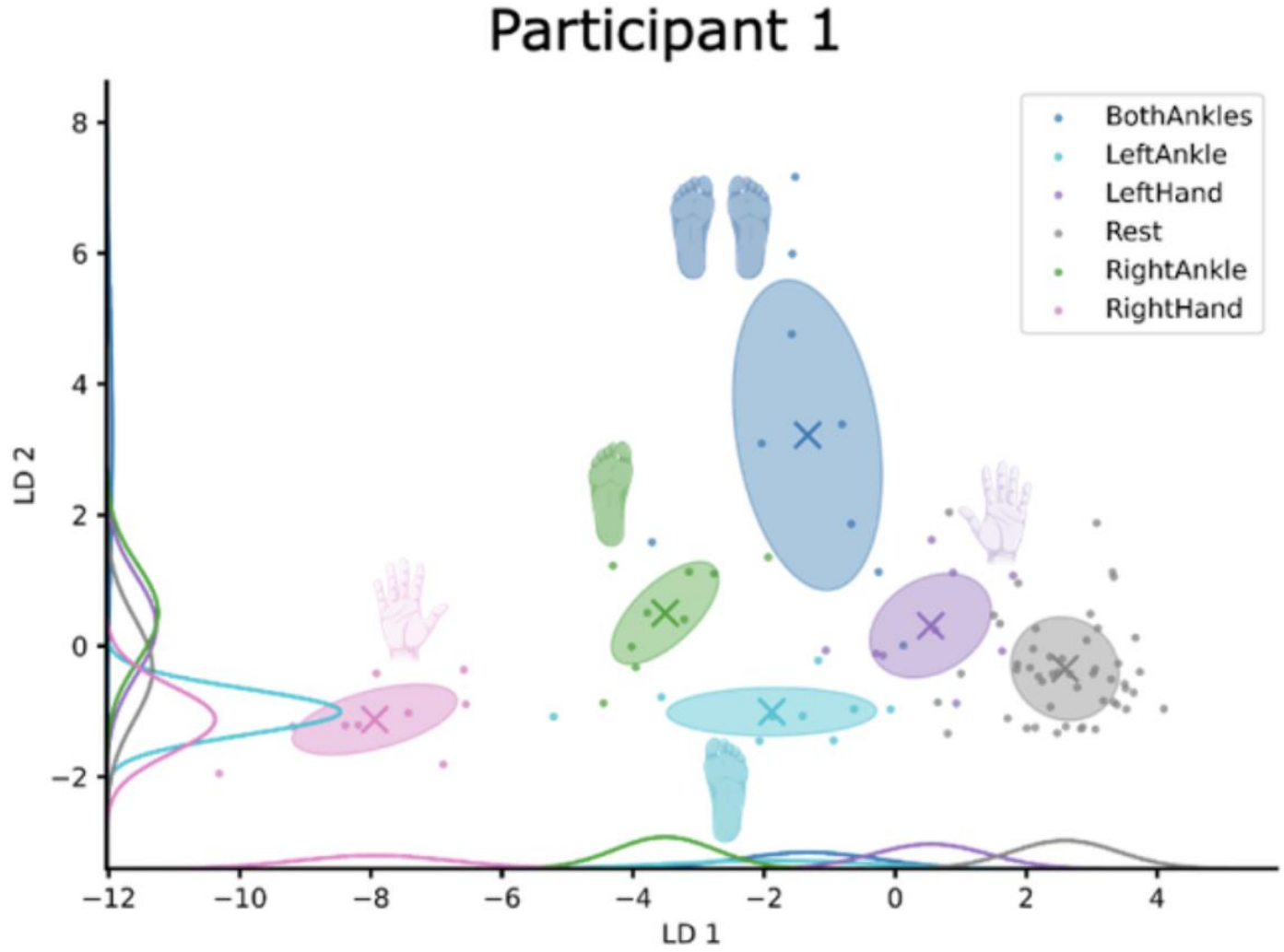




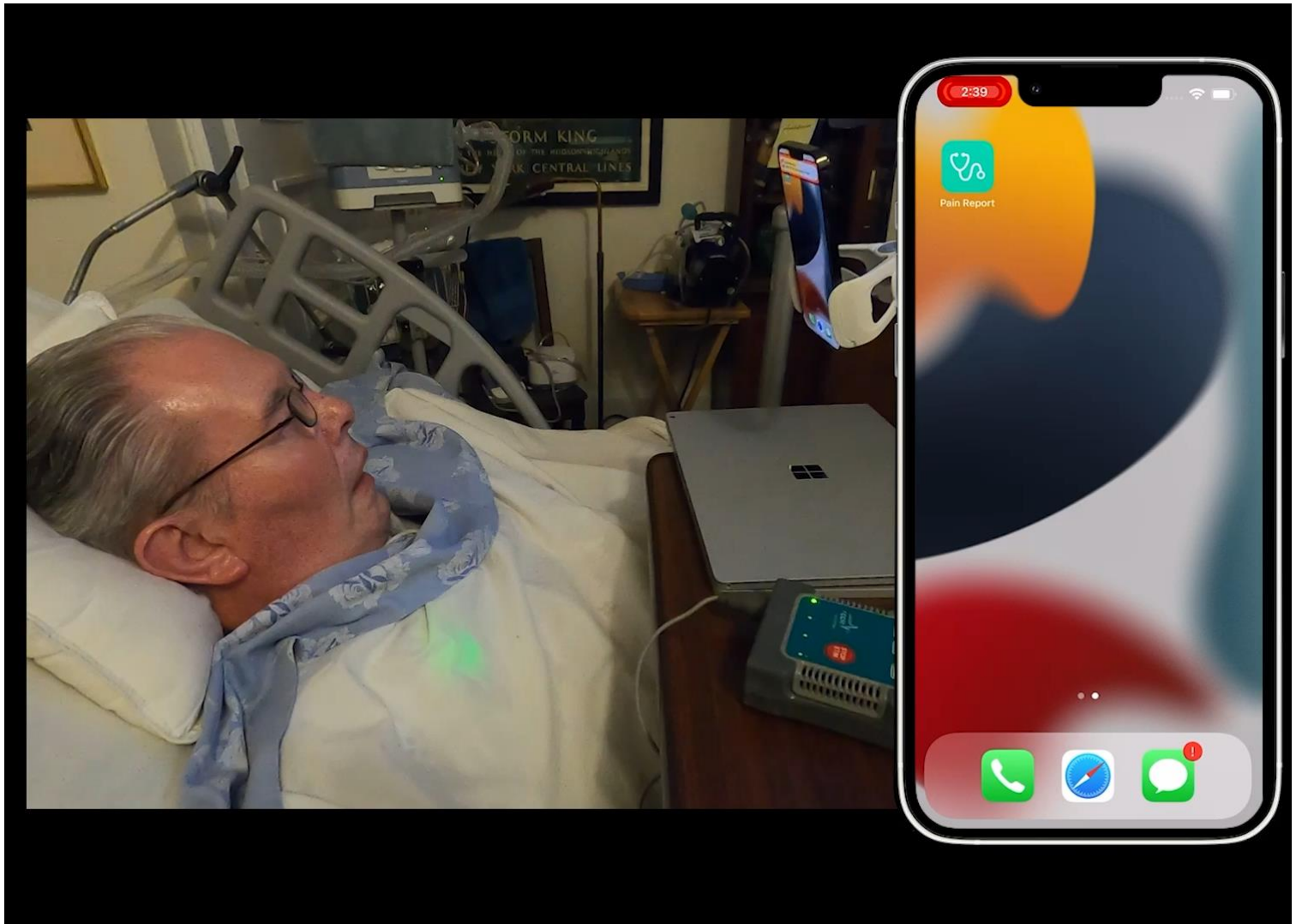
Beta, Gamma, and High Gamma Features exhibit significant motor modulation across time



Discriminable Patterns of Motor Features Associated with Different Movement Types



Demo: Completing health report with Stentrode BCI (single switch control)



synchron

Stimulating the nervous system to amplify motor function

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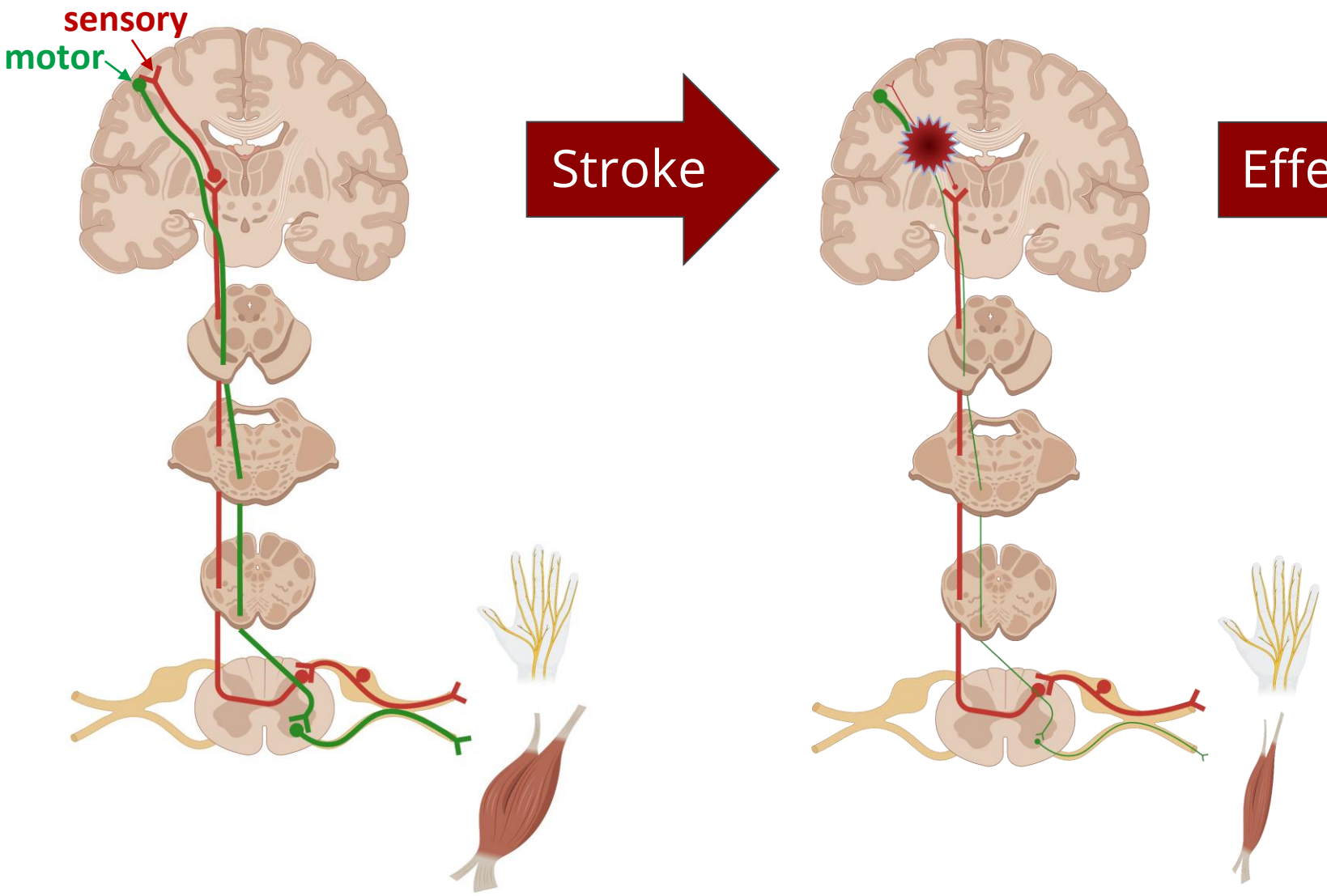
Luigi Borda

Prakarsh Yadav

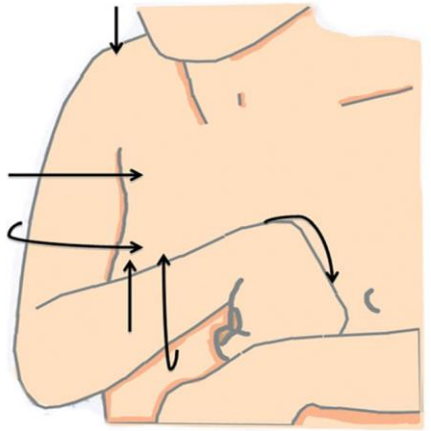
Lauren Parola

Omar Refy

Stroke Damages Motor and Sensory Neural Circuits

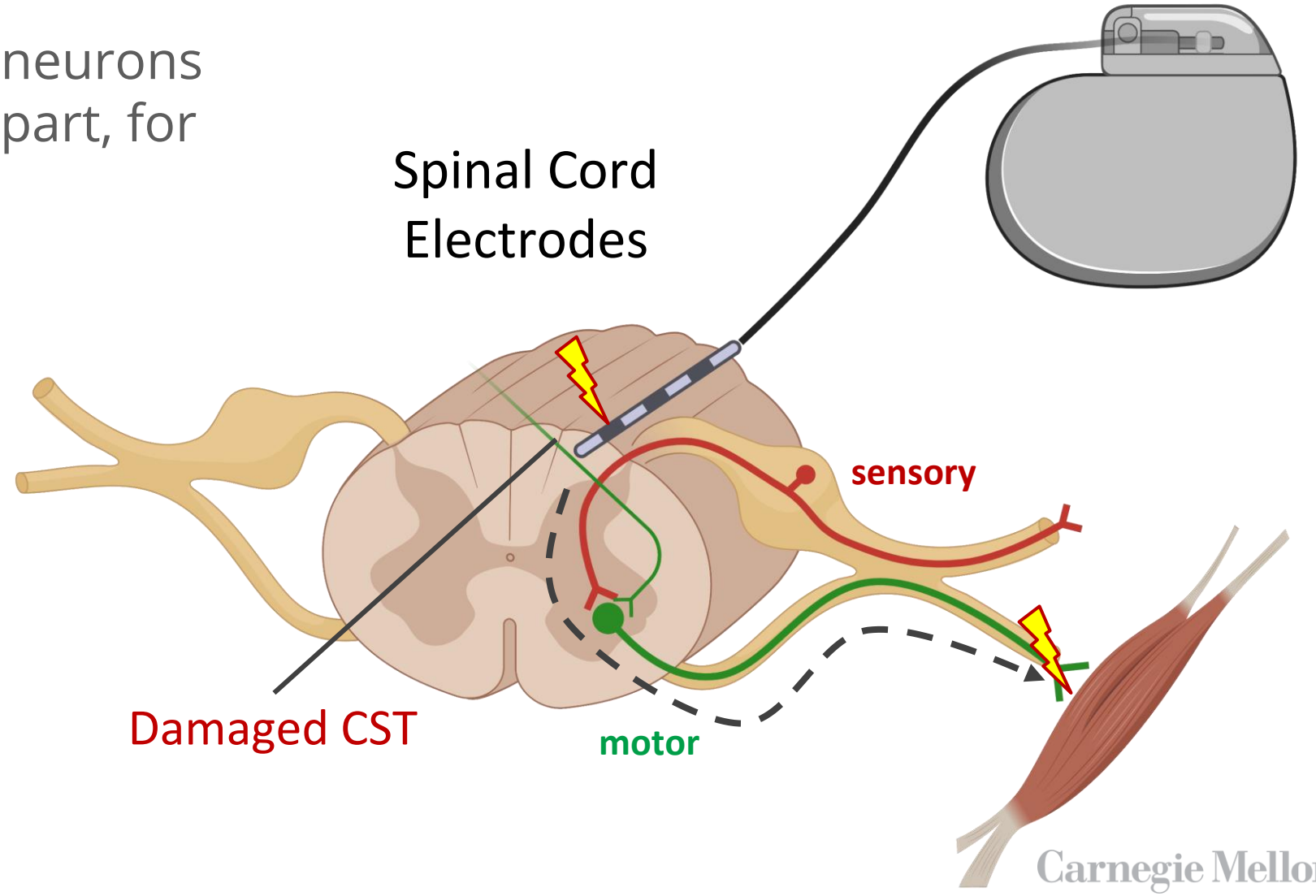


- Muscle weakness throughout the limb
- Abnormal coordination
- Spasticity
- Impaired sensation



Electrical Stimulation of Primary Afferent Neurons Drives Inputs to Spinal Motor Neurons

Stimulating DRG neurons compensates, in part, for loss of CST input



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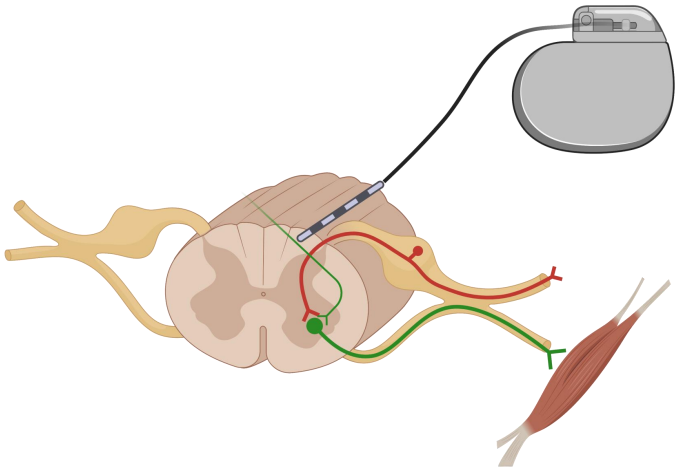
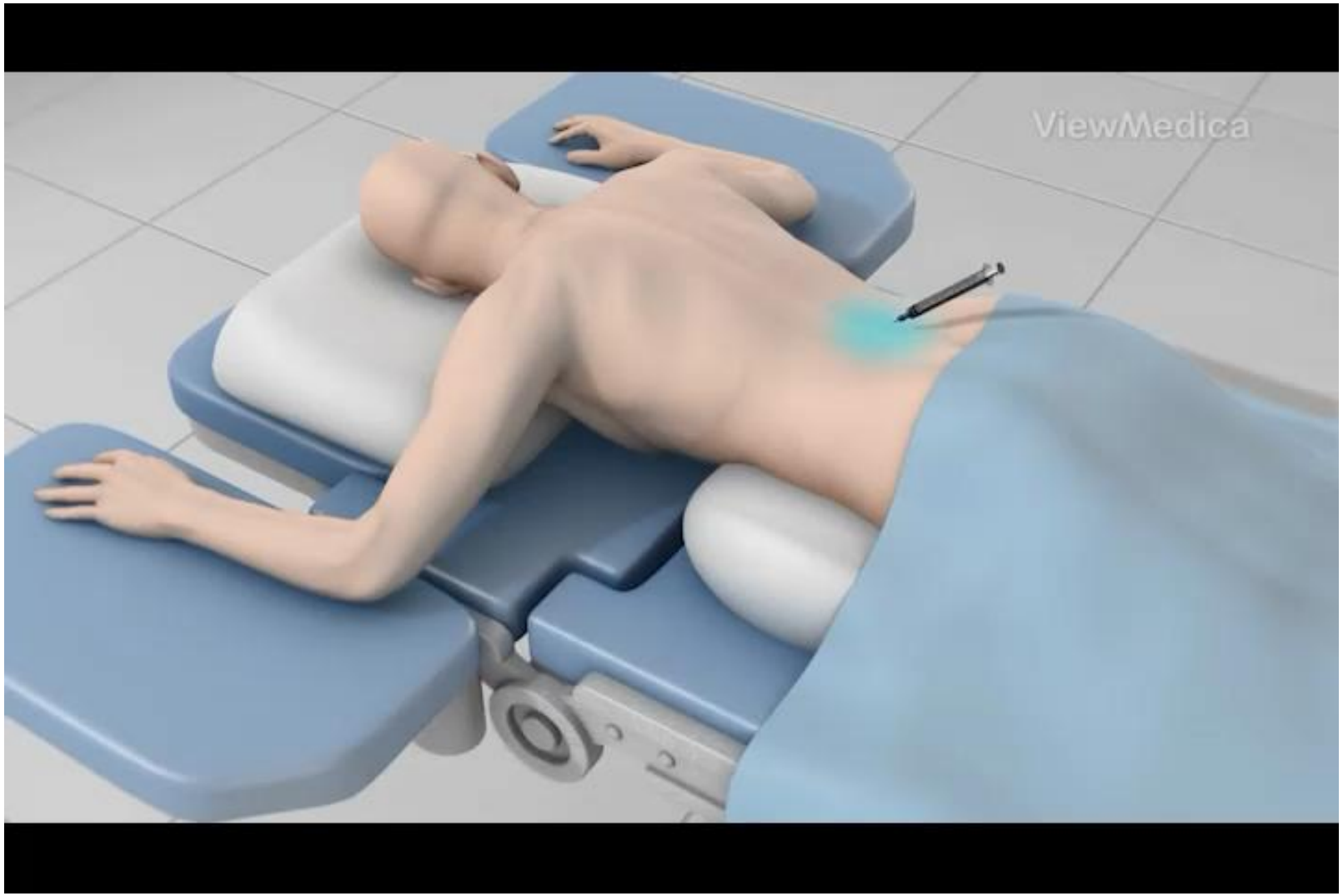
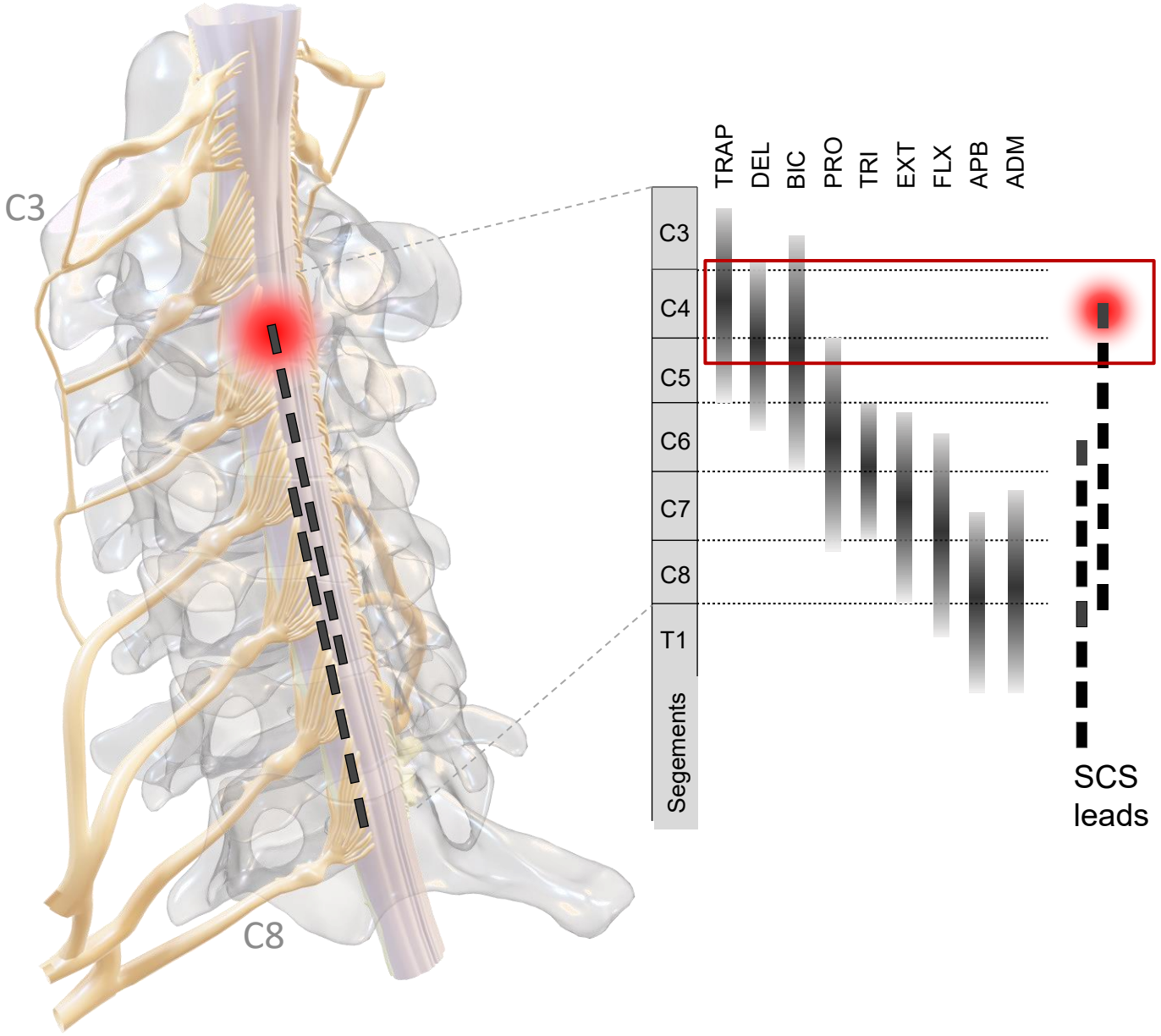
Epidural Spinal Cord Stimulation (SCS) for Stroke Rehabilitation

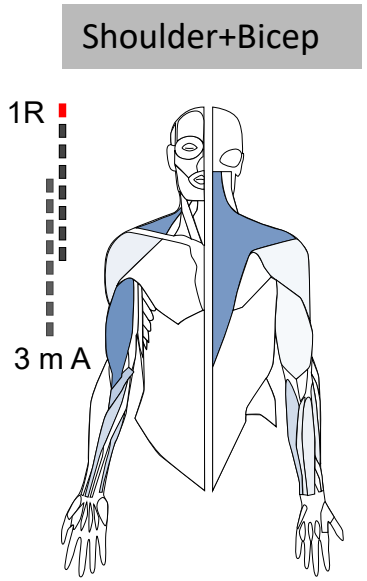
2 x Percutaneous linear spinal leads positioned over cervical dorsal root entry zone (30 days)





SCS selectively recruits muscles





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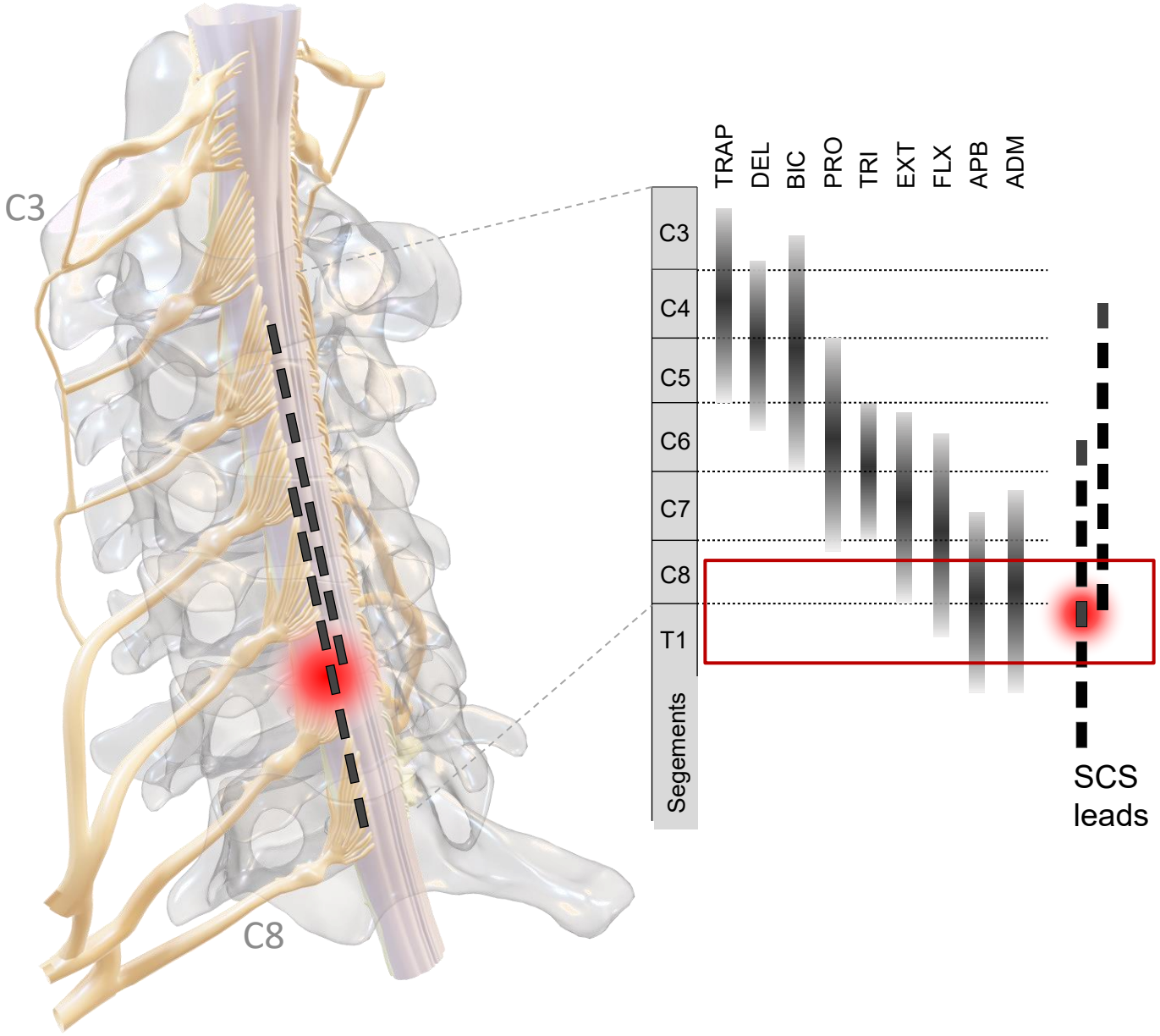

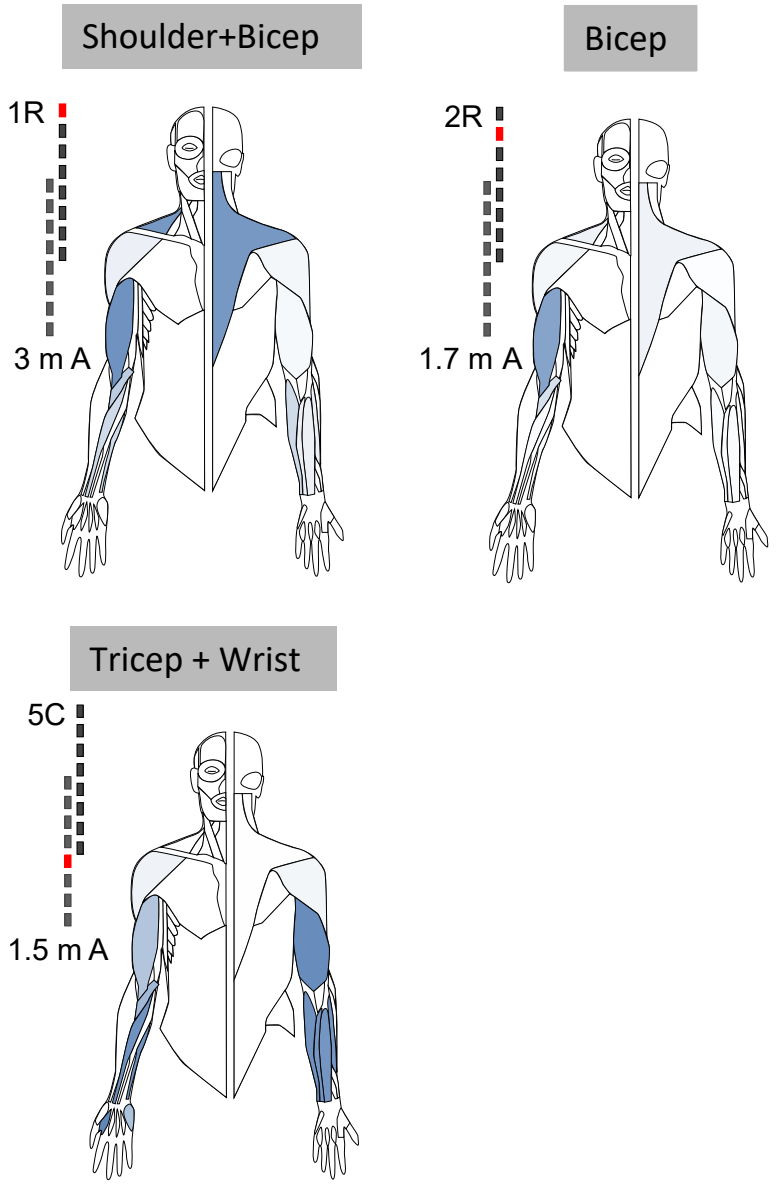

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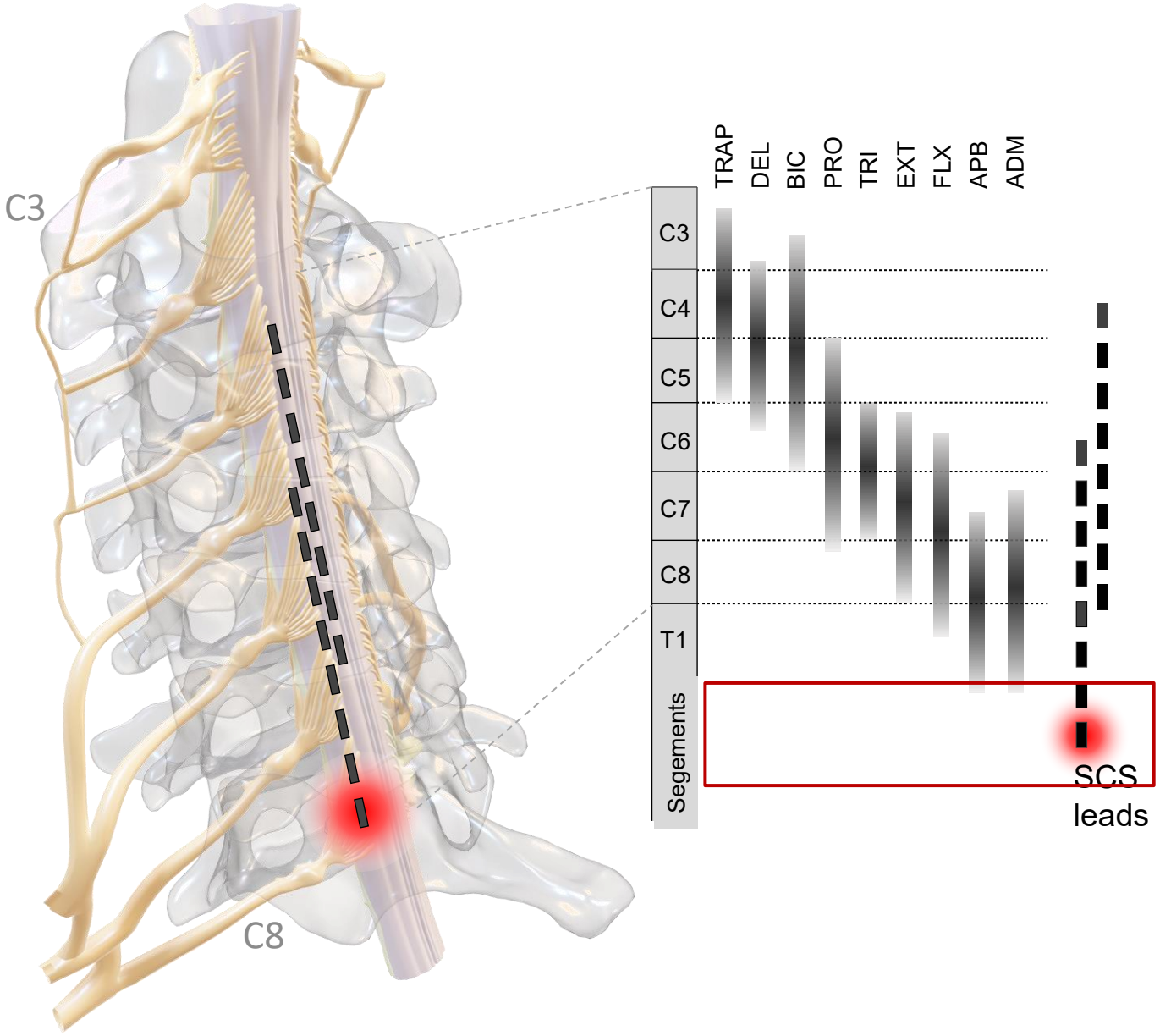
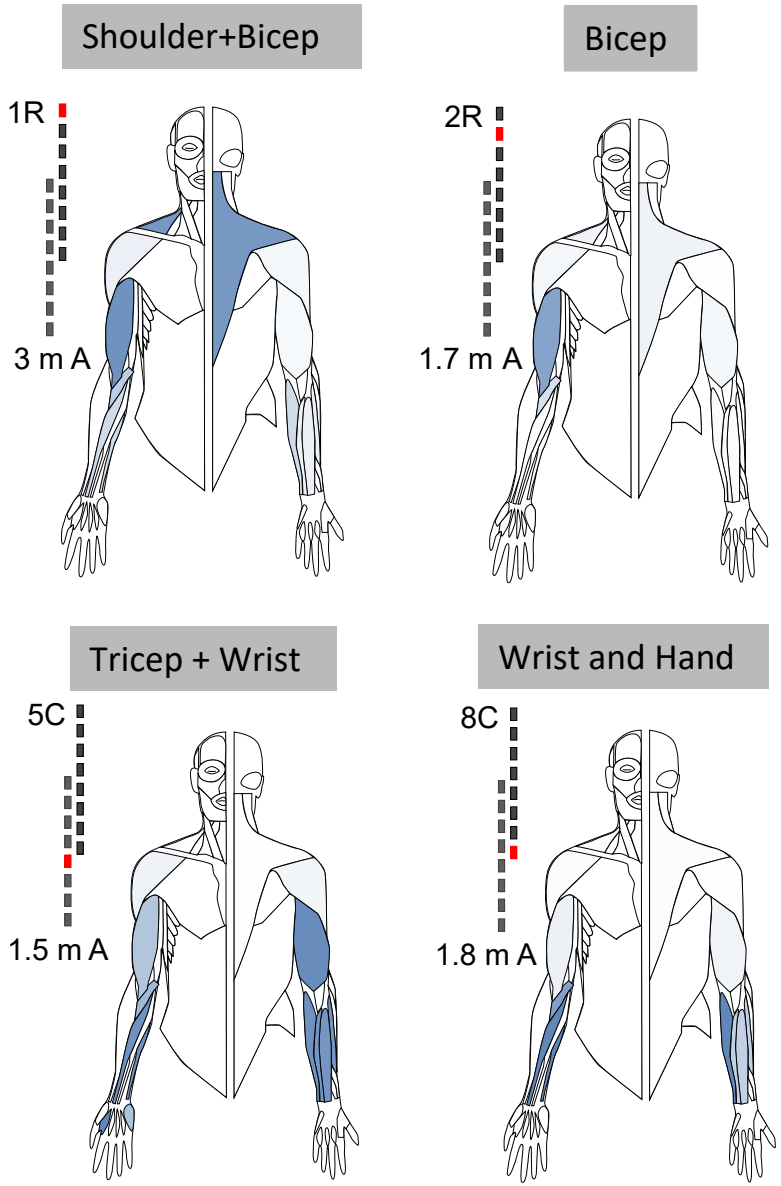
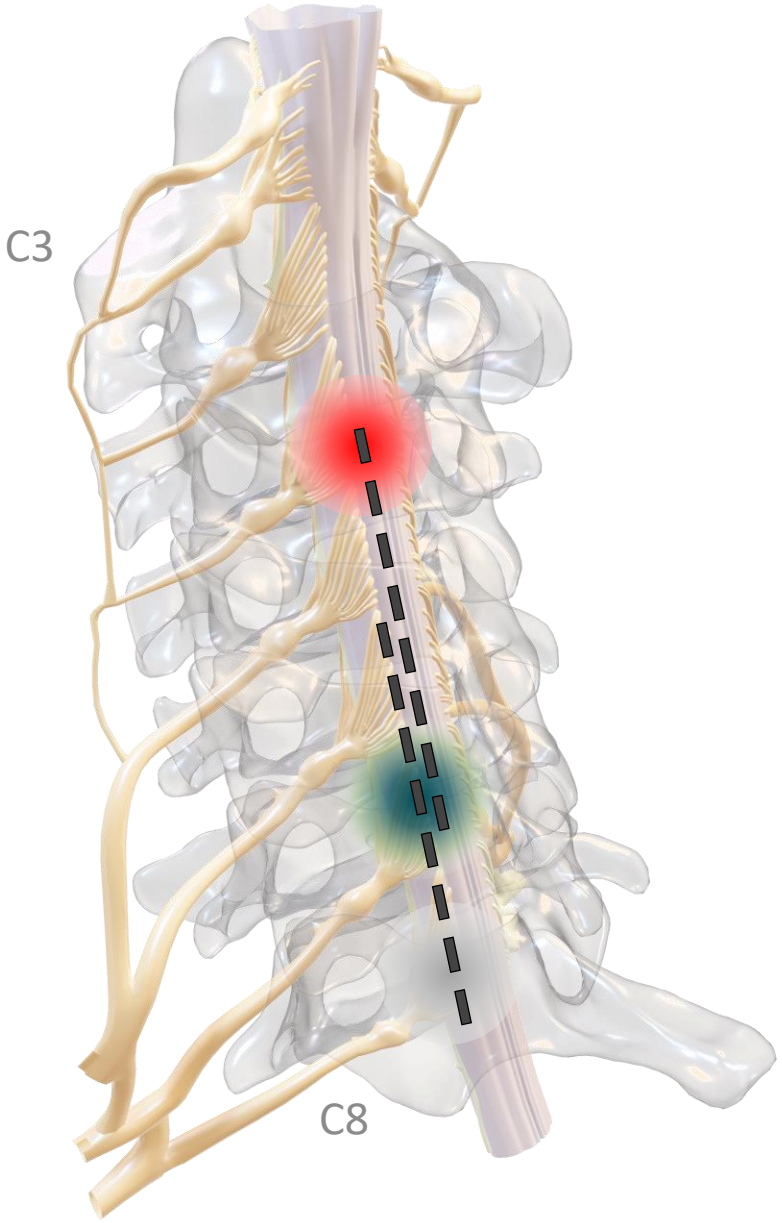




Functional restoration through targeted **(sub threshold)** SCS



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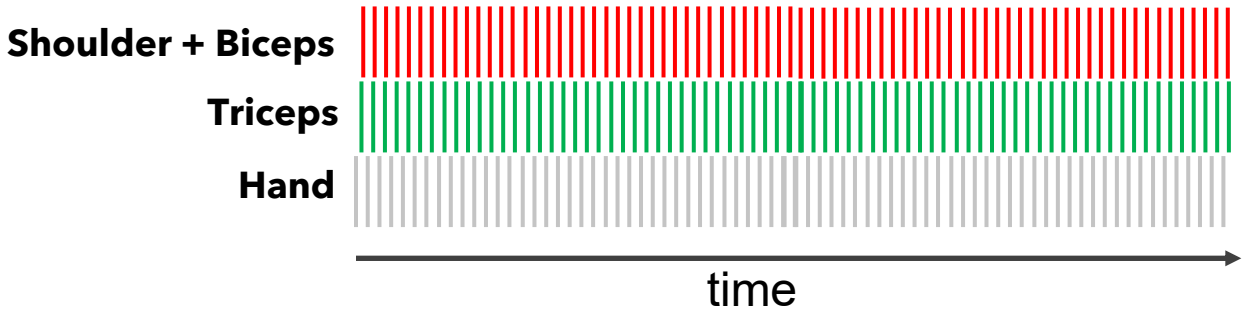
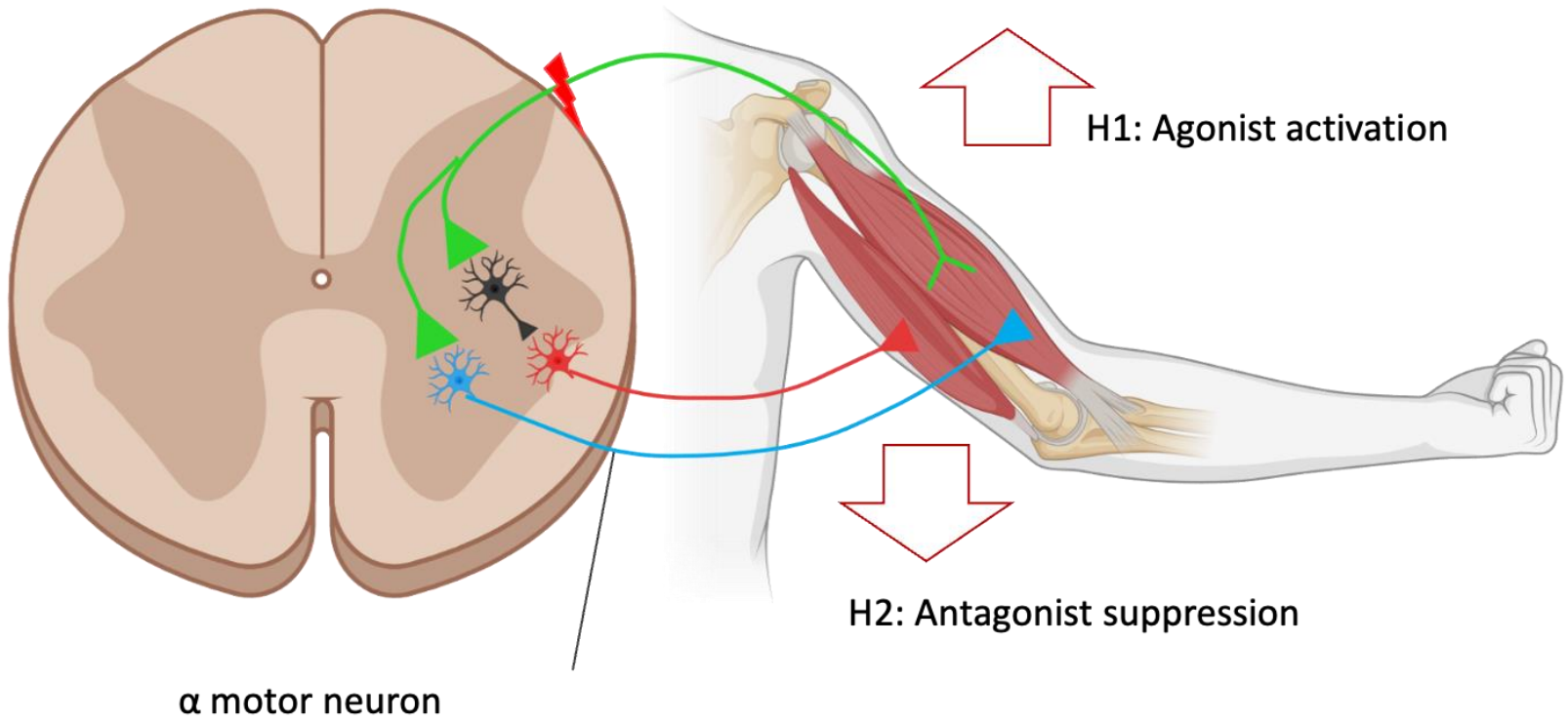
EPIDURAL STIMULATION OF THE CERVICAL SPINAL CORD FOR POST-STROKE UPPER LIMB PARESIS

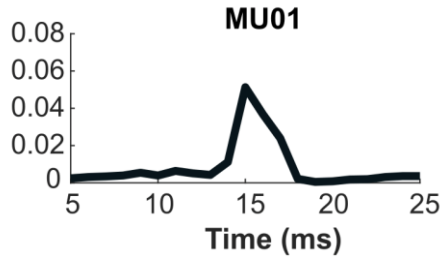


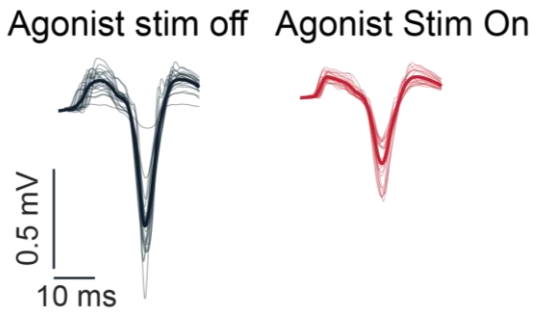
SCS Improves Function for Daily Activities

Takeaway: Electrical stimulation of DRG neurons restores natural control of agonist-antagonist activity

Synergistic effects of agonist facilitation and antagonist inhibition yield net increases in joint torque



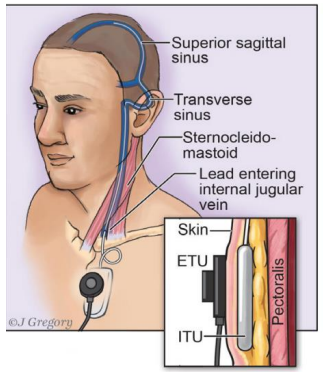


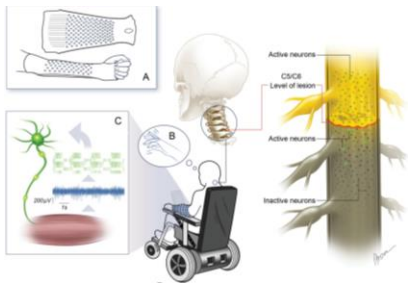


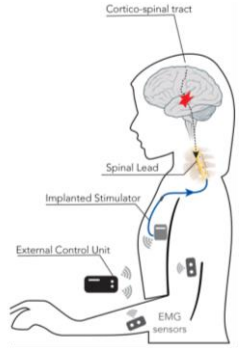
Summary

Implantable brain-computer interfaces and wearable myoelectric interfaces can detect and interpret motor intent to restore independent motor function to people with severe paralysis.

Electrical stimulation of dorsal root ganglion (DRG) neurons can amplify motor output and improve motor control in the arm and hand in people with chronic hemiplegia after stroke







Questions?

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Funding

NIH National Institutes of Health

National Institute of Neurological Disorders and Stroke

NIH The BRAIN Initiative®

Meta