Effects of Movement-Based and Cognitive Priming on Brain Function

Hannah Ryan, SPT
Katie Fabian, SPT
Michael Lewek, PT, PhD
Jessica Cassidy, PT, PhD
UNC – Chapel Hill

THE UNIVERSITY *of* NORTH CAROLINA *at* CHAPEL HILL

UNC SCHOOL OF MEDICINE Allied Health Sciences
Division of Physical Therapy

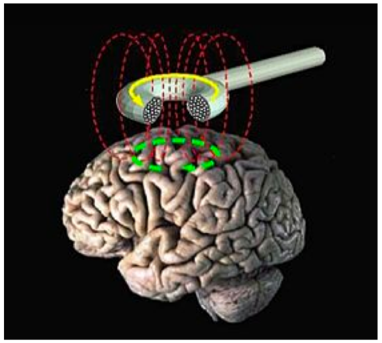
What is “Priming” in Neurorehabilitation?

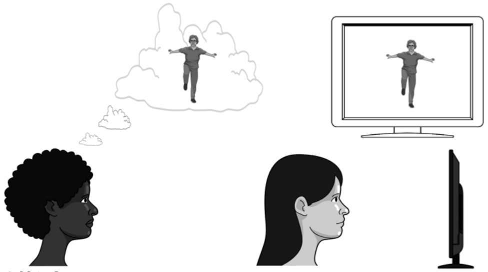
Stimulus → Intervention → Outcome

Types of Priming

Priming

- Stimulation-based
- Pharmacological
- Cognitive
- Movement-based

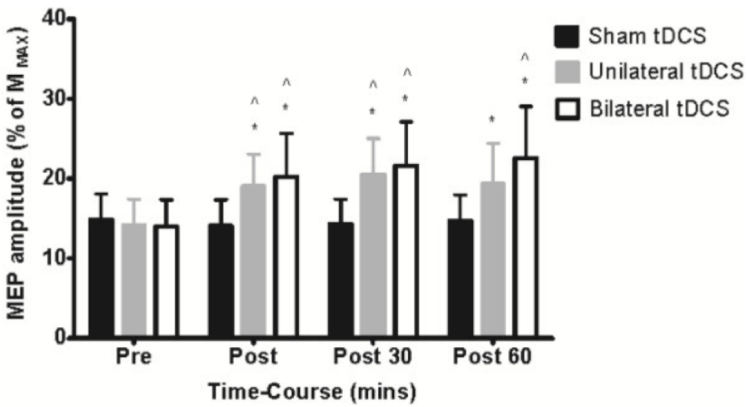




Cuenca-Martinez et al., 2018

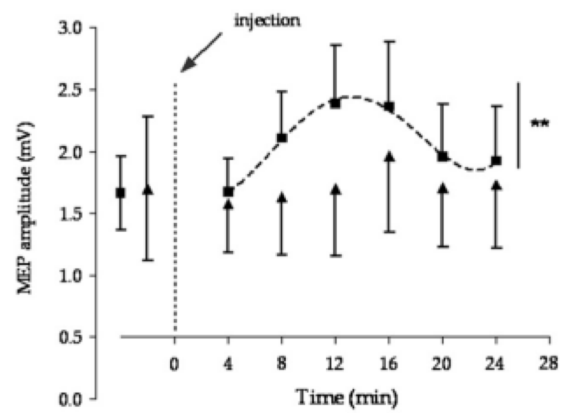
Widely Studied Modes of Priming

Stimulation-Based



Kidgell et al., 2013

Pharmacological



Milani et al .,2010

These modes of priming have the potential to enhance motor learning through increases in cortical excitability.

"Clinic-Ready" Modes of Priming

Cost=low

Equipment=minimal

Contraindications=few

Training=minimal

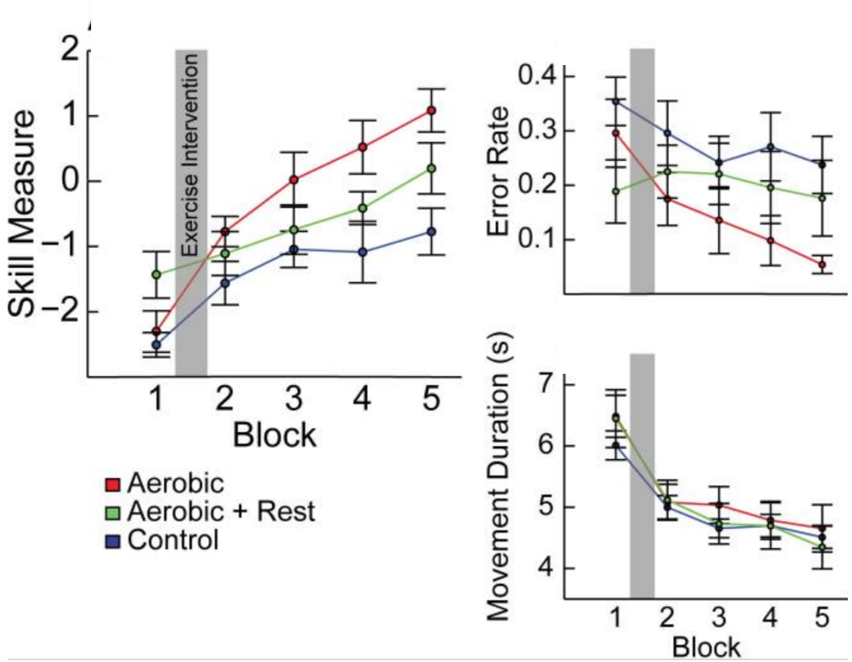
Stoykov et al., 2015; Stoykov et al., 2017

Clinically Feasible (Clinic-ready) Modes of Priming

- **Movement-based**
  - Bilateral
  - Unilateral
  - Aerobic
- **Cognitive**
  - Motor Imagery
  - Action Observation

Modulation of Motor Learning with "Clinic-Ready Priming"

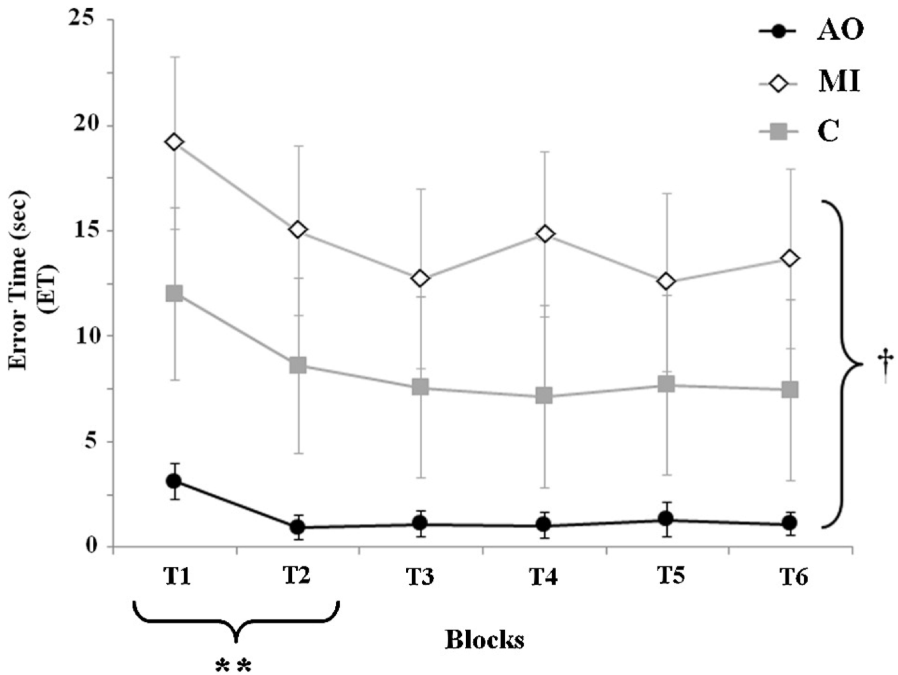
Movement-based: Aerobic



Statton et al. 2015

Modulation of Motor Learning with "Clinic-Ready Priming"

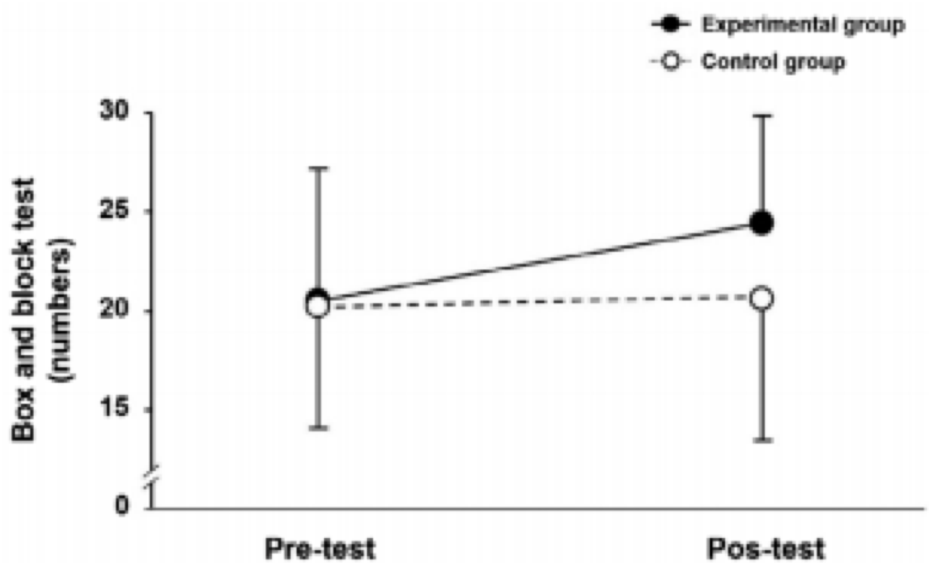
Cognitive: Action Observation (healthy)



Gonzalez-Rosa, 2015

Modulation of Motor Learning with "Clinic-Ready Priming"

Cognitive: Action Observation (stroke)



Kuk et al. 2016

Despite these encouraging findings, we do not understand the neurological underpinnings of movement-based and cognitive priming.

Importance of Understanding Neurological Underpinnings

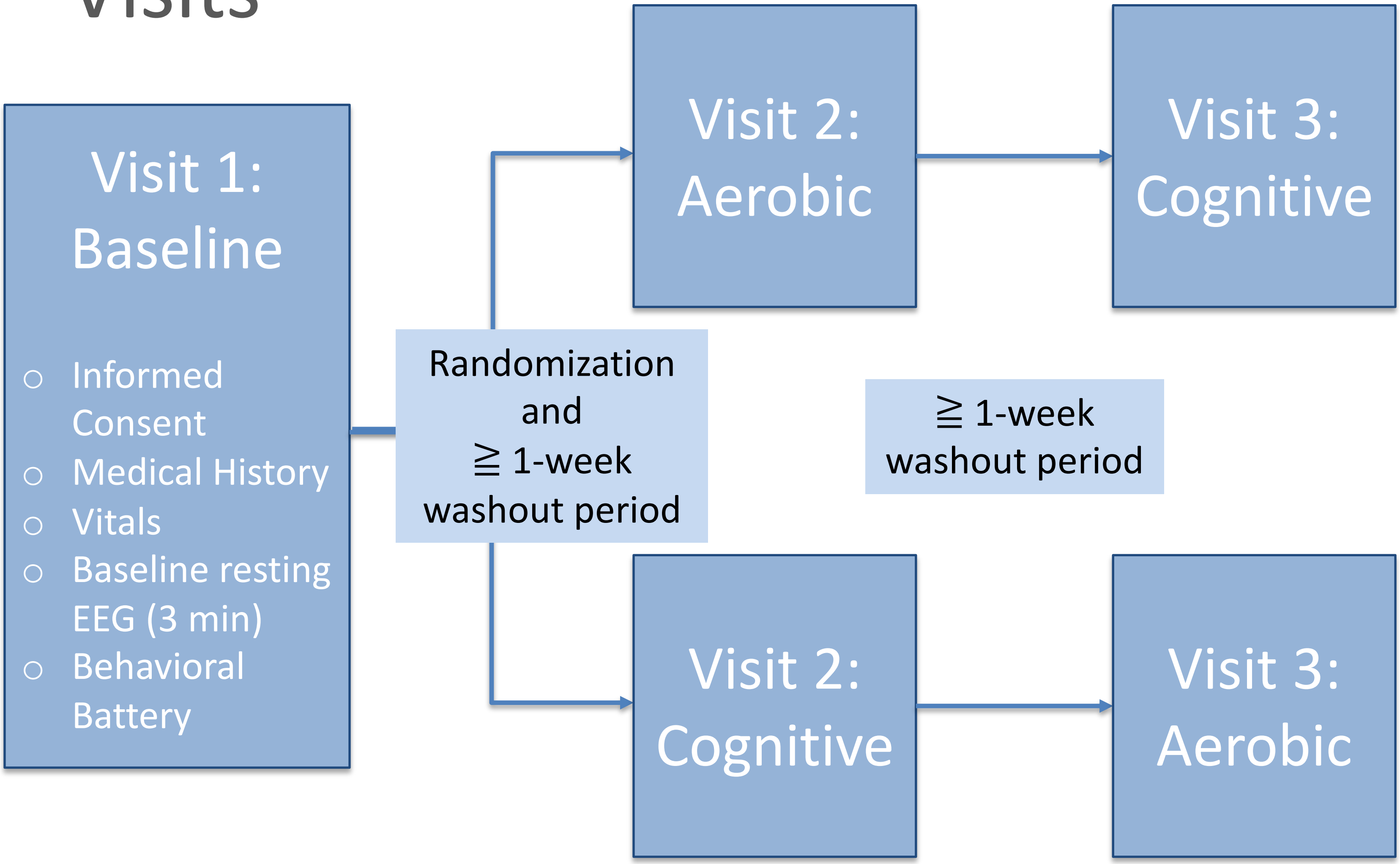
- To identify characteristics of “responders”
- To properly dose priming intervention
  - Timing
  - Duration
  - Type

Purpose/Hypothesis

- **Purpose:** to elucidate the neurological underpinnings of movement-based (aerobic) and cognitive priming (action observation) in healthy individuals using EEG

- **Hypothesis:** EEG recordings will reveal changes in power and coherence in motor-related brain regions in the **high beta frequency range**

Visits


Visit 1: Baseline
Informed Consent
Medical History
Vitals
Baseline resting EEG (3 min)
Behavioral Battery
Randomization and ≧ 1-week washout period
Visit 2: Aerobic
Visit 3: Cognitive
≧ 1-week washout period
Visit 2: Cognitive
Visit 3: Aerobic

Visits

Visit 1: Baseline

- Informed Consent
- Medical History
- Vitals
- Baseline resting EEG (3 min)
- Behavioral Battery

Randomization

Aerobic Priming:

- Vitals
- 3-minute resting EEG
- 5-minute walk on treadmill at 60 - 80% maxHR
- HR and O2 saturation monitored continuously during walking activity.
- Only treadmill speed (not incline) was adjusted
- 3-minute EEG post-intervention

Visits

Visit 1: Baseline

- Informed Consent
- Medical History
- Vitals
- Baseline resting EEG (3 min)
- Behavioral Battery

Randomization

Cognitive Priming:

- Vitals
- 3-minute resting EEG
- Watch 5-minute video of people walking on treadmill-attention task
- 3-minute EEG post-intervention

EEG

Collection

Data Pre-Processing

Laplacian

Coherence and Power

- Dense-array 256-lead EEG system
- 3-minute EEG recordings
- Participants seated and resting while maintaining attention on screen two feet away.

EEG

Collection

Data Pre-Processing

Laplacian

Coherence and Power

- Matlab
- Low and high-pass filters set (40 Hz and 0.5 Hz)
- Visual inspection
- Independent Component Analysis (ICA)
- Removal of muscle activity, line noise, eye movement, etc.

EEG

Collection

Data Pre-Processing

Laplacian

Coherence and Power

- Spatial filter to mitigate effects of volume conduction

EEG

Collection

Data Pre-Processing

Laplacian

Coherence and Power

Outcome Measures

Coherence

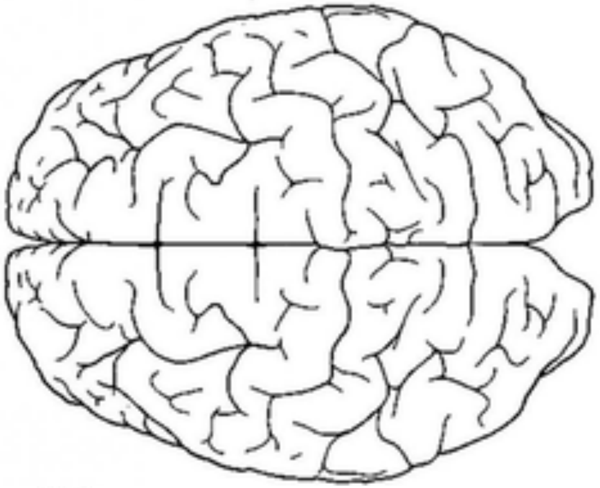
- Functional connectivity
- Consistent differences in signal amplitude and phase.
- Values range from 0 (random amplitude and phase differences) to 1 (consistent amplitude and phase differences)

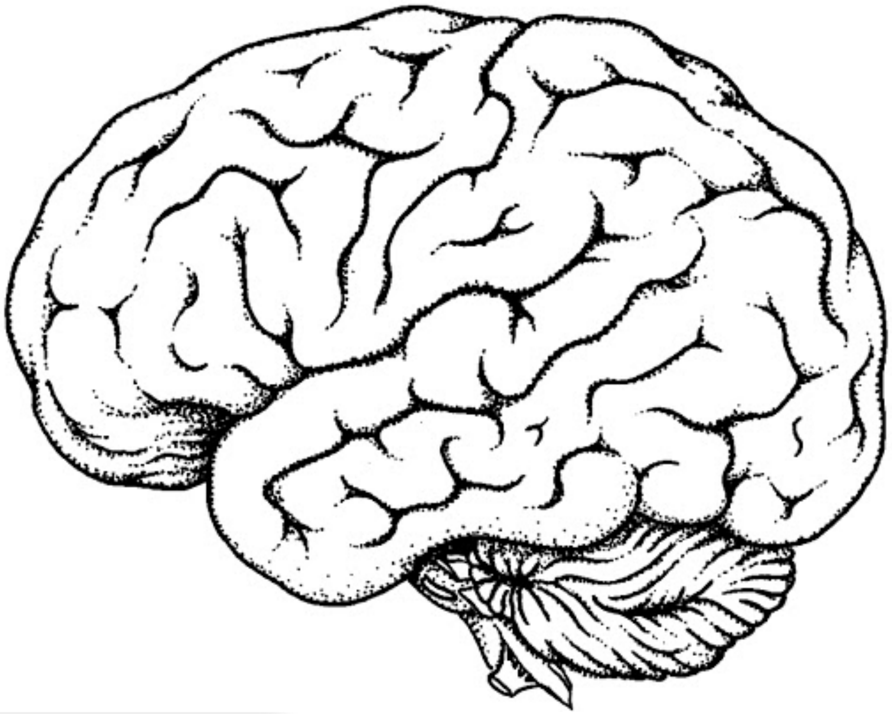
Power

- Magnitude of electrical activity in a defined frequency band
- Relative power of given electrodes compared to total power in 20 – 30 Hz range

Areas of Interest

- left (dominant hemisphere) primary motor cortex (lM1)
- supplementary motor cortex (SMA)
- left dorsal premotor cortex (lPMd)
- left parietal (lPr) cortex
- right M1 (rM1)





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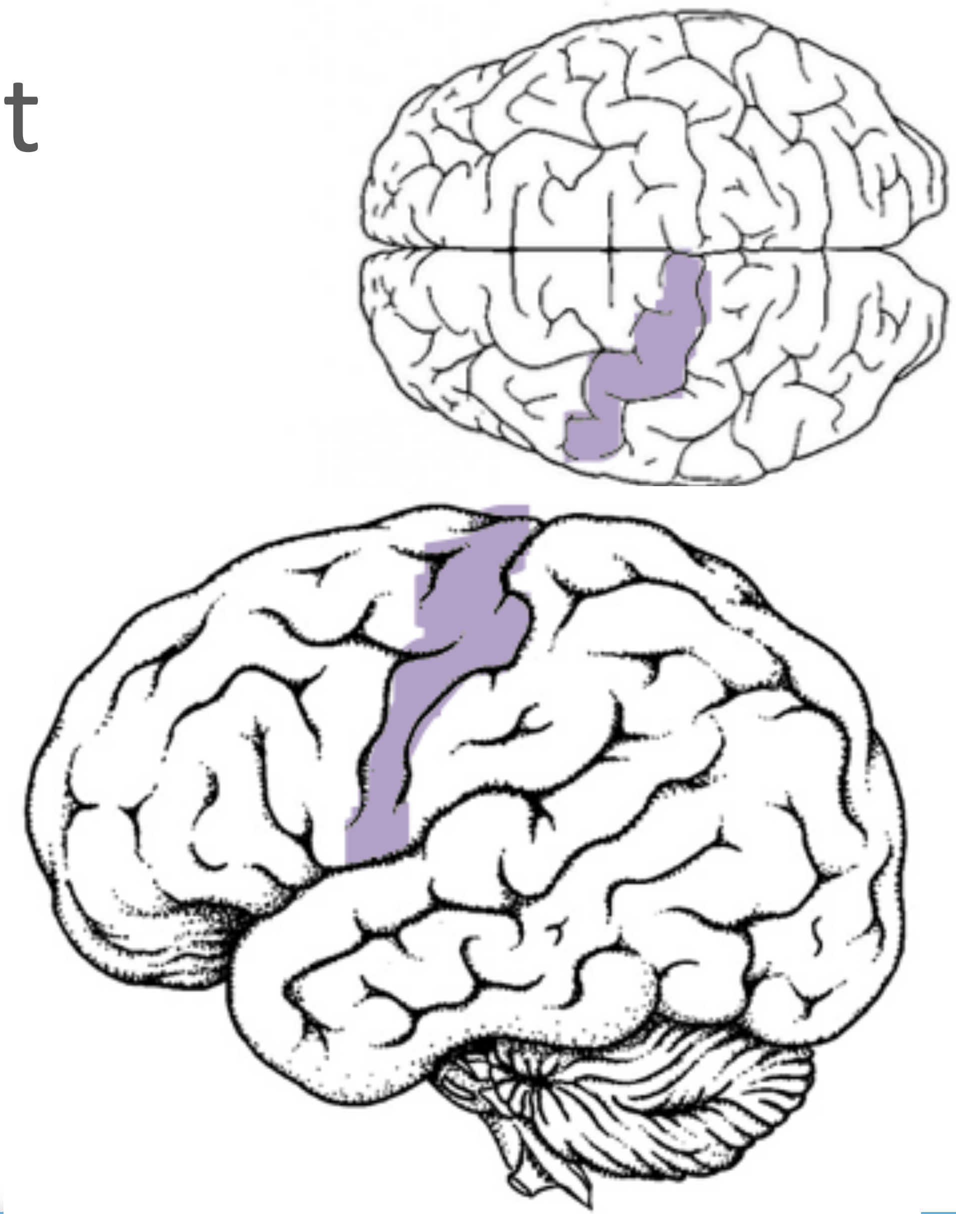

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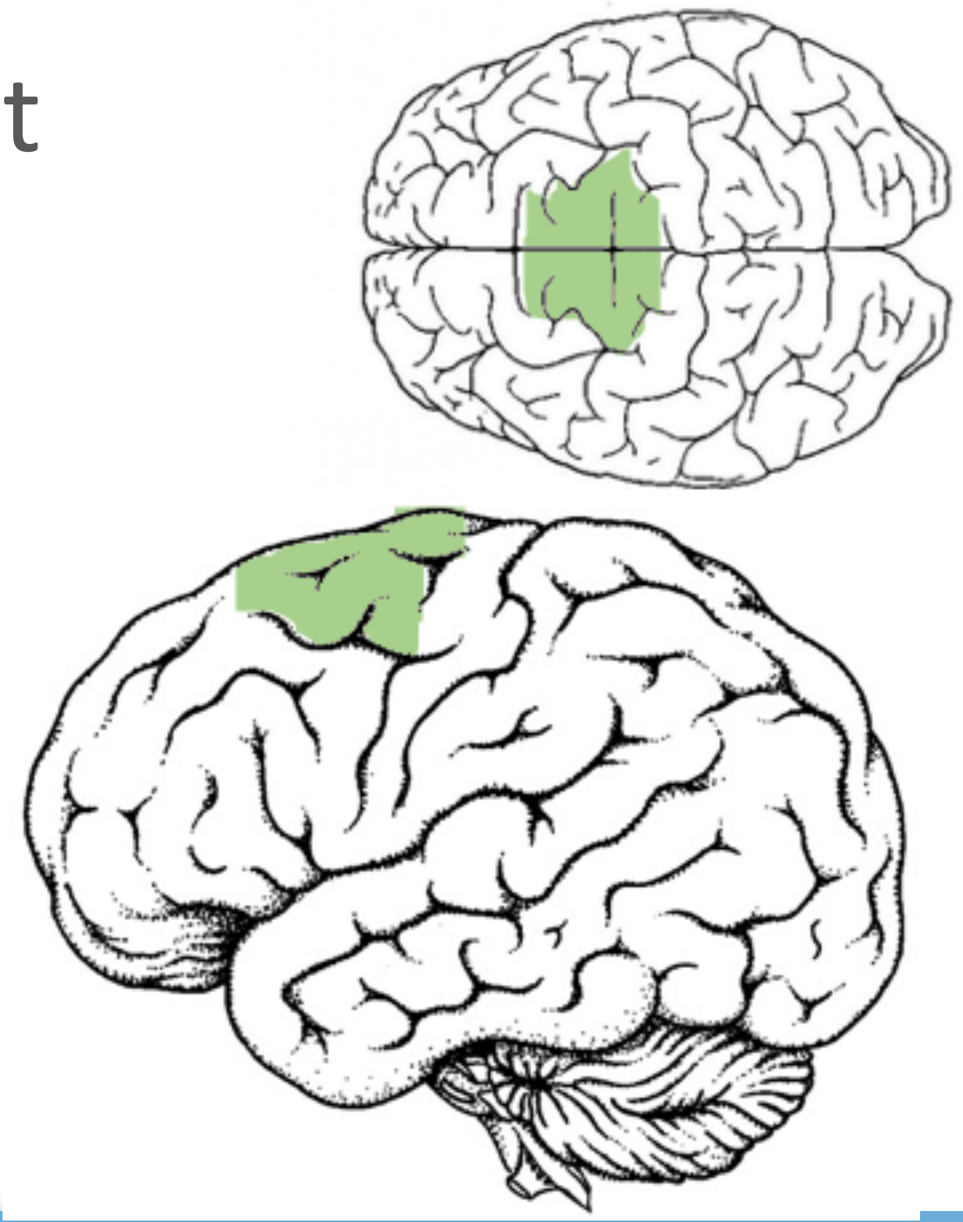

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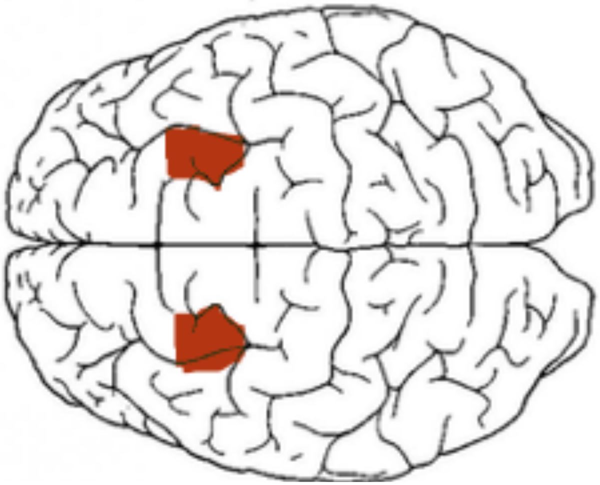

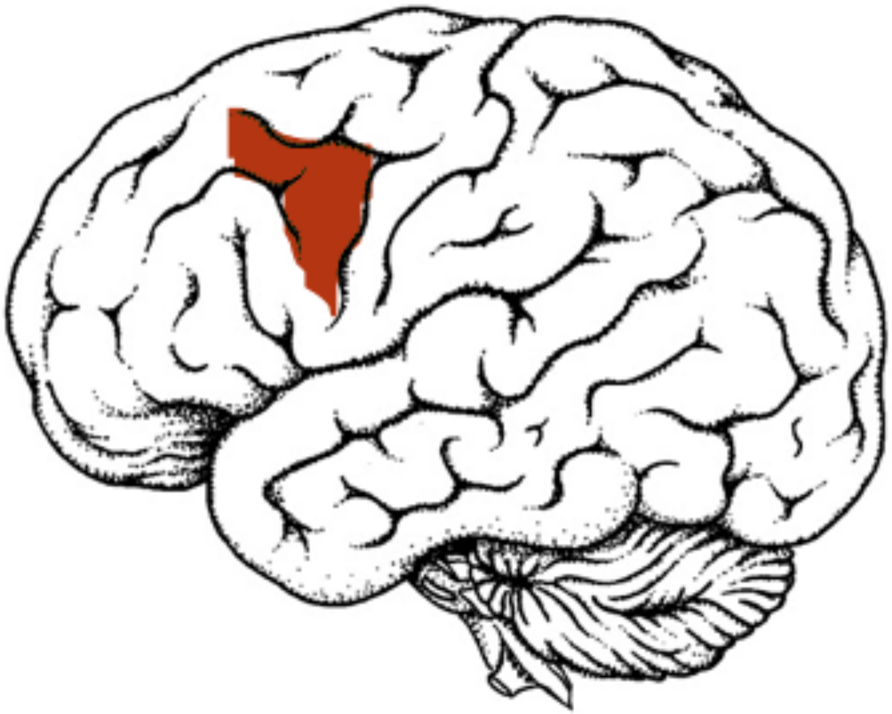

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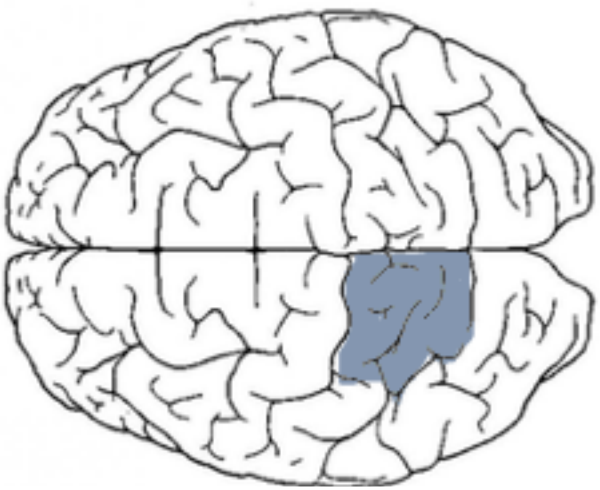

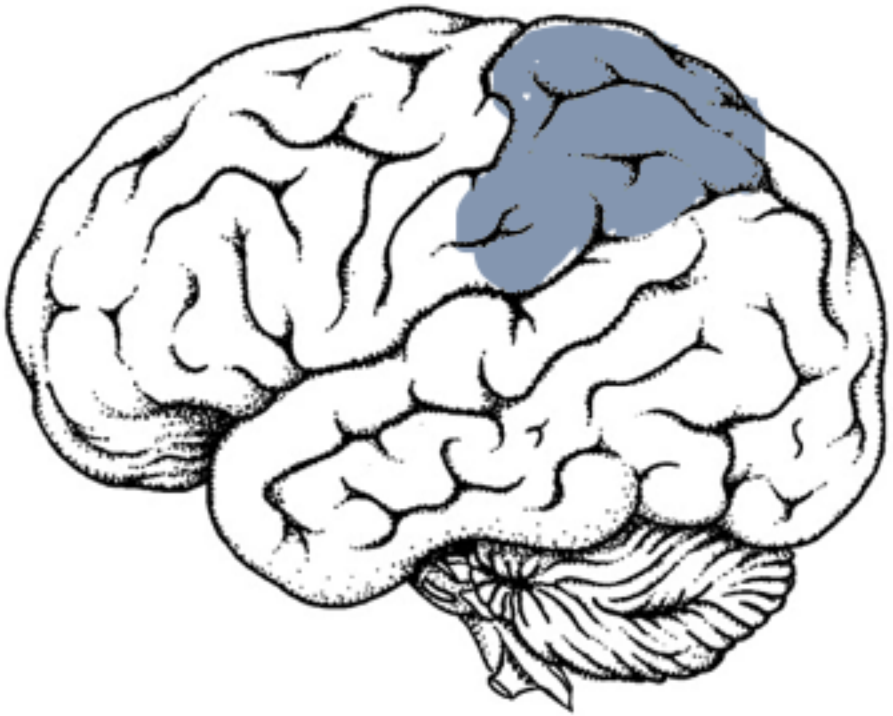

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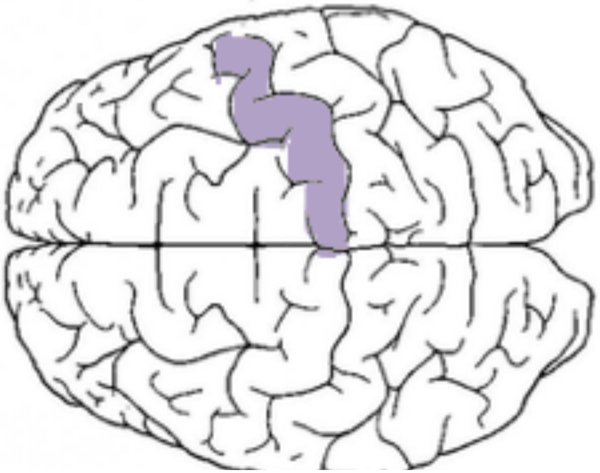

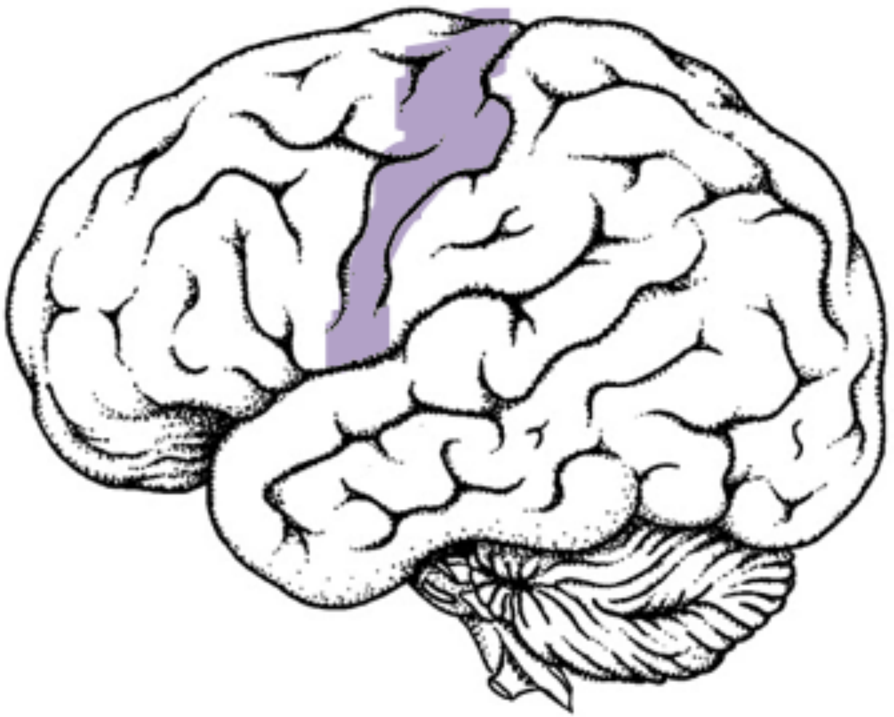

Participants

- 18 Participants enrolled.
- Full data collected from 17 individuals.
- 9 of the 17 data collections were useable after processing.

Measure	Mean	St Dev
Vitals		
R HR (bpm)	68.63	± 12.22
R BP (mm HG)	114.3 / 70.8	± 13.66 / 7.48
Age (years)	24.24	± 2.76

Handedness	
R	100.0%
Sex	
Female	77.8%
GPPAQ	
Active	66.7%
Moderately Active	11.1%
Inactive	11.1%
Moderately Inactive	0.0%

Results

Coherence

- Significant increase in high beta frequency band between lM1 and SMA after 5 min aerobic priming intervention.

Power

- No significant changes in power in any distinct areas found due to aerobic or cognitive priming

Limitations / Discussion

- 5 minute duration of priming intervention
  - Clinical relevance
- Ramp up time to THR during aerobic priming extended duration of intervention

	Mean	Standard Deviation
Time before starting 5 minute walk	178.8 seconds	± 74.3 seconds

Limitations / Discussion

- Time to initiation of post-intervention EEG varied significantly between modes of priming

	Mean	Standard Deviation
Aerobic	221.1 seconds	± 73.9 seconds
Cognitive	46 seconds	± 28 seconds

Importance/Takeaways

- Priming for lower extremity movement
- Use of EEG to further understand neurological effects
  - Most use TMS

Priming may be mode-specific for walking in healthy individuals.

Future Directions

- Analyze additional frequency bands
- Larger sample size
- 10-, 20-, 30- minutes post-priming intervention
- Instructions for action observation
- Patient populations

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