Resting State EEG in Early Stroke Rehabilitation

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Capstone Project

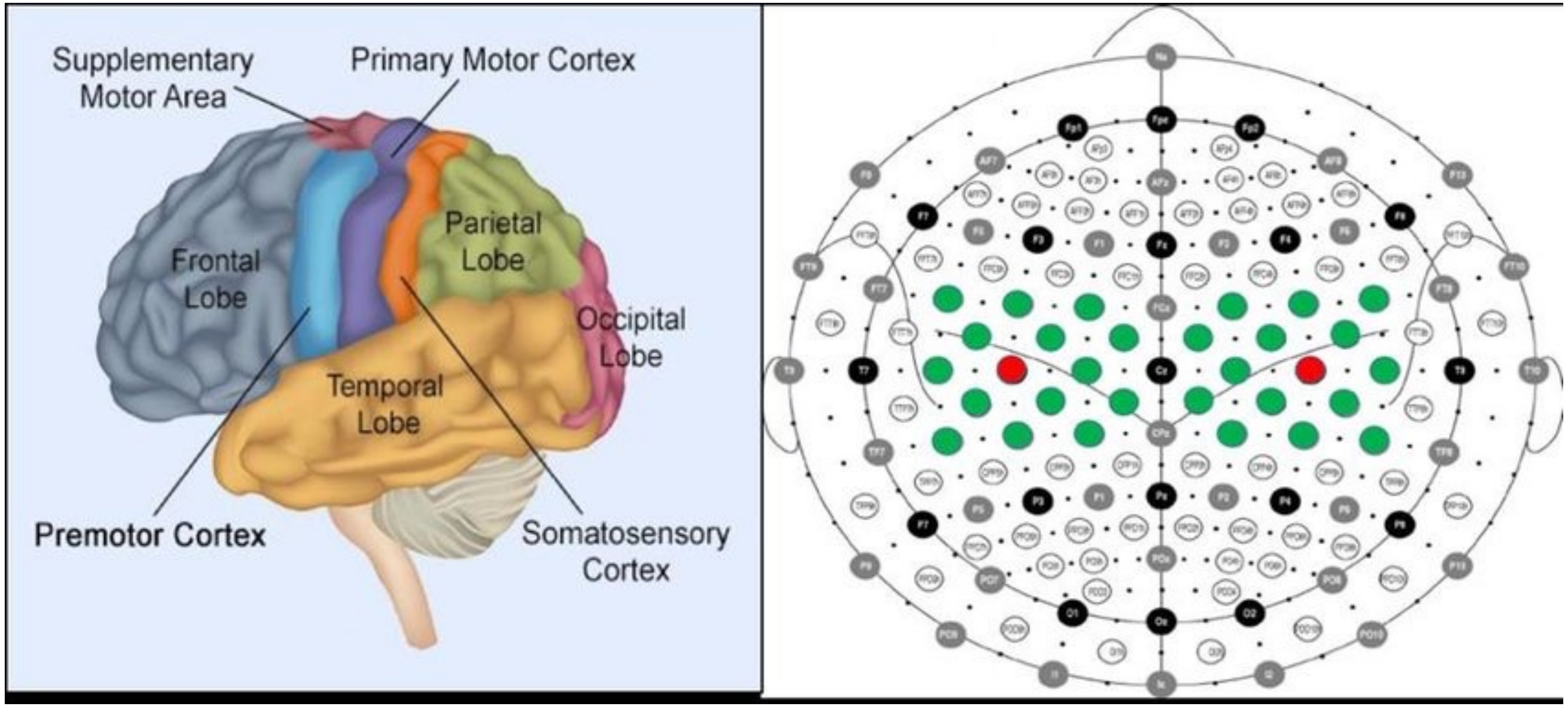
What is Electroencephalography (EEG)?

- Non-invasive tool that uses electrodes on scalp to measure electrical activity from large neurons of cerebral cortex
- Functional neuroimaging technique
- Brain waves used to determine active brain areas = function
- Resting state or task-oriented

Pros	Cons
temporal resolution (milliseconds), non-invasive, inexpensive, accessible	poor spatial resolution, prep time

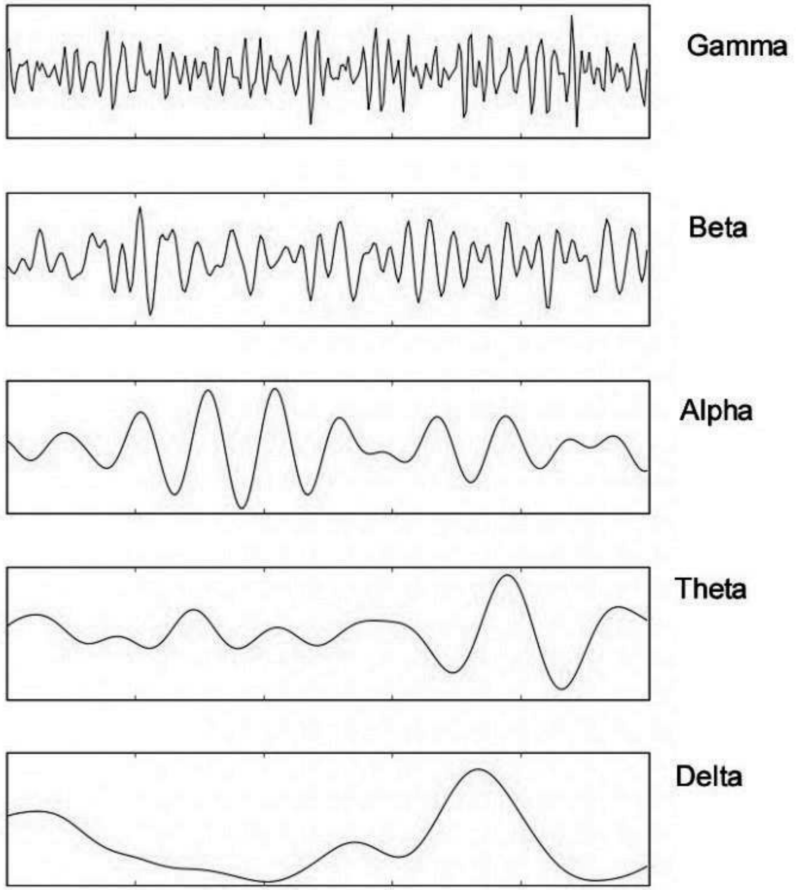
EEG Measures

- **Power**: synchronization <u>within</u> cortical regions
- **Coherence**: synchronization <u>between</u> cortical regions (connectivity)

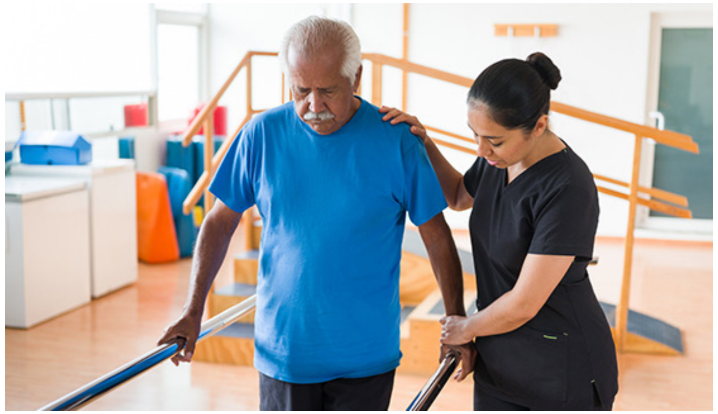


Neural Activity and Behavior

- Frequencies:
  - **Delta (1-3 Hz),** Theta (4-7 Hz), Alpha (8-12 Hz), Beta (13-30 Hz), Gamma (>30 Hz)
- Oscillations represent behavioral processes
  - Attention, working memory, movement preparation, learning, motivation, perception
- Literature is exploring use of EEG for stroke
  - Markers of cortical activity in stroke and recovery processes
  - Prognosis for recovery
  - Brain computer interface (Biasiucci, 2018)



EEG Applied to Stroke

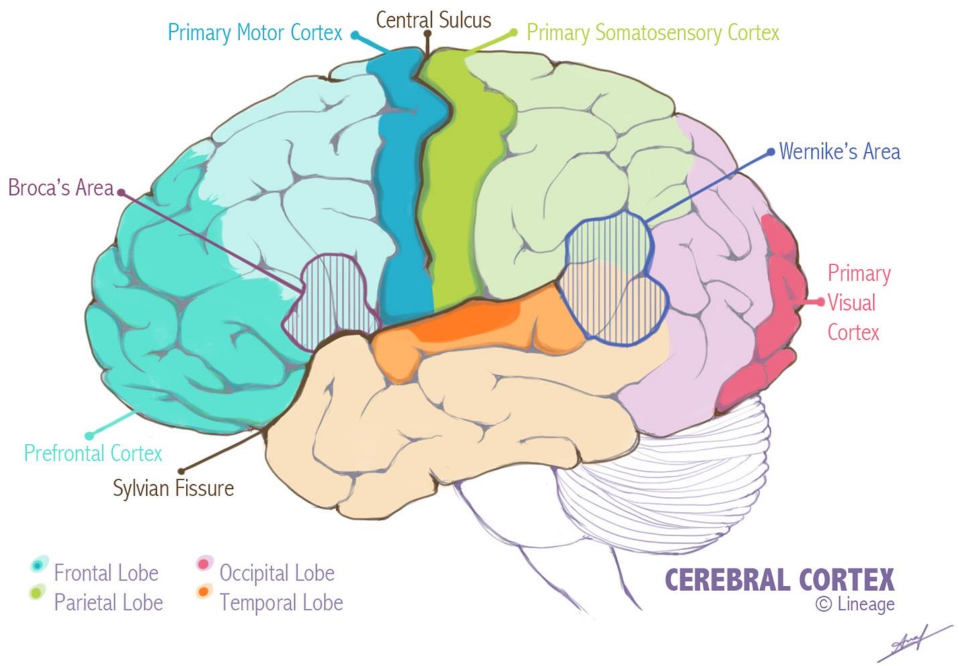


- Stroke is a heterogenous condition
- Structural neuroimaging is well-established, but functional measures still under development for clinical use (Boyd, 2019)
- Clinical measures: can help predict subsequent recovery
  - Challenge to determine outcomes, interventions, and goals based on clinical measures alone
- Neuroimaging biomarkers: can help predict **both motor recovery and motor outcome after stroke** (Stinear, 2017)
  - Combination of biomarkers can support a personalized rehab plan

Delta as a Biomarker in Previous Works

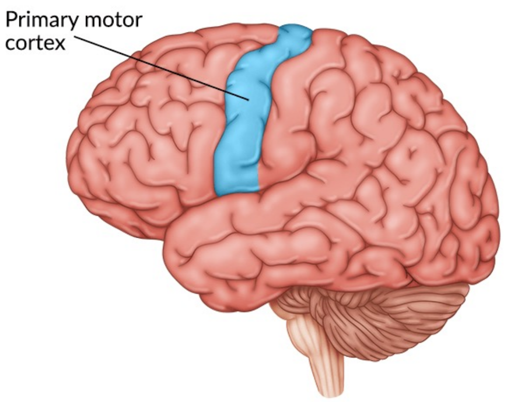
- Greater **delta power** in ipsilesional sensorimotor cortex and contralesional frontoparietal cortex
  - → greater motor impairment and stroke severity (Wu et al., 2016)
- Reduction in **delta coherence** between bilateral primary motor cortices
  - → improved motor recovery (Cassidy et al., 2020)

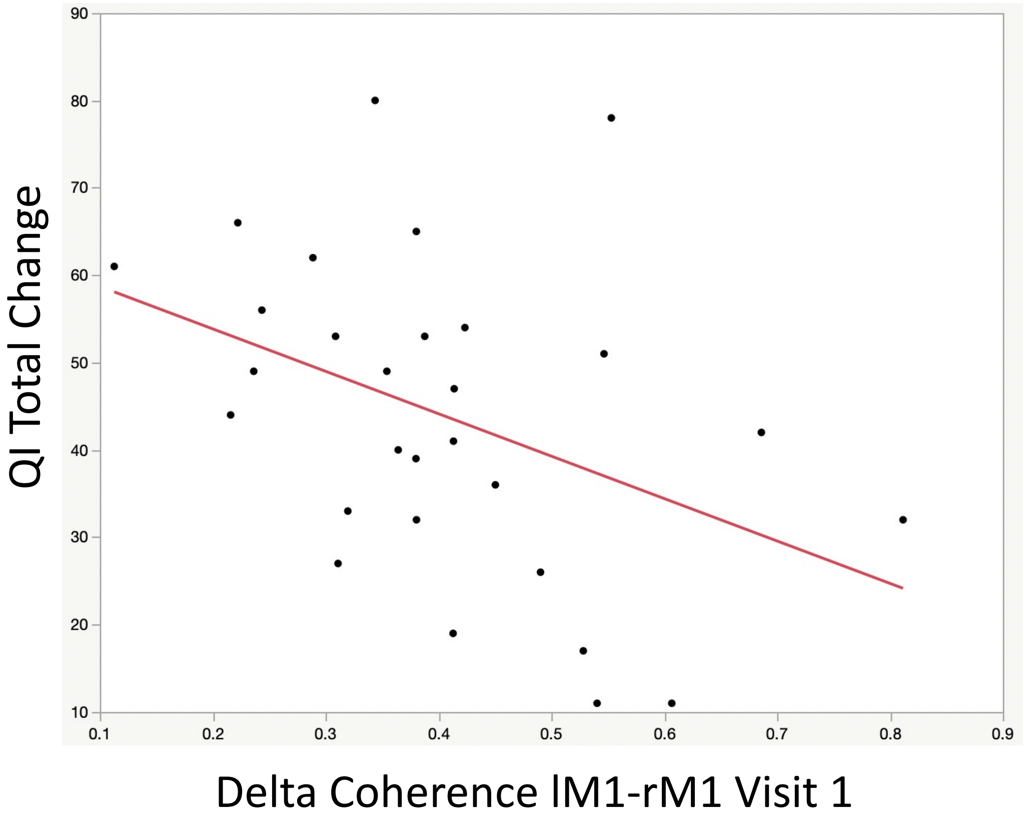
- **Delta (1-3 Hz) – associated with greater neural injury**



Our Research Findings

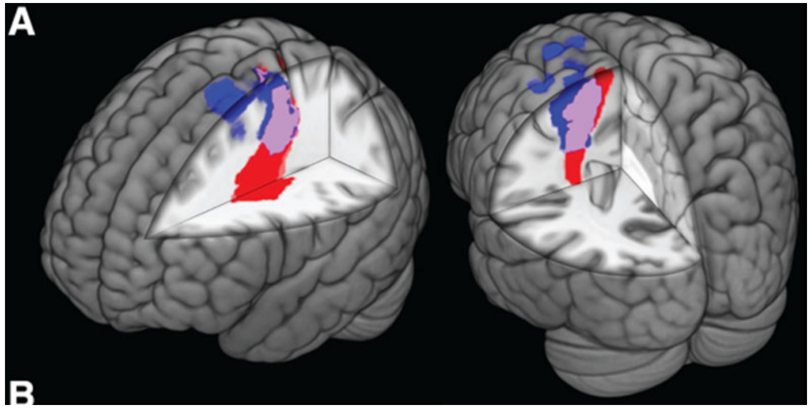
- Delta coherence between bilateral primary motor cortices at admission predicts **16% variance in QI change**
  - $R^2 = 16.2\%$
  - Statistically significant ($p = 0.03$)
  - Based on $n = 29$
- Negative relationship between delta coherence and QI change
  - Less delta coherence at admission = greater QI change at discharge



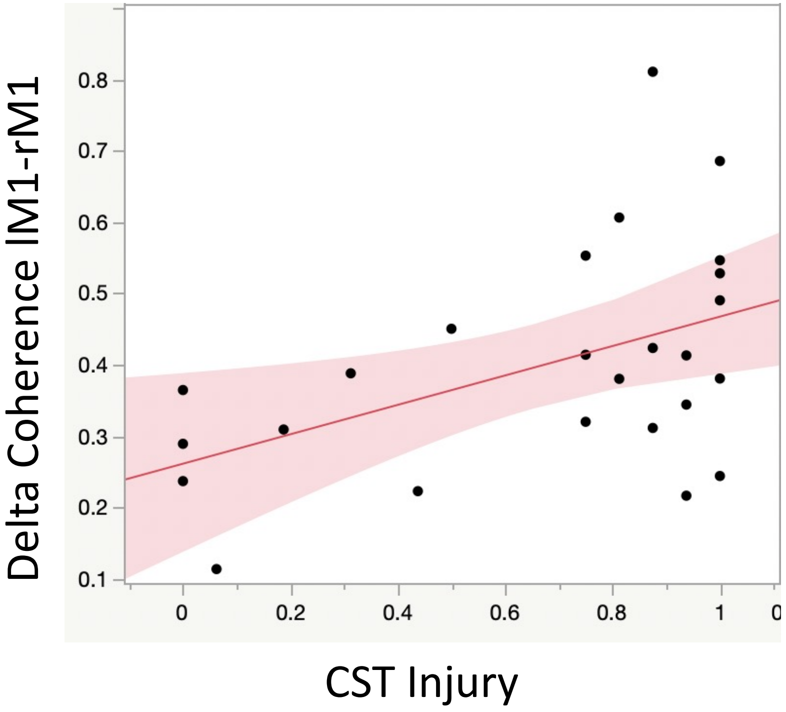


Our Research Findings

Lesion
Injury by lesion
CST



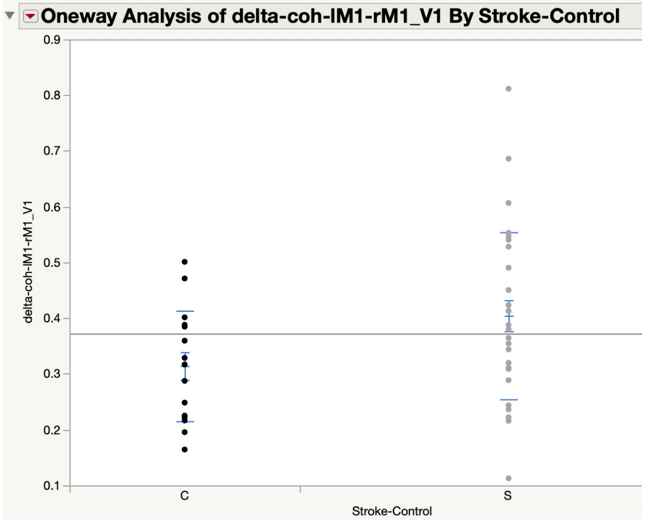
- Lower UEFM (greater motor impairment) at admission was associated with greater delta coherence
  - Negative correlation (ρ = -0.402)
  - Statistically significant (p = 0.031)
- CST injury at admission was associated with greater delta coherence
  - Positive correlation (ρ = 0.4223)
  - Statistically significant (p = 0.035)
- **Delta coherence reflects CST injury and motor impairment at admission**



Delta Coherence: Stroke vs. Controls

- <u>At admission</u>: delta coherence was significantly different
- <u>At discharge and 3 months post-stroke</u>: difference not significant

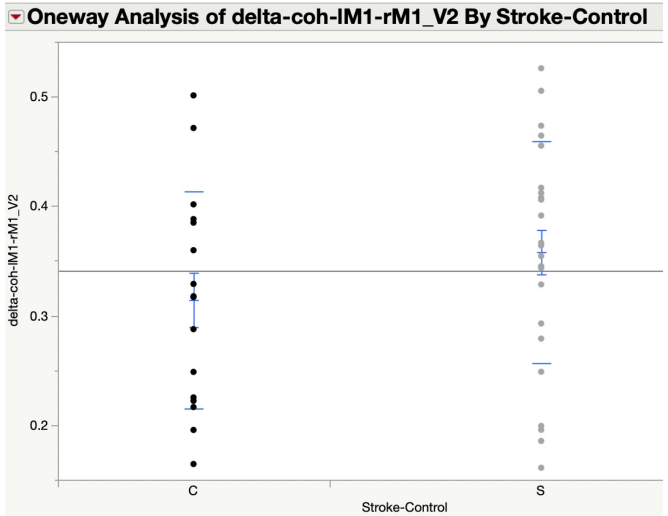
IRF Admission



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%
C	16	0.3142996	0.0991576	0.0247894	0.2614622	0.367137
S	29	0.4044146	0.1498192	0.0278207	0.3474264	0.4614028

IRF Discharge



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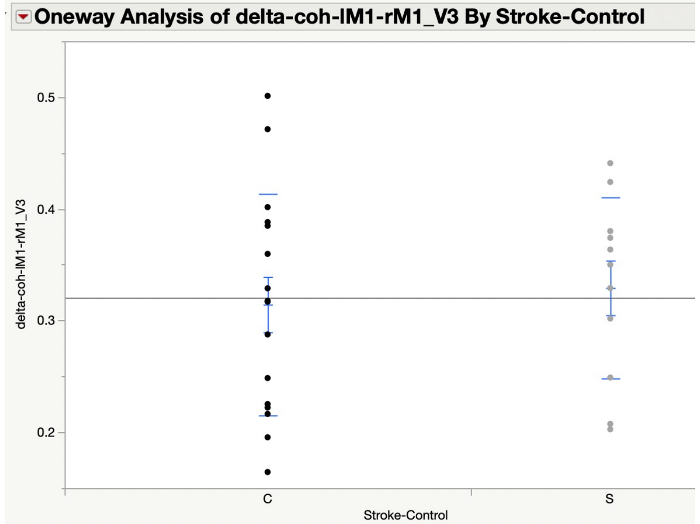
3-Months Post-stroke



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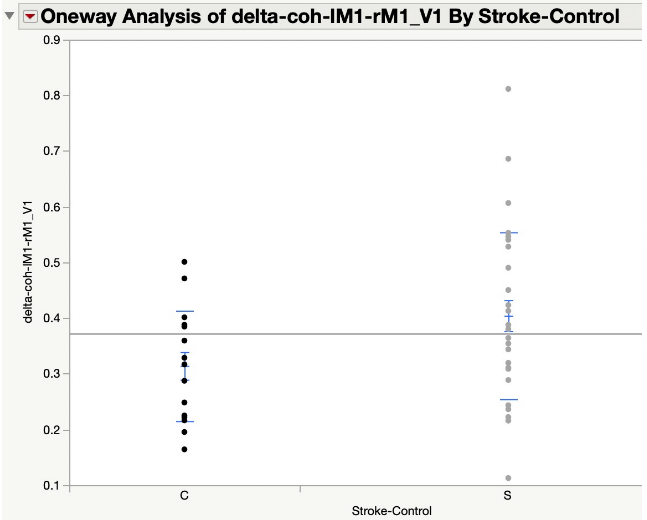
Delta Coherence: Within-subject Change

- Delta coherence decreased within subjects over time
  - Significant difference from admission to 3 months post-stroke; from discharge to 3 months post-stroke

IRF Admission



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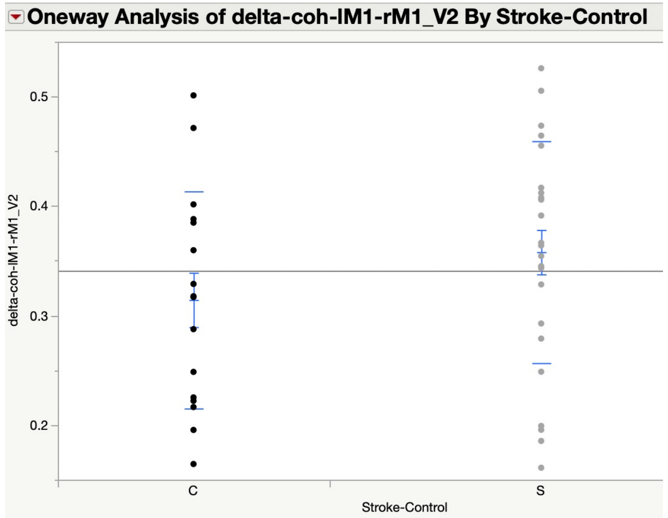

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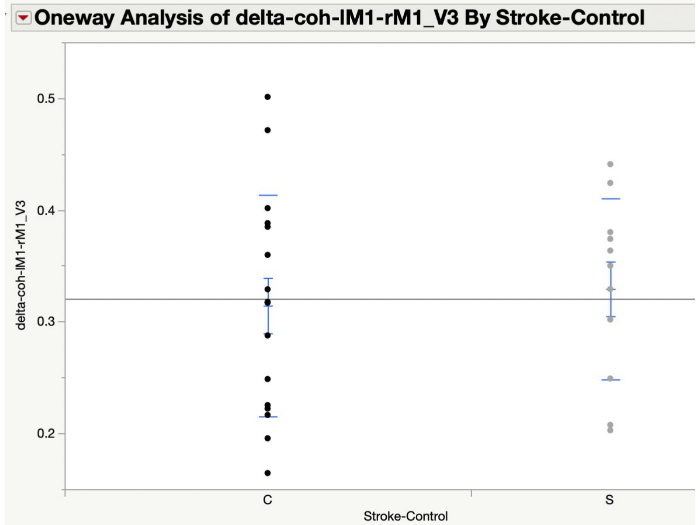

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Conclusions – why does this matter?

- Delta coherence between bilateral primary motor cortices appears to be a valuable biomarker for stroke recovery in early rehab
  - Correlated with QI change, motor impairment, and CST injury
  - Generally decreases over time towards control values

- These findings add to existing evidence that EEG can identify biomarkers which can contribute to clinical decision-making
  - Complements behavior-based clinical measures
  - Guides prognosis – if high delta coherence present, may indicate lower potential for motor recovery
  - Allows patients to be paired with personalized treatment and goals

- EEG is a feasible measure at bedside, takes only 3 min, and one day could hopefully become a standard part of clinical practice

References

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