Motor power modulations during imagined movements

Neuromatch 2022

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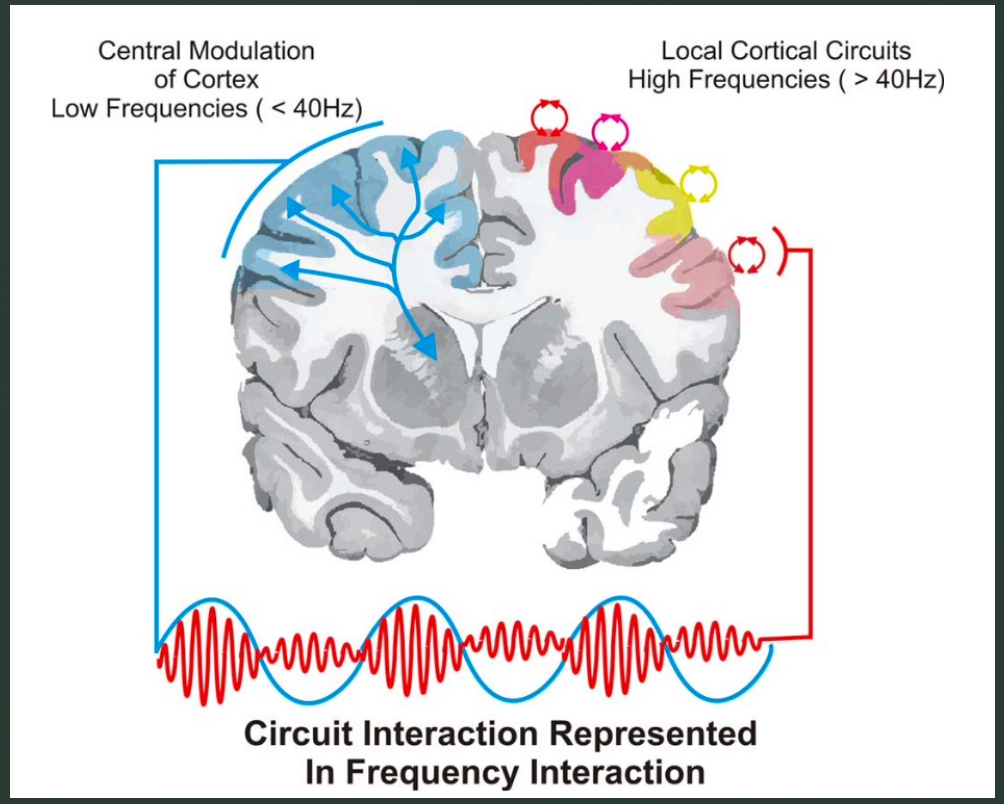
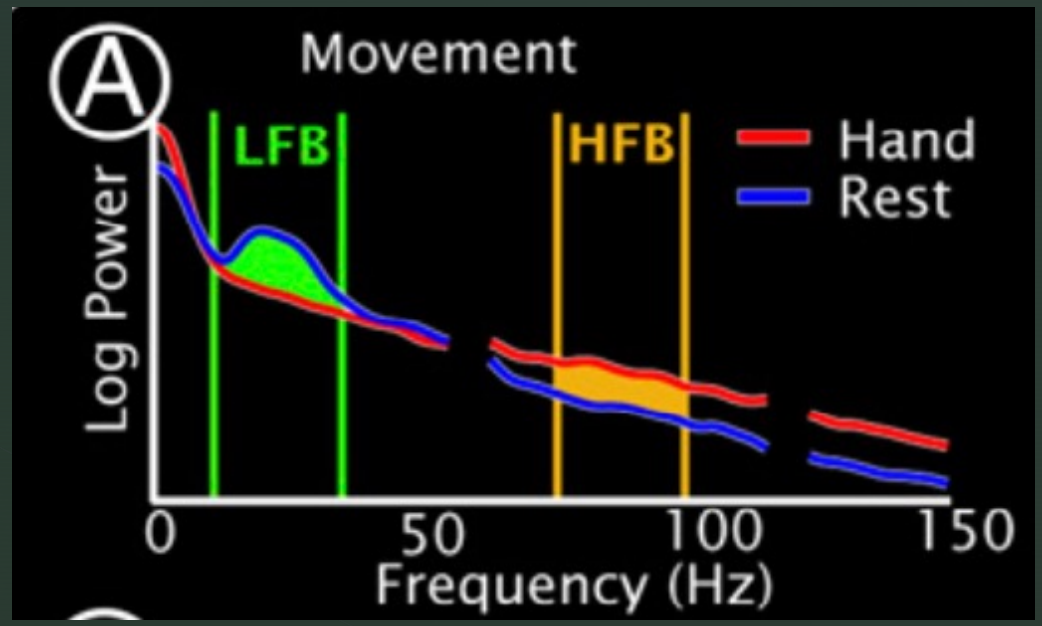
Background



Schalk and Leuthardt (2011)

Miller et al. (2010)



- **High beta** power inhibits movement
  - Event related desynchronization (ERD) is necessary for movement to occur
- **High gamma** frequency increases during movement (ERS)

Aims

1. **Replicate** prior ERD/ERS findings
2. **Investigate** how power profiles during imagined and actual movements differ
3. **Design and build** ML pipeline to classify actual and imagined movements, with and without high gammas

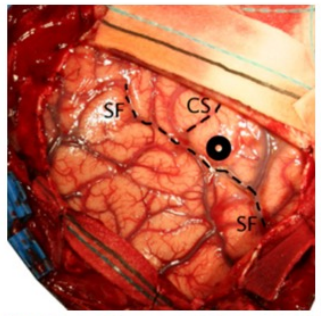
Hypotheses

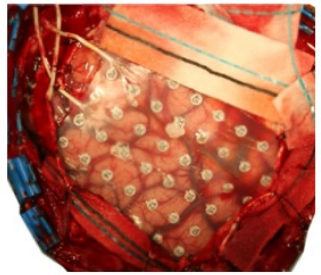
A. Similar ERD in beta frequency between actual and imagined
B. Attenuated changes in high gamma frequency for imagined movements in comparison with actual movements
C. Models without high gamma input will significantly underperform in the discrimination task

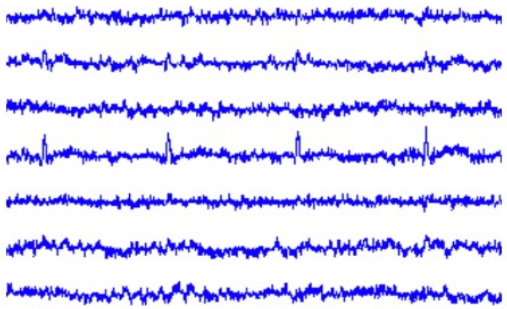
Data

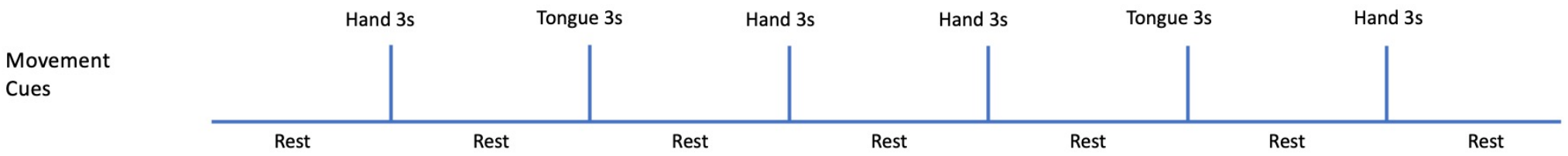
- ECoG recordings from subjects undergoing treatment for medically refractory epilepsy
- Two interleaved tasks at rate of once per second (1 Hz), alternating between task and rest, on-screen cue:
  - hand (synchronous flexion/extension of all fingers)
  - tongue (protrusion/retraction of tongue with mouth open)
- Two conditions: real movement, imagined movement
- Dataglove or EMG to verify absence of movement during imagined condition

Data


SF
CS
SF

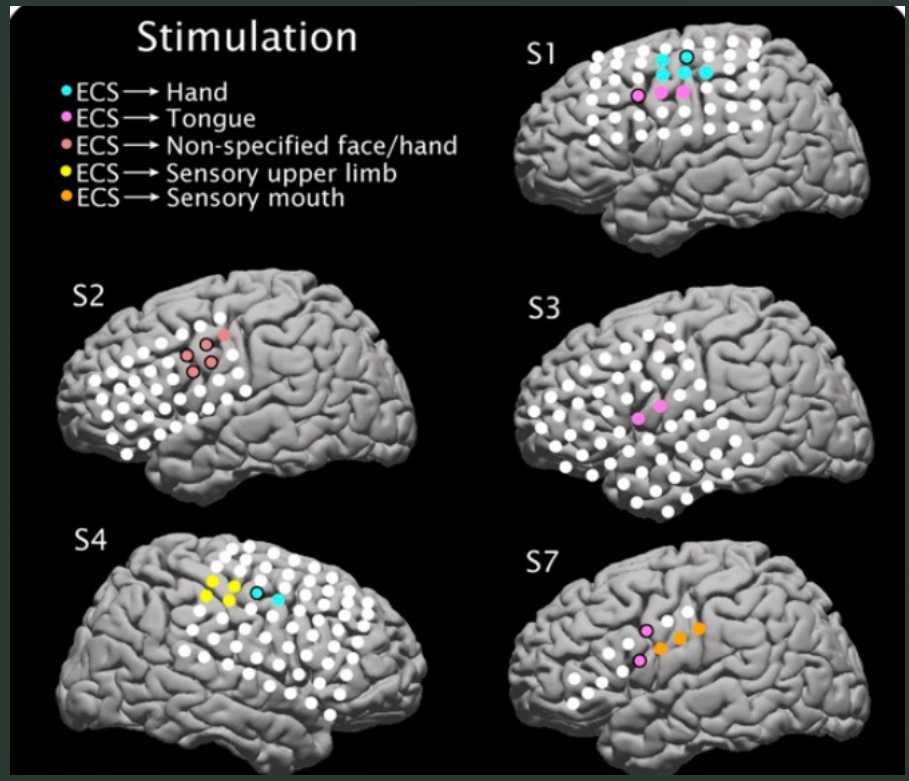





Movement Cues
Hand 3s
Tongue 3s
Hand 3s
Hand 3s
Tongue 3s
Hand 3s
Rest
Rest
Rest
Rest
Rest
Rest
Rest

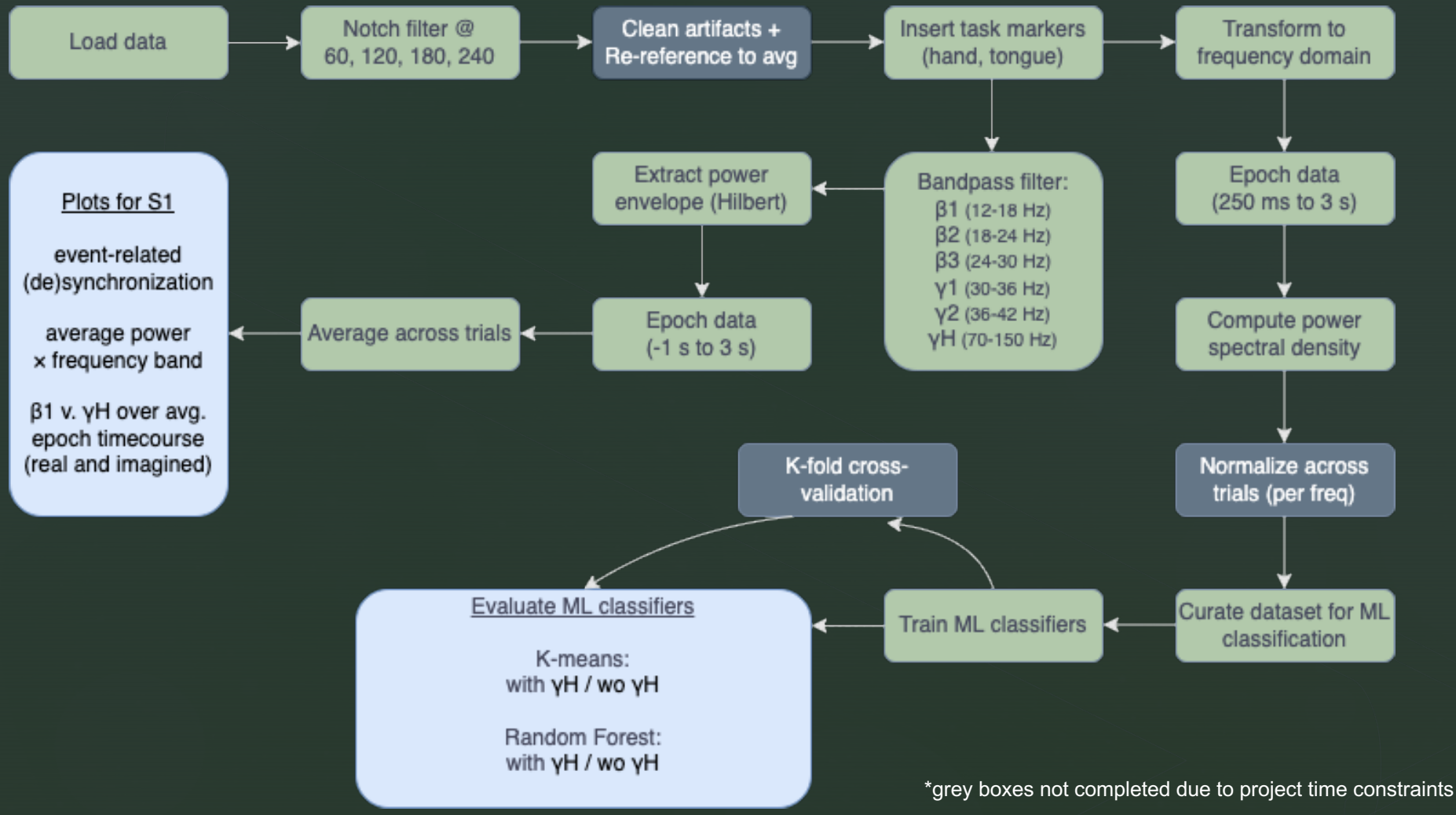
Data

- Electrocortical mapping for five participants (for clinical purposes)
- Provides indication of electrodes where stimulation causes movement
- Analyzed S1



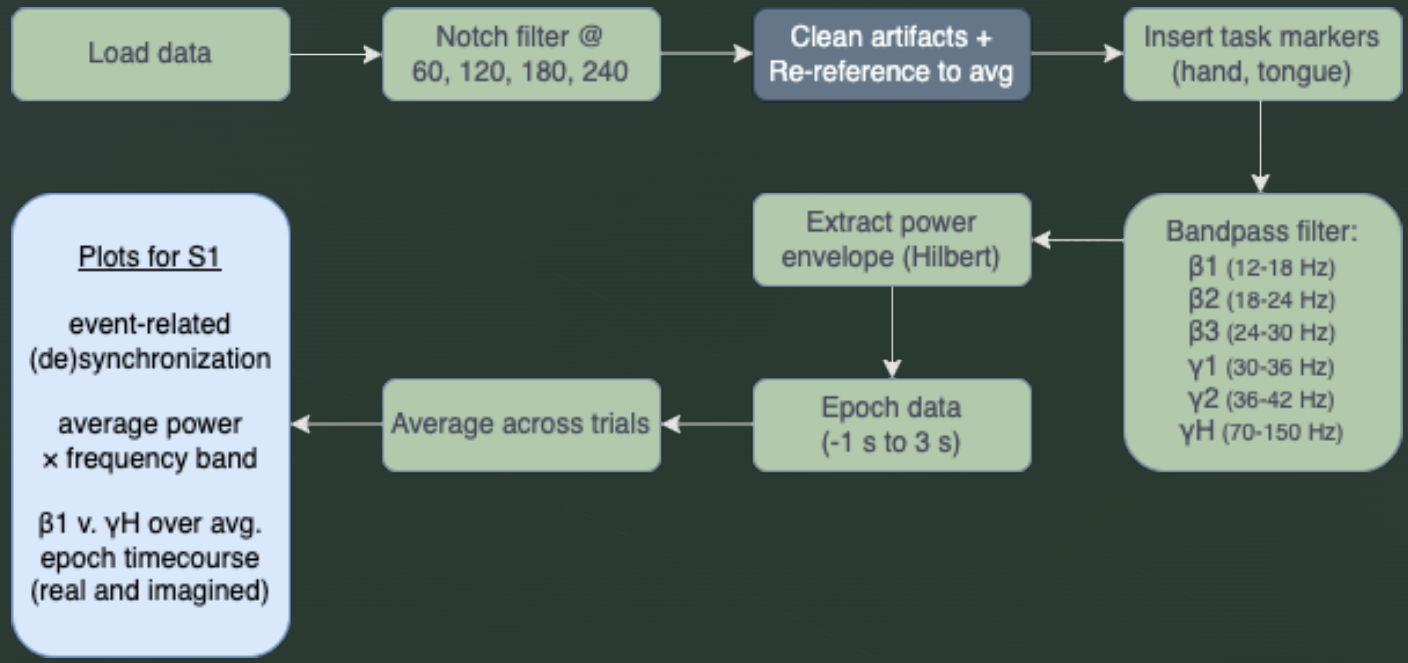
Miller et al. (2010)

Methods



*grey boxes not completed due to project time constraints

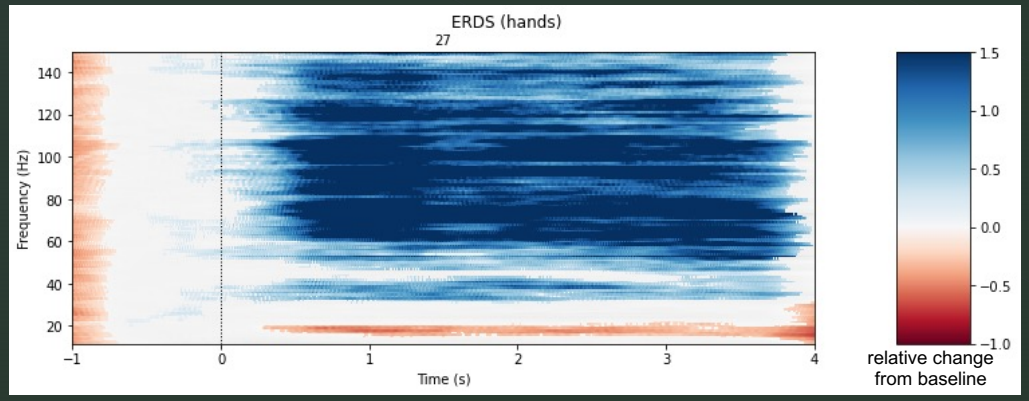
Exploratory
Aims 1 and 2



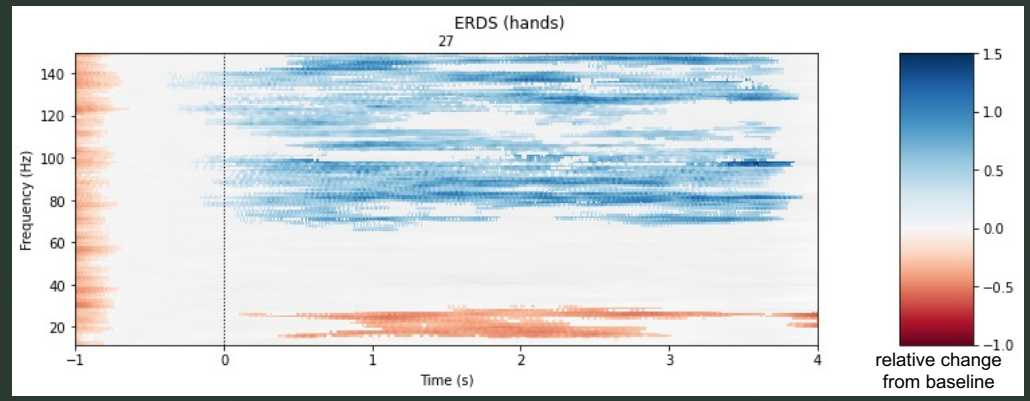
*grey boxes not completed due to project time constraints

Aim 1:
Replicate prior ERD/ERS findings

actual movement

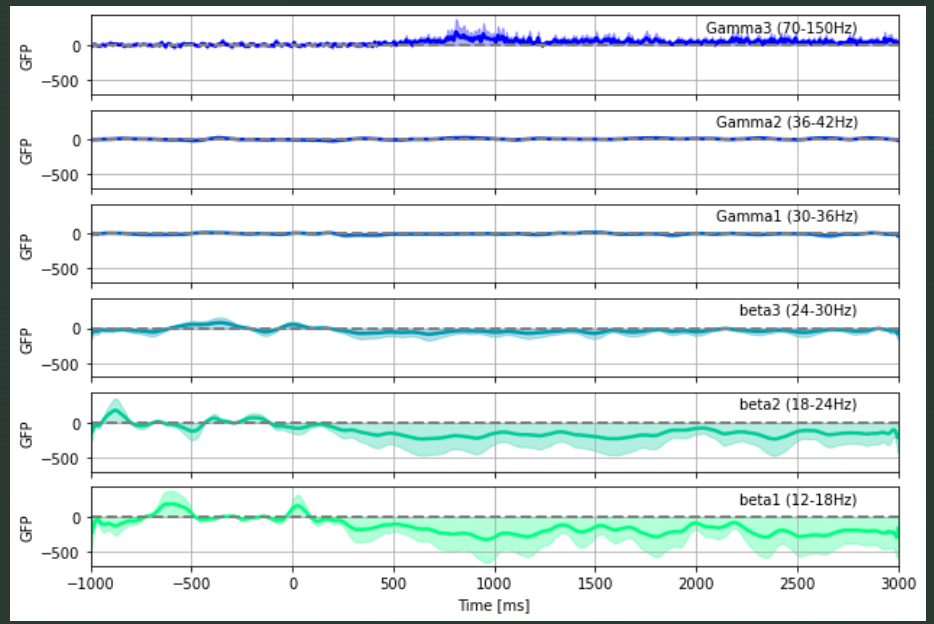


imagined movement

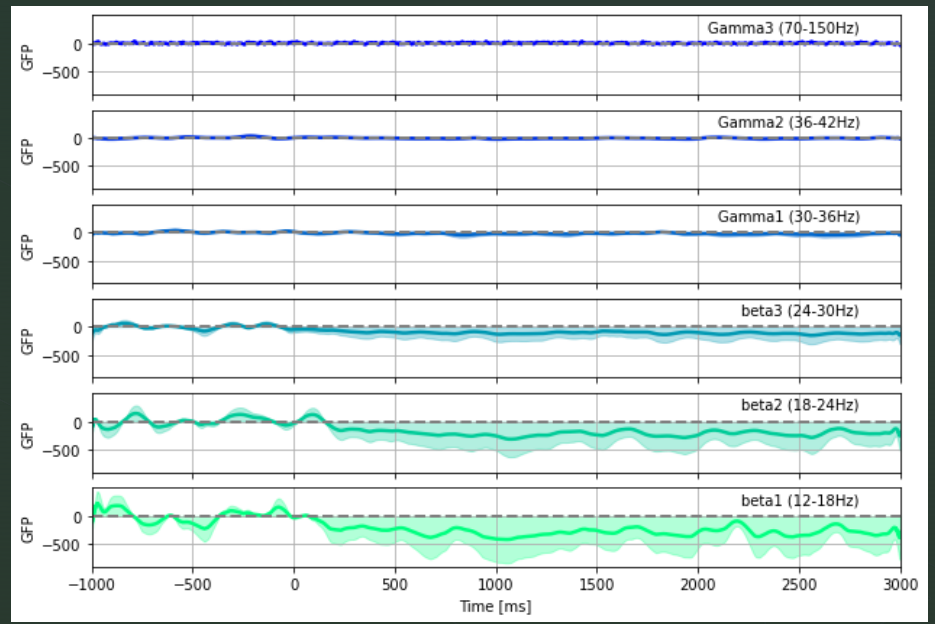


Aim 1:
Replicate prior ERD/ERS findings

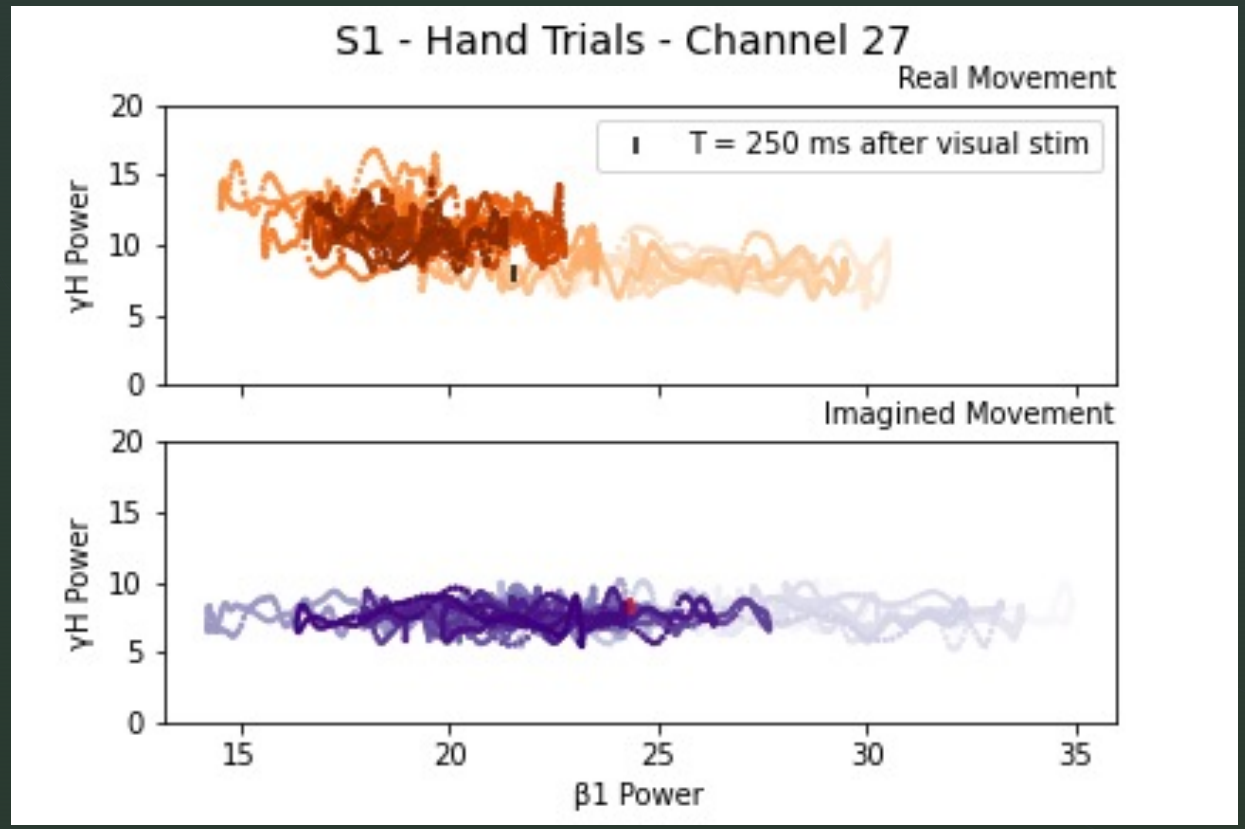
actual movement



imagined movement



Aim 2:
Investigate real v. imagined power



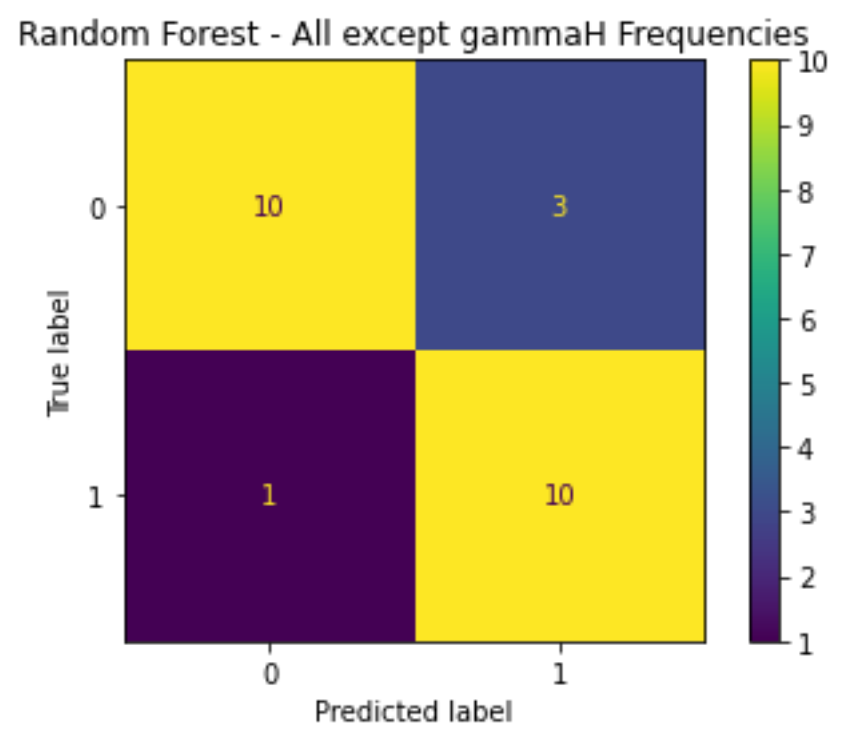
color (light > dark) indicates time course over epoch window (-1000 to 3000 ms)

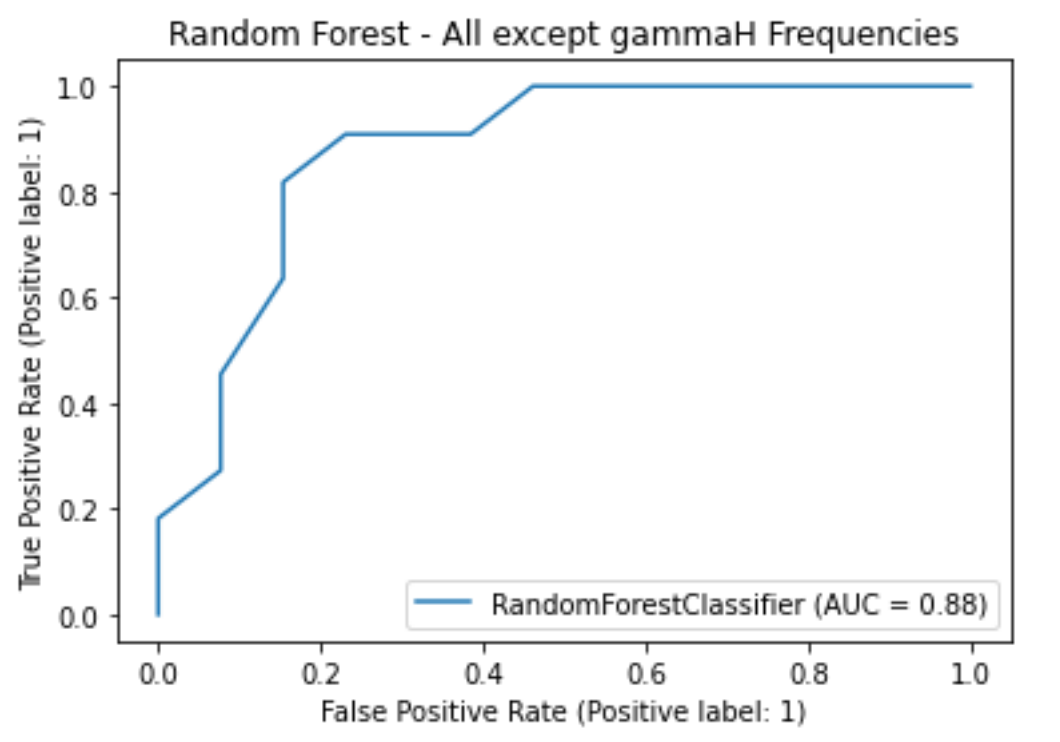
Aim 3

To what extent do lower frequency bands distinguish actual versus imagined movement?

*grey boxes not completed due to project time constraints

Aim 3:
Classify without high gamma





Aim 3:
Classify without high gamma

Conclusions

1. Similar ERD in beta frequency between actual and imagined ✓
2. Attenuated changes in high gamma frequency for imagined movements in comparison with actual movements ✓
3. Low frequency only models will significantly underperform in the discrimination task

Better performance than anticipated (but models with high gamma still perform better...)

Limitations

- specific subject population reduces generalizability of findings
- project time constraints led us to simplify our preprocessing:
  - did not re-reference data to the average
  - did not perform ICA or other methods to identify and remove noisy (or epileptic) epochs in the channels we analyzed
- project time constraints led us to simplify our analyses:
  - did not z-score across trials within bands before classification
  - single randomized split for training/test (no thorough cross-validation)

Code Availability

https://github.com/jessb0t/motorImagery

References

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- Code for creation of the GFP graphics based on the detailed example provided here: https://mne.tools/stable/auto_examples/time_frequency/time_frequency_global_field_power.html

Thanks!

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Neuromatch Organizers and Volunteers