Cortical activity during motor execution, motor imagery, and imagery-based online feedback

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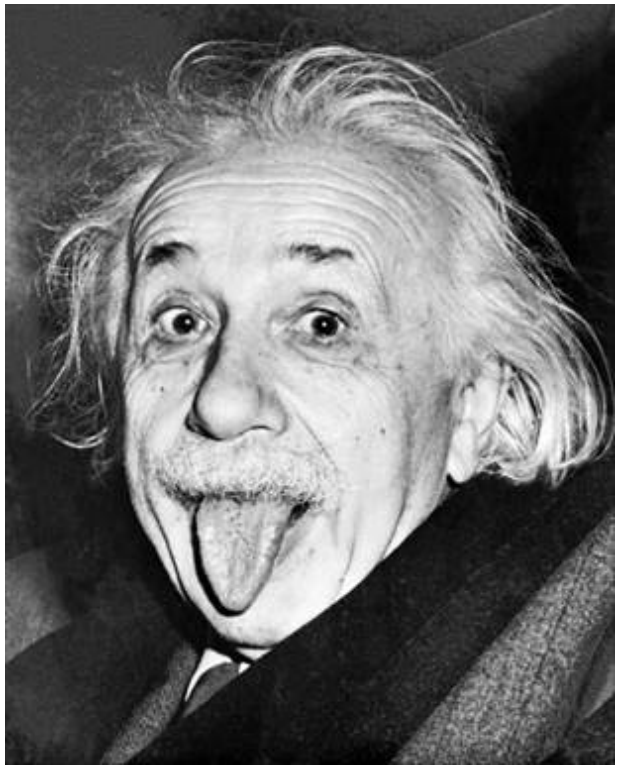
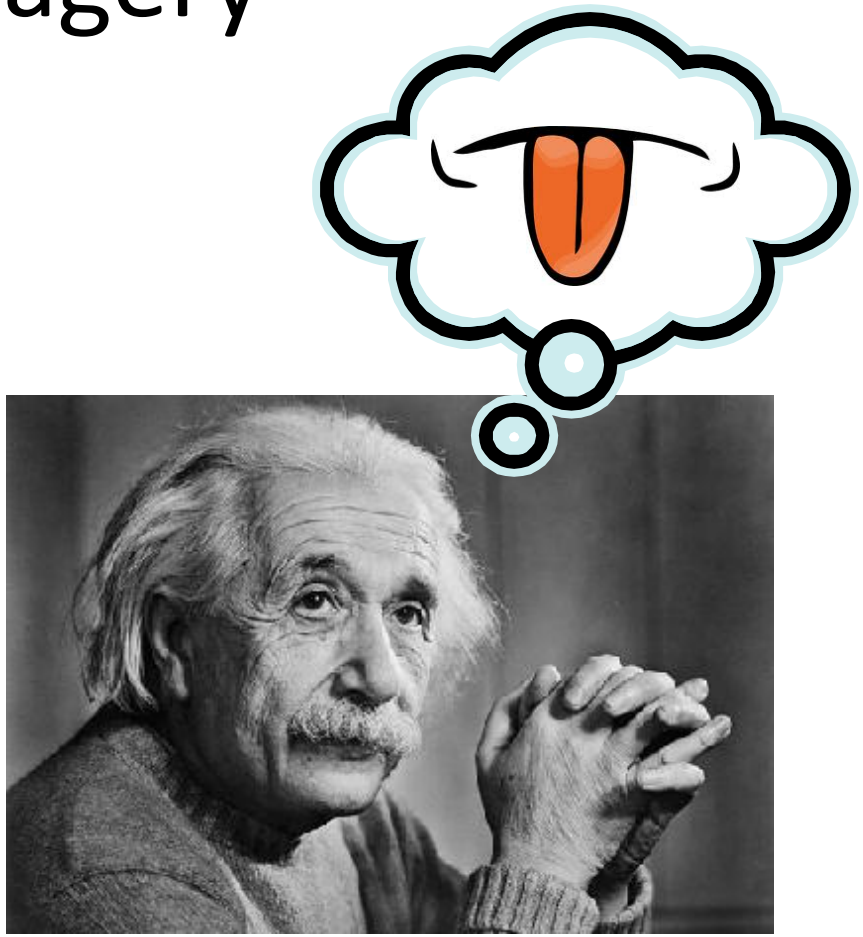
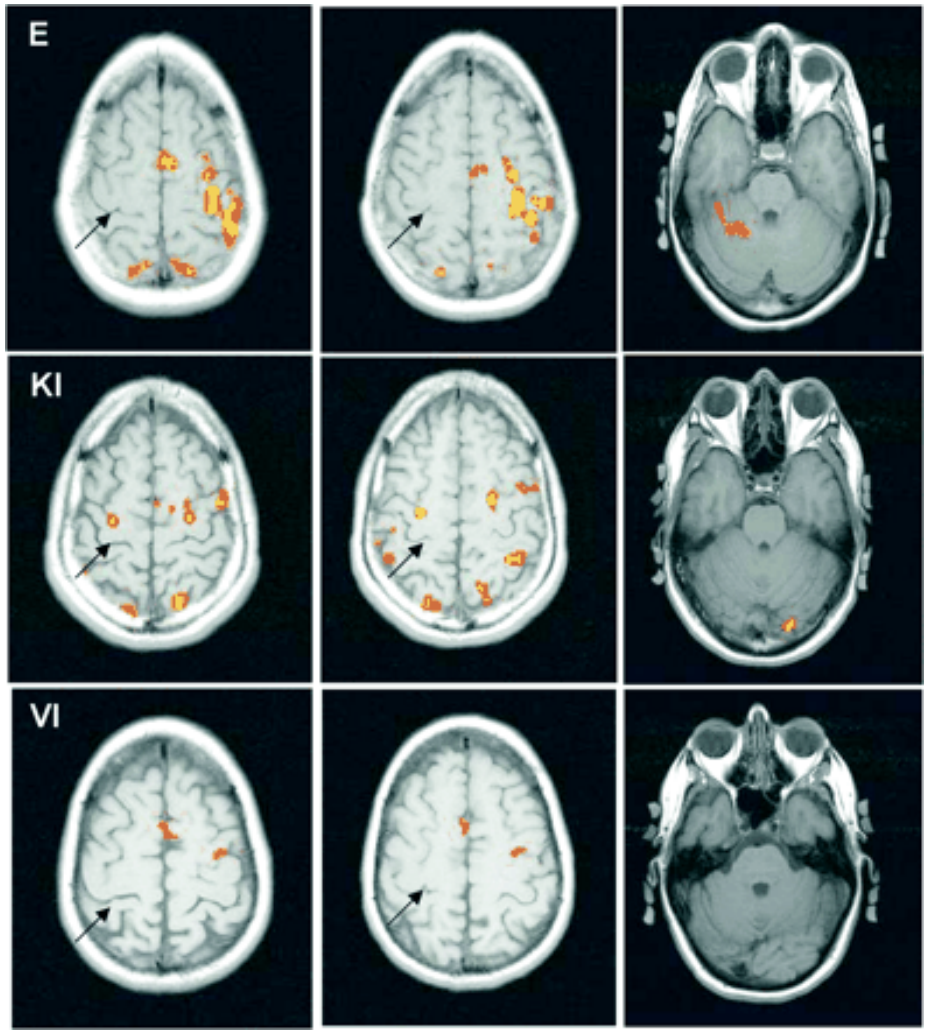
Motor Imagery



VS

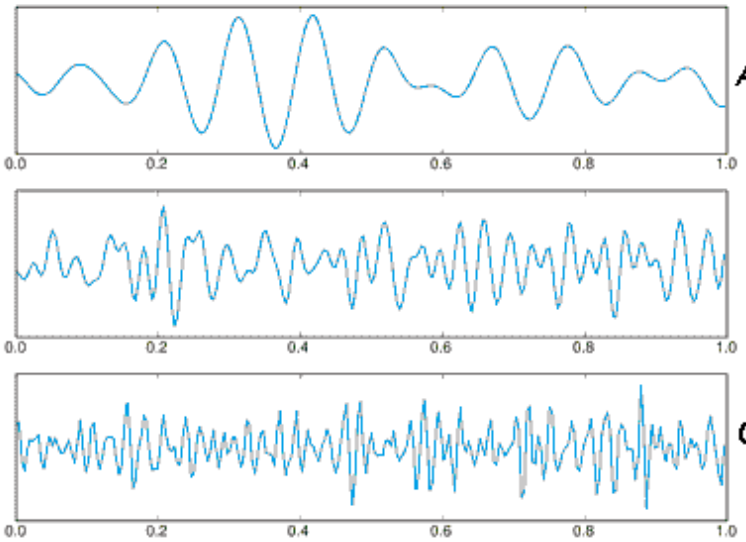


Brain activity during motor action vs imagery



Solodkin et al, 2004

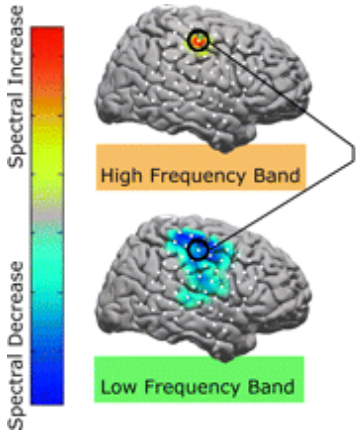
Motor rhythms in cortex

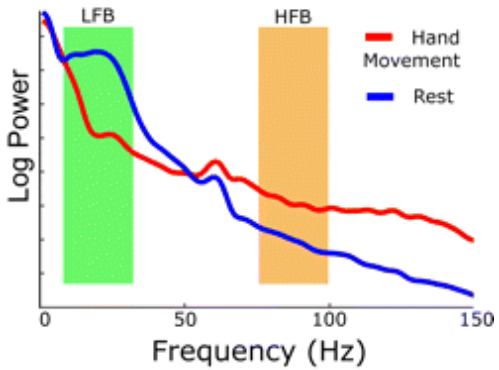


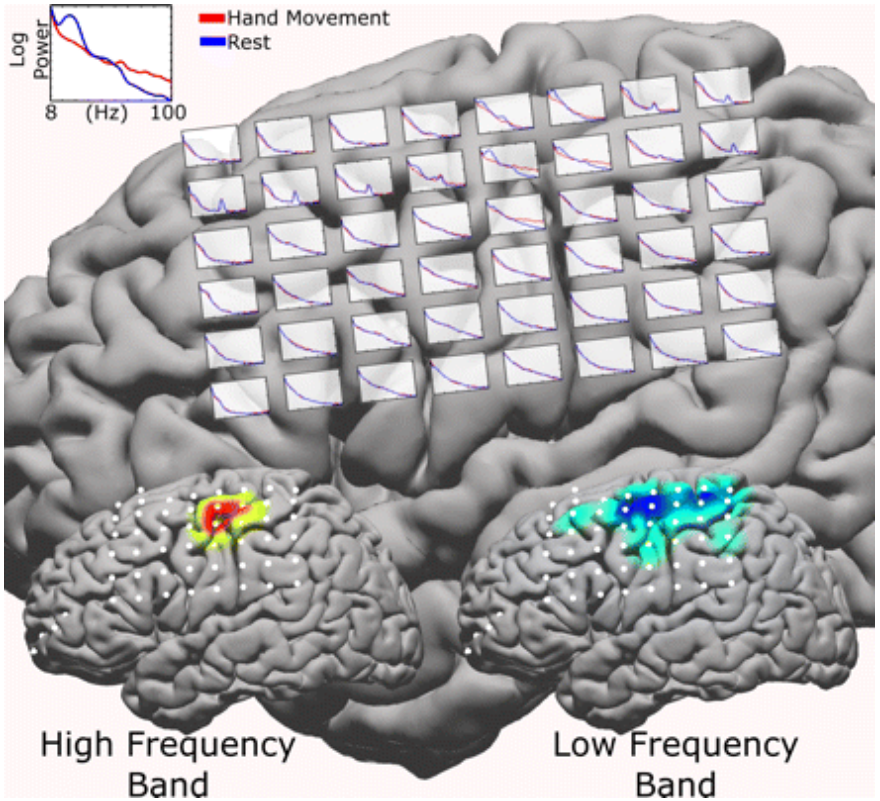
Aplha waves
8-13 Hz

Beta waves
14-25 Hz

Gama waves
25-150 Hz







Miller et al, 2007

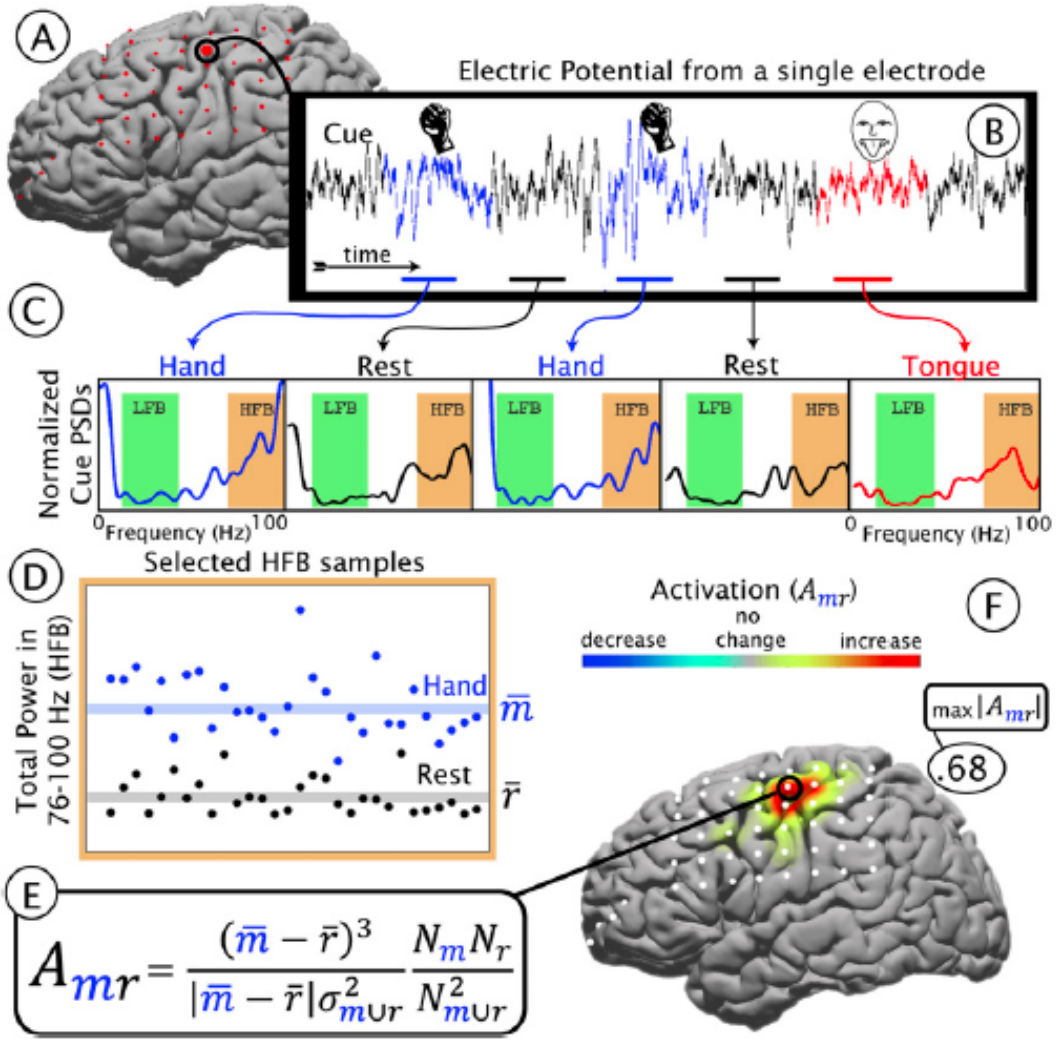
Goals of the paper

- Does M1 show imagery-related activity measured via ECoG?
- How do ECoG signals compare between real and imagined movements?
- Can imagined movements measured with ECoG be used to drive a BCI?

Methods

- 8 patients implanted with 4x8 or 8x8 grid
- 3 Tasks
  1) **Active movements** – clench-release of hand, stick out tongue, shoulder shrug, say the word "move"
  2) **Image movements** – same as before
  3) **Imagery based BCI** (4 subjects)

Quantification of brain activity

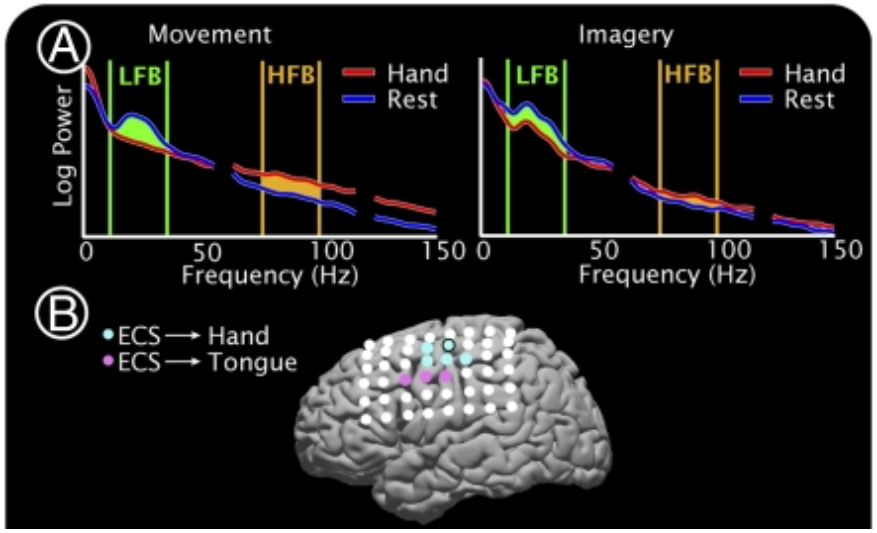


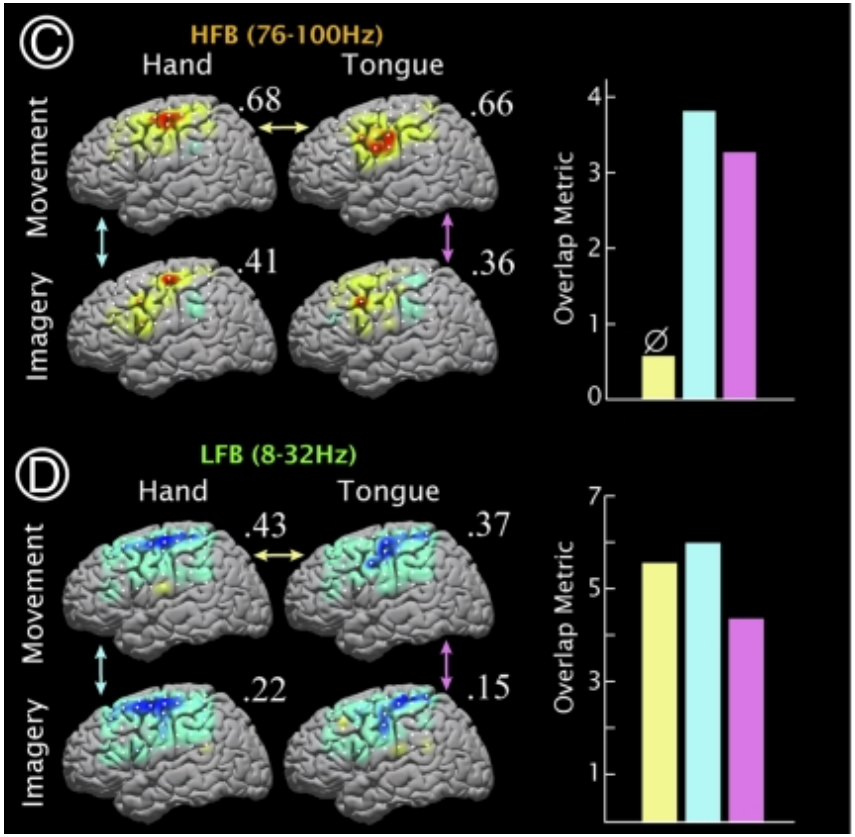
Signal Analysis

- What is the signal?
  - High frequency (76-100 Hz) or low frequency (8-32 Hz) band
- Calculated power of that frequency band amongst the population of neurons
- Linear transformation of the power in a chosen frequency band controlled cursor

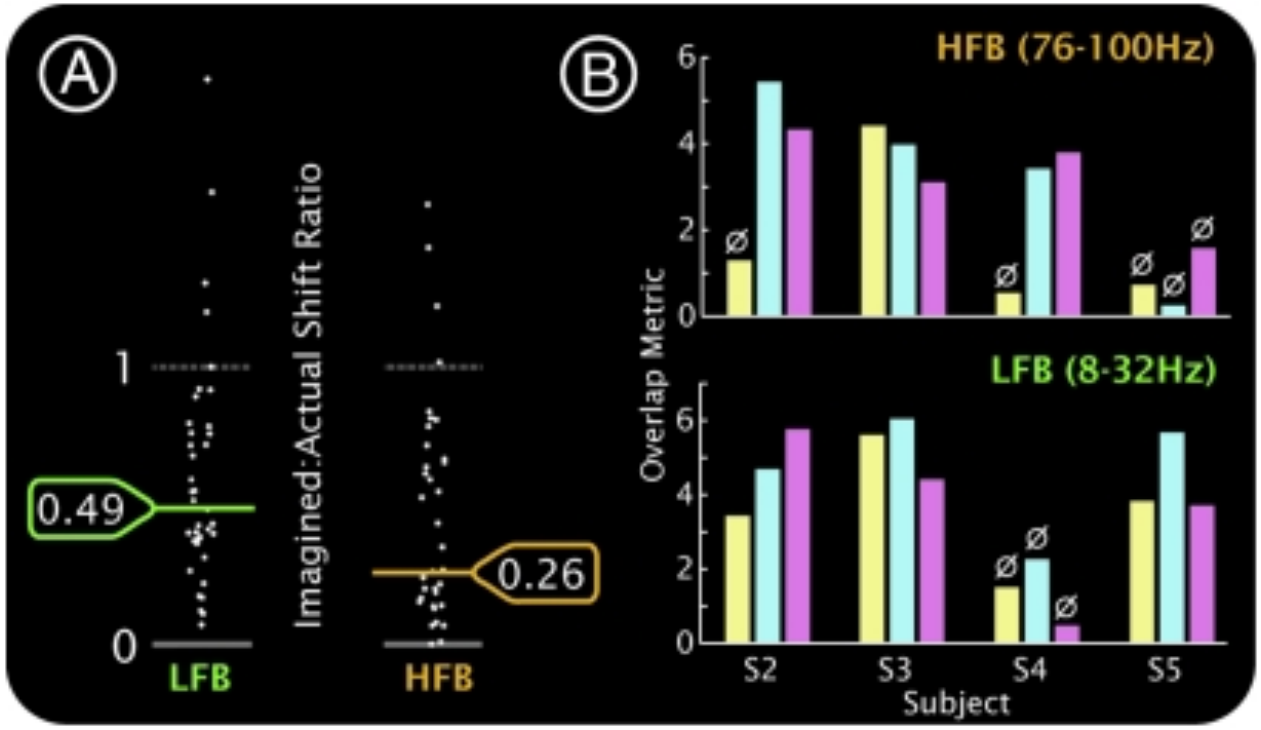
$$\dot{y}(t) = g(P(t) - P_0)$$

Cortical activity during real and imagined movements

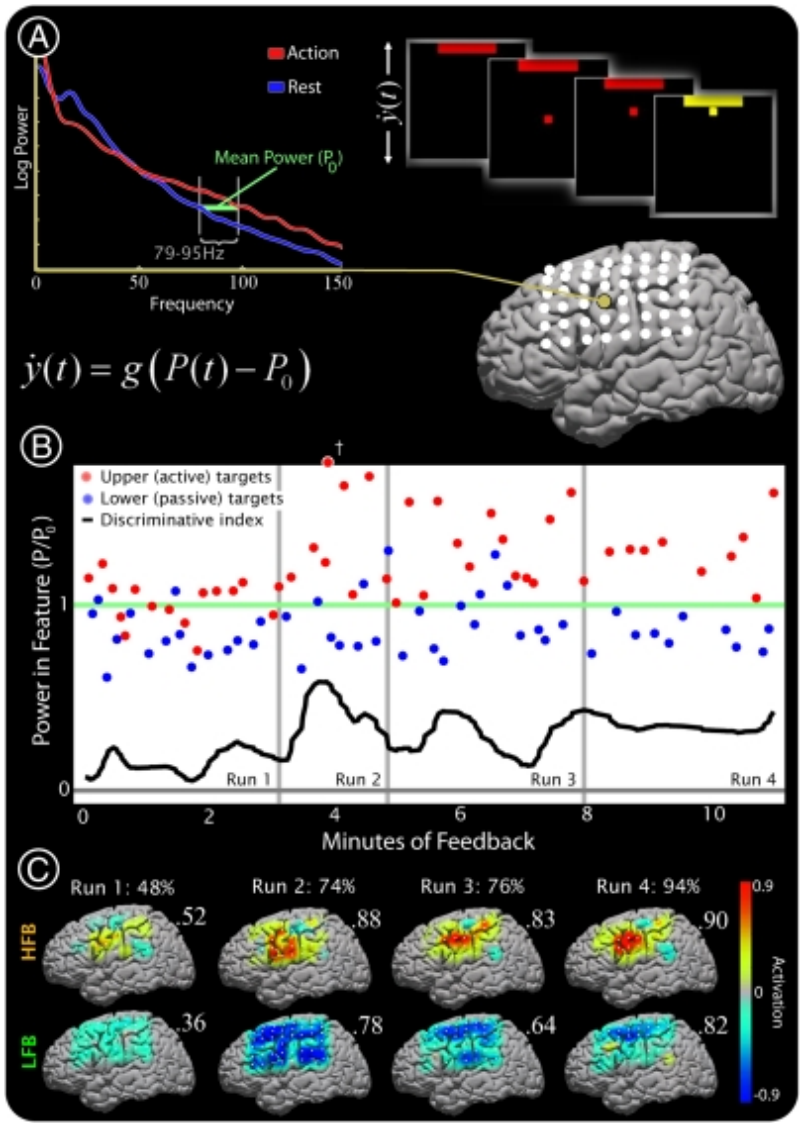




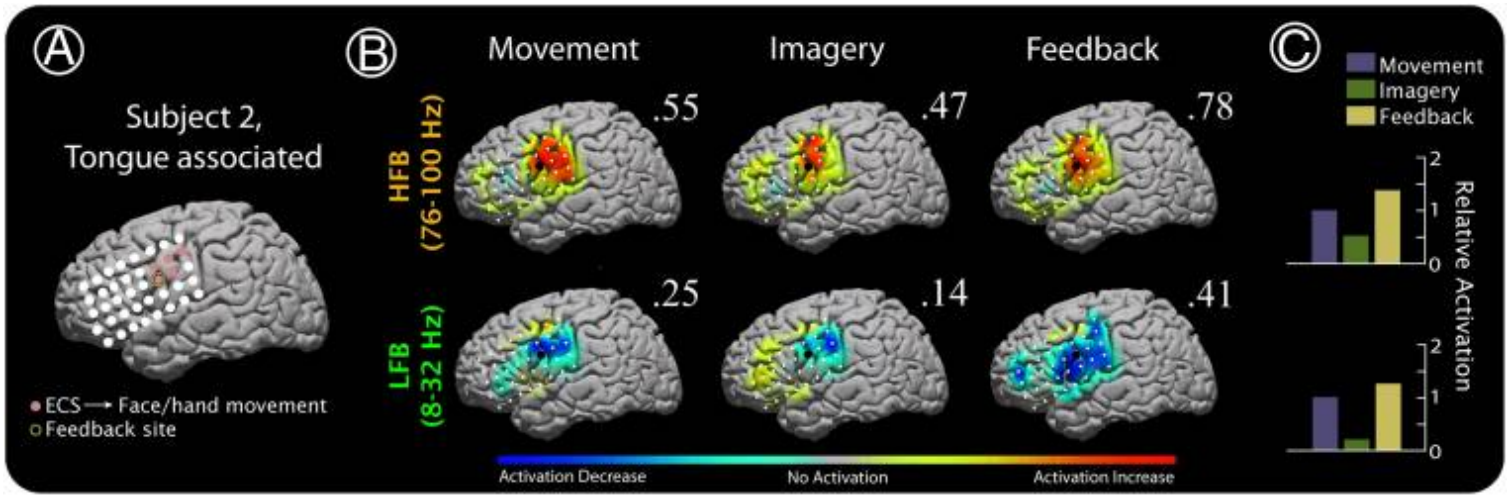
HFB and LFB overlap across subjects



Using imagery-based signal to control a cursor



Relative activity across tasks



Conclusions

- M1 shows imagery-based activity that is spatially similar to active movements
  - LFB has broad activation that overlaps across tasks
  - HFB has focal activation that is task specific
- Imagery-based activity was lower in amplitude than active movement
- Imagery-based activity could drive a cursor
  - ECoG activity with feedback increased over pure imagery

Things to discuss

1) Neural underpinnings for decrease in activity during imagery?
   - Activating subset of neurons, lower overall FR to prevent movement
   - How is this reconciled when feedback is introduced?
2) Replacement of motor imagery with the thought of moving the cursor up and down
   - Applications for linking brain regions that survived a stroke? (Similar to what Eb discussed on Tues.)
3) How does ECoG technique compare to invasive for BCI application?
4) Potential for tapping into "goal based" brain signals?
   - One of the tasks in this study had the subject think the word move