Functional MRI Encoding Model Reveals Population-Level Vibration Frequency Tuning in Human Cortex

Md. Shoaibur Rahman, Jeffrey M. Yau

Department of Neuroscience, Baylor College of Medicine, Houston, TX

Introduction

- Vibration frequency perception is a crucial capacity that enables humans to recognize and manipulate objects.
- Vibration frequency sensing activates somatosensory areas, but a little is known about the neural representation of frequency in those areas.
- Here, we studied population-level vibration frequency representation using fMRI encoding model that predict BOLD response profile on a voxel-wise basis.

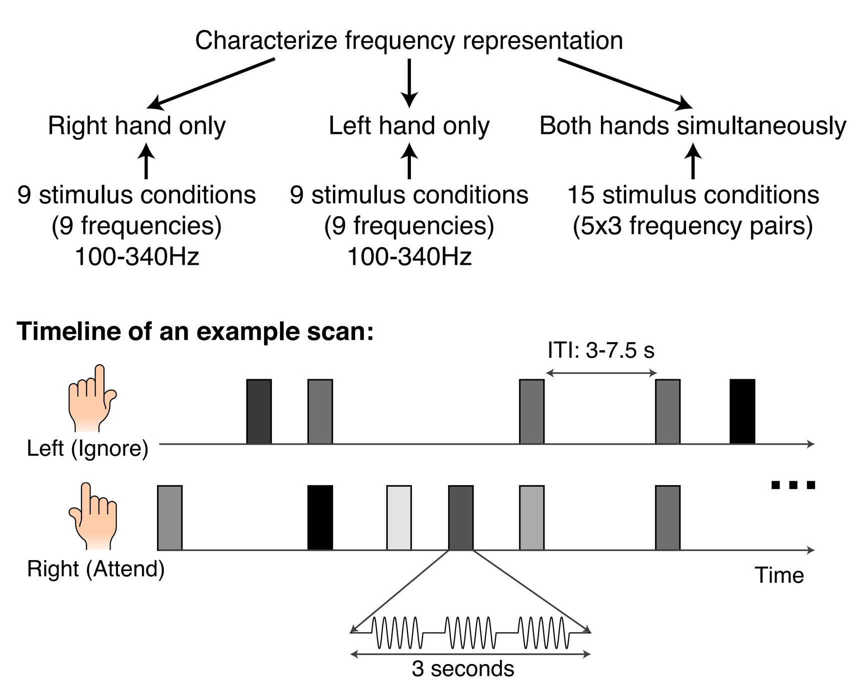
Questions

Q1. How is vibration frequency represented in the brain?

Q2. How is vibration frequency information combined over the hands?

Methods

- **Event-related fMRI experiment**: 5 subjects scanned in 3T scanner; 12 runs or 4560 volumes/subject in 2 sessions.
- **Task**: Respond to odd-ball events (middle vibration differs)
- **Data** preprocessing, analysis and visualization using AFNI, SUMA, and Python 3.
- **Metrics**:

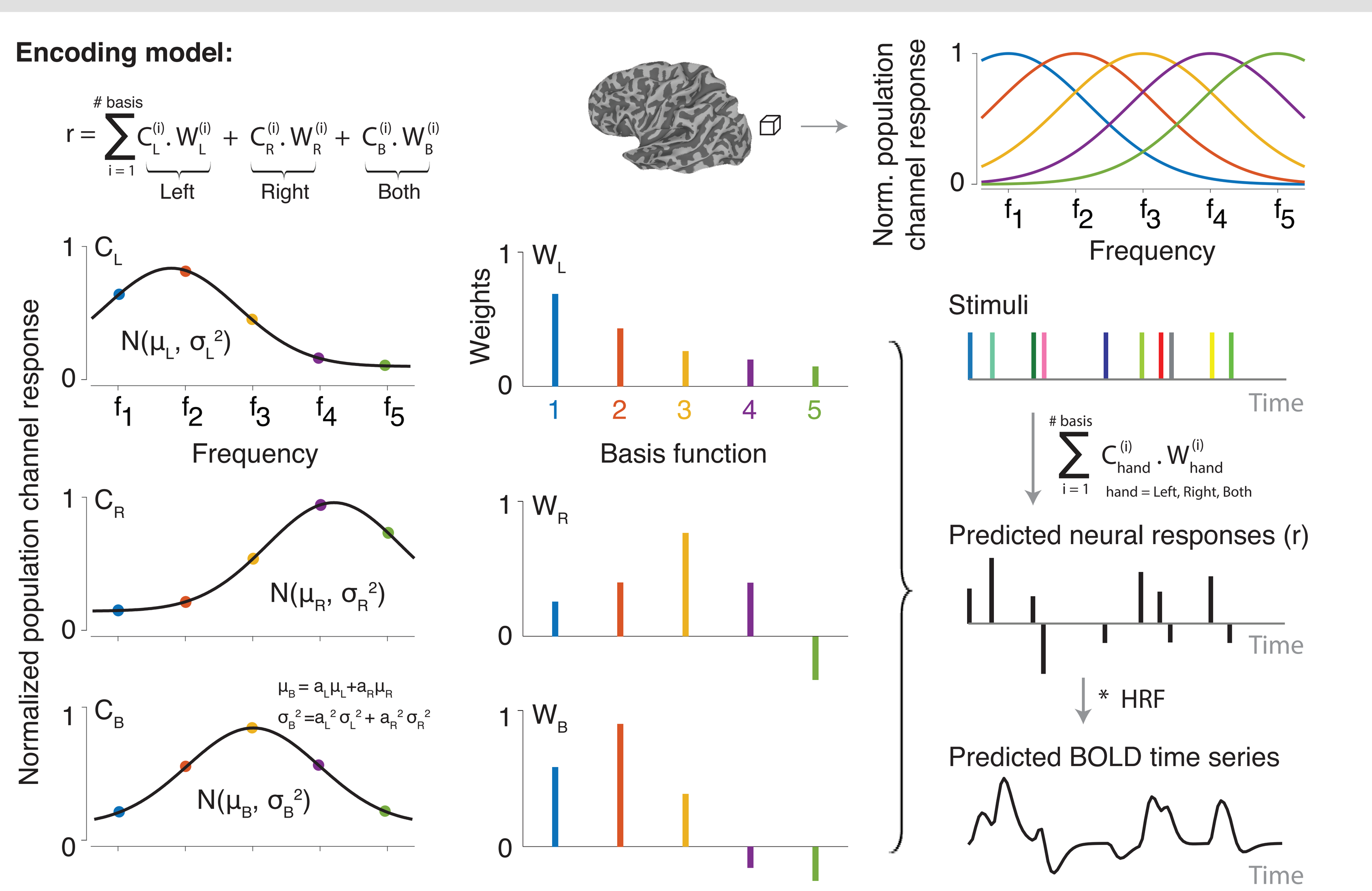


Hand preference: $\sum_{i=1}^{\#basis} |w_i|$

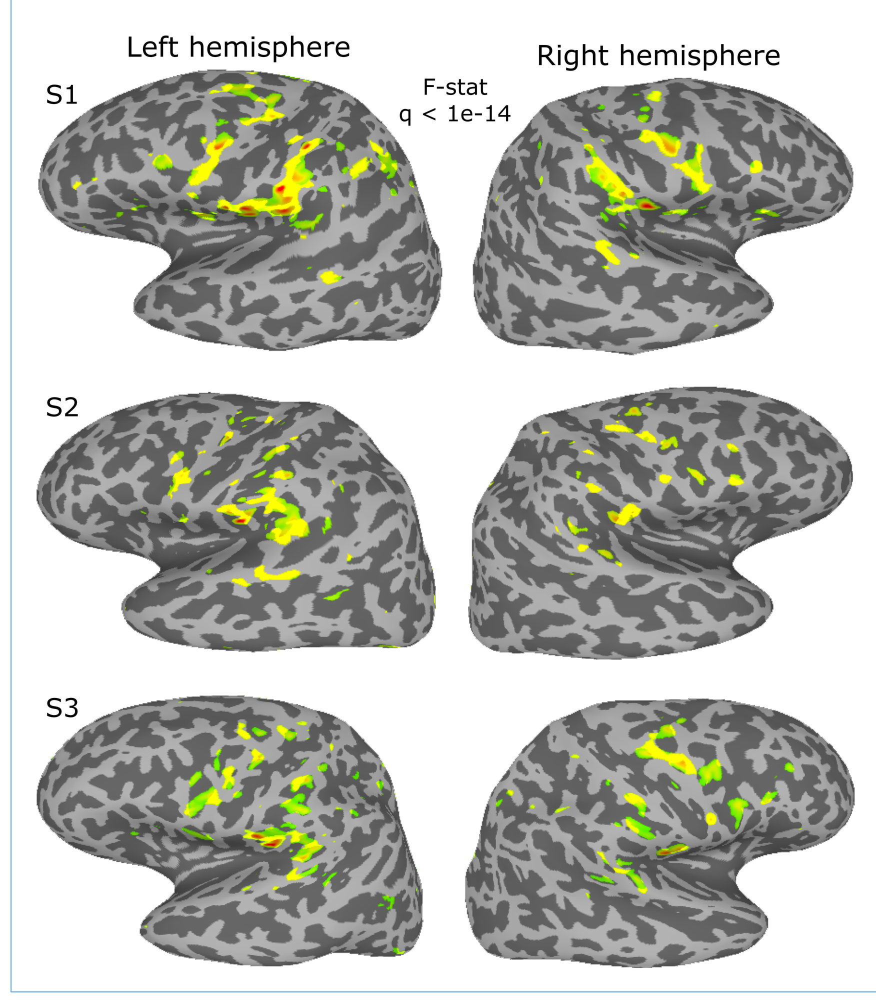
Frequency selectivity: $w_{max} - \frac{1}{\#basis - 1} \sum_{i=1}^{\#basis} w_i , \quad i \neq \text{argmax}(w)$

w_i: weights associated with the stimulated hand and frequency-tuned basis functions.

Encoding Model

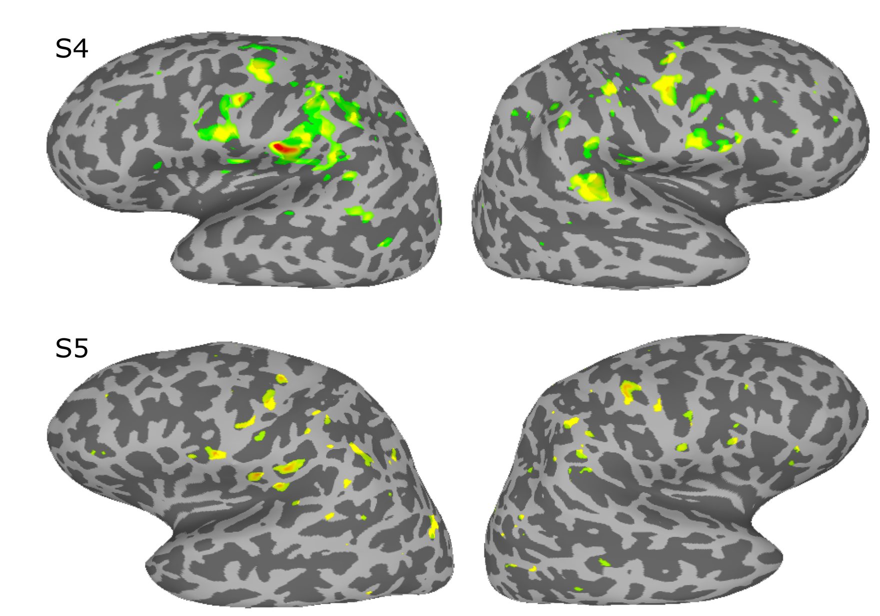


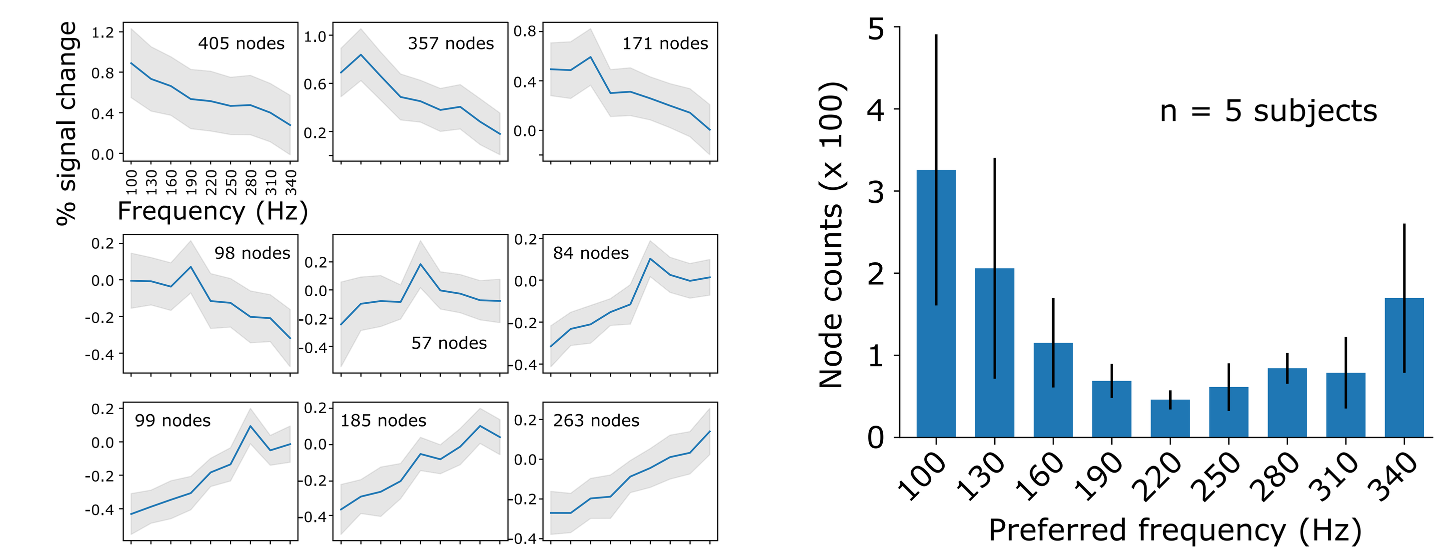
Sensorimotor areas respond to hand stimulation in a frequency-dependent manner



Univariate analysis:

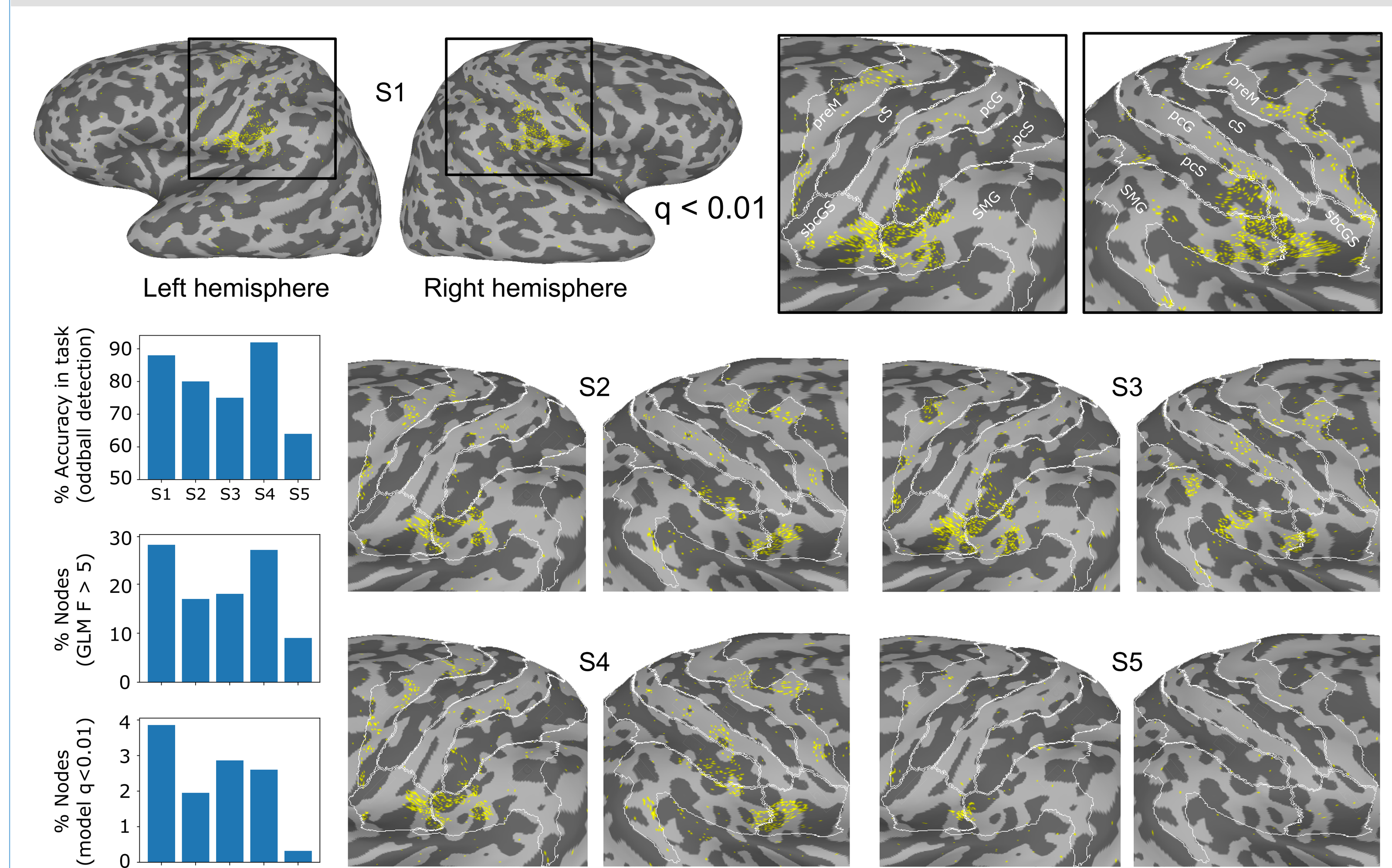
- Fit General Linear Model (GLM)
- Extract F-statistic (overall significance)
- Extract **β** coefficients (% signal change)





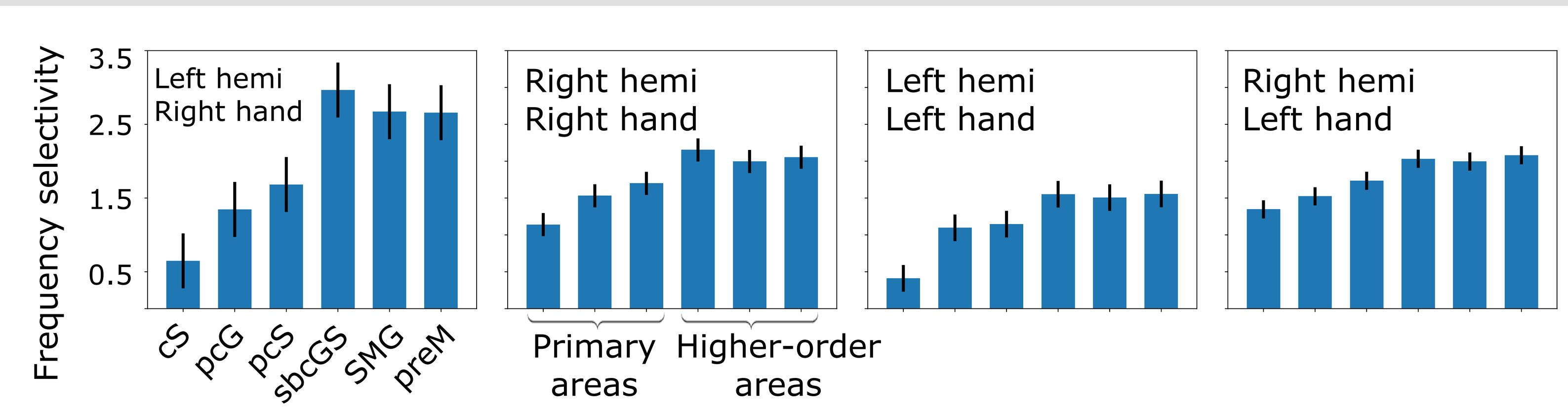
- Sensorimotor areas of each participant were activated by the vibration stimuli.
- Sensorimotor areas responded differentially to different vibration frequencies.
- More nodes responded to lower/higher frequencies, while fewer nodes responded to intermediate frequencies.

Encoding model indicates population-level vibration frequency tuning in sensorimotor areas

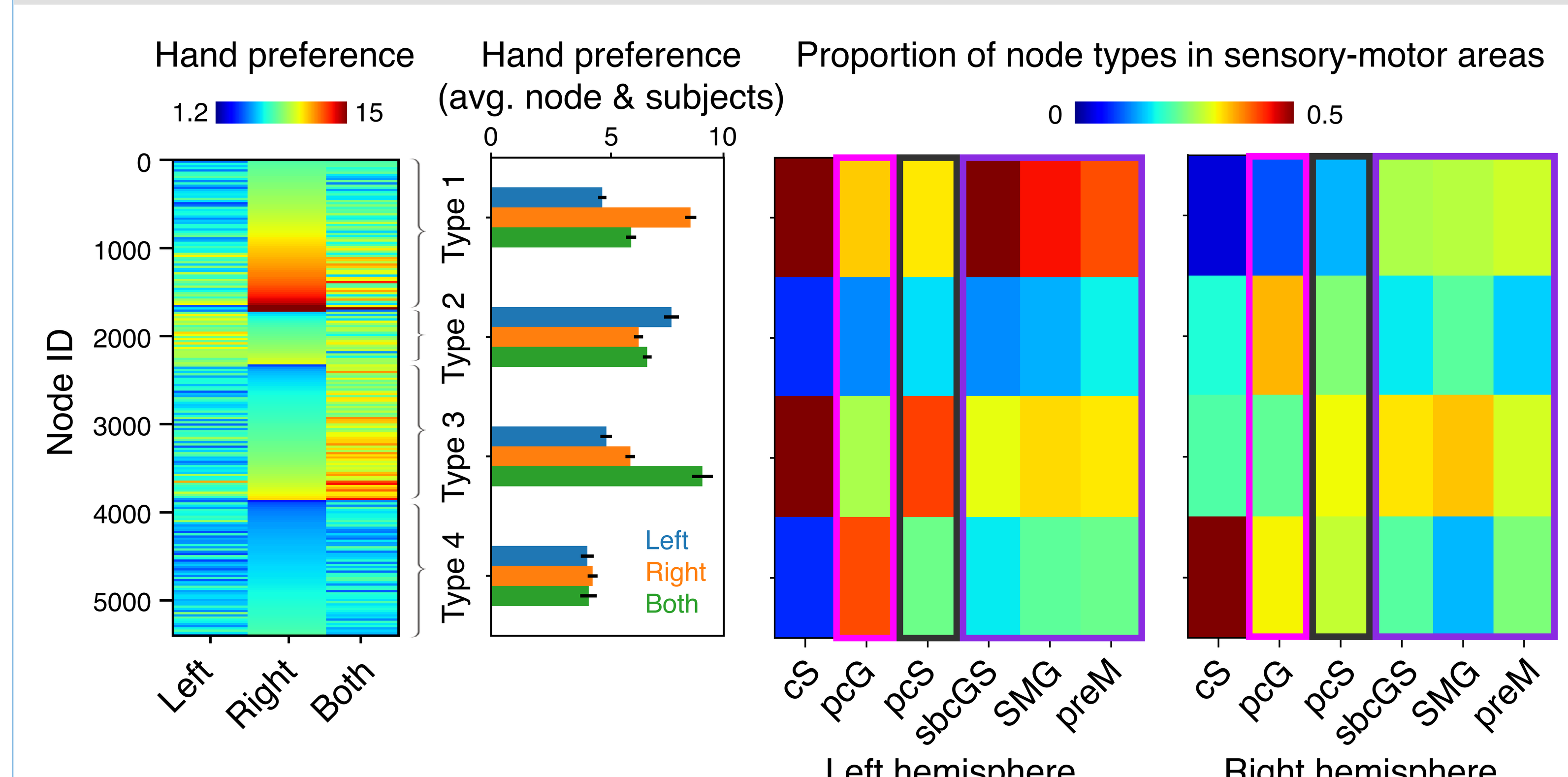


- Frequency-tuned basis functions can predict population neural responses.
- Vibration frequency information can be linearly integrated over the hands.

Higher-order areas are more selective for frequency



Response preferences for the two hands evolve over the somatosensory cortical hierarchy



Summary

- Sensorimotor areas respond differentially to hands and vibration frequency.
  - Primary somatosensory areas are likely more selective to hands.
  - Higher-order areas are likely more selective to vibration frequency.
- Frequency-tuned basis functions can predict population neural responses.
- Vibration frequency information is linearly integrated over the hands.
- Preliminary results will be improved and confirmed by updating the encoding model with a overly completed basis functions.

This work was supported by BCM, the Alfred P. Sloan Research Fellowship, and 1R01NS097462. This work was performed at the BCM Core for Advanced MRI. We thank Lexi Crommett for technical assistance.

Contact: jeffrey.yau@bcm.edu