Quantifying waveform shape of EEG alpha and mu oscillations across development

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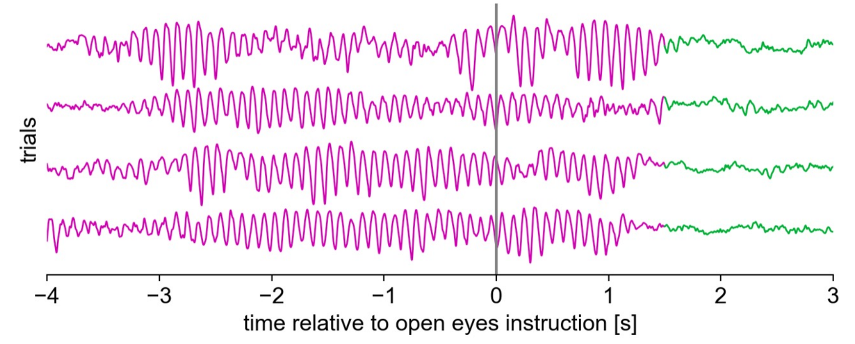
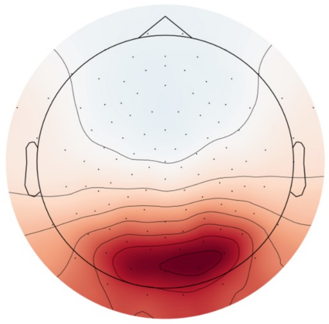
Introduction
Alpha versus mu oscillations

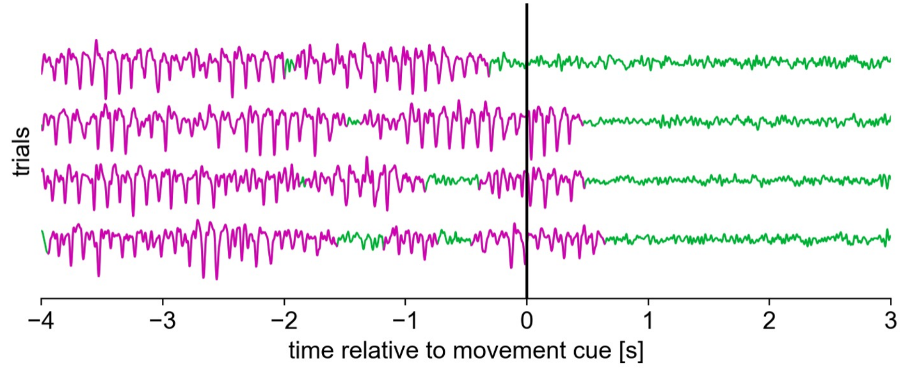
Alpha (8-13 Hz)



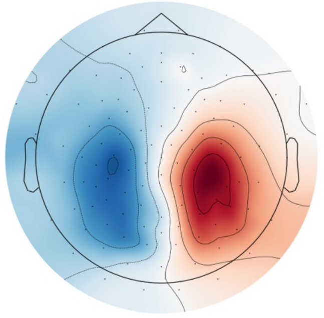
Strongest with eyes closed
Most prominent in occipital cortex
Reduced task reactivity in autism spectrum disorder (ASD) (Keehn et al., 2017)
Implicated in visual attention deficits seen in attention deficit hyperactivity disorder (ADHD) (Vollebregt et al., 2016)



Mu (8-13 Hz)



- Strongest when stationary
- Most prominent in sensorimotor cortex
- Diminished functional suppression in ASD (Hobson & Bishop, 2017)
- Associated with inability to inhibit task-irrelevant sensorimotor areas in ADHD (Ter Huurne, 2017)



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Introduction

Alpha Oscillations Change Across Development

- Increased alpha center frequency with age in occipital cortex (Lindsley, 1939)
- Decreased alpha amplitude with age in occipital cortex (Lindsley, 1939)
- Mu center frequency and amplitude changes with age have yet to be investigated

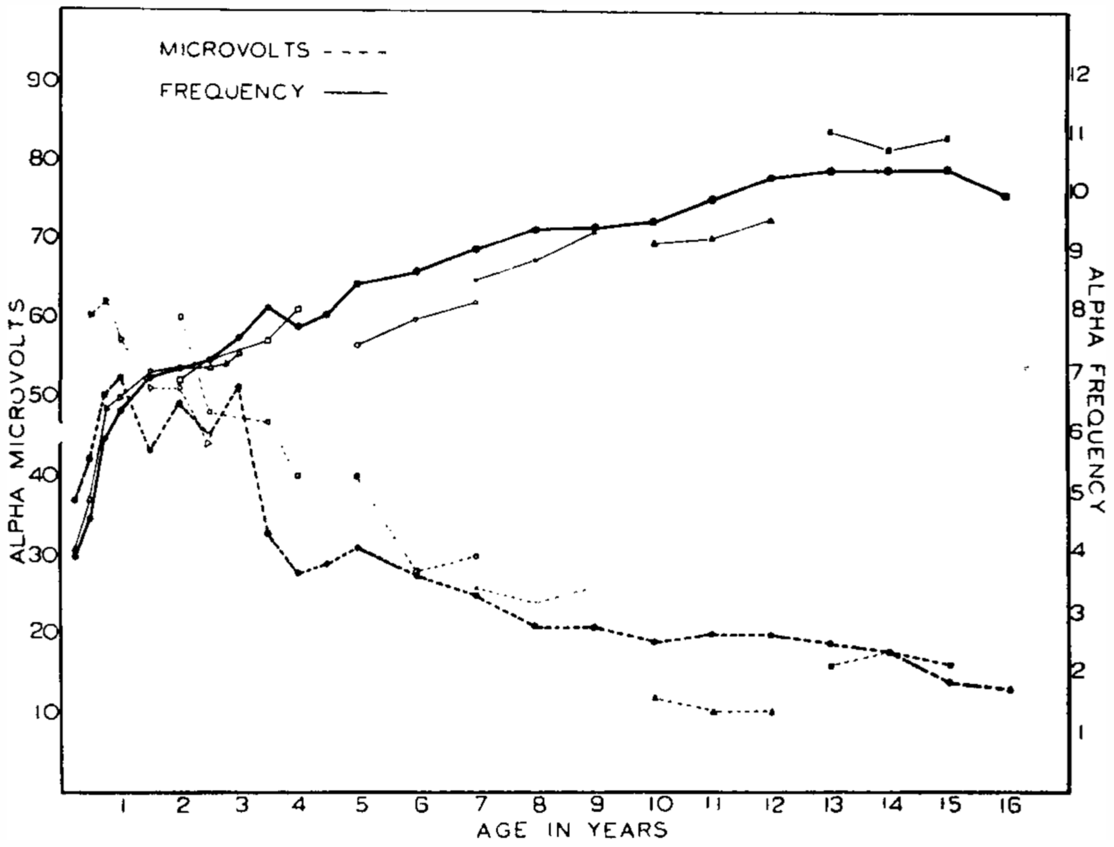
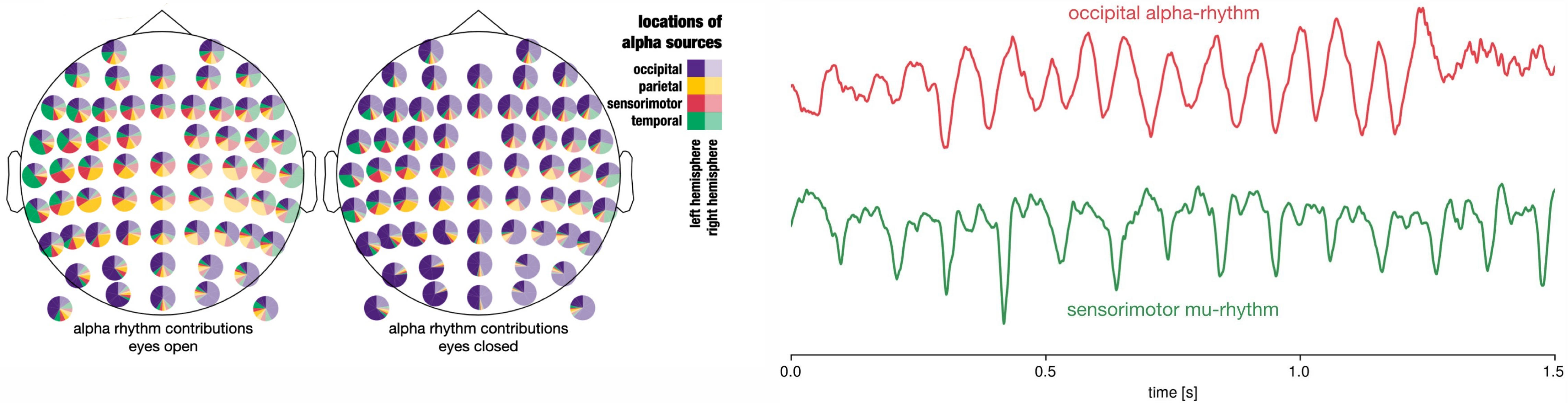


Figure from Lindsley (1939)

Introduction

Distinguishing Alpha and Mu Oscillations



- Spatial mixing has made alpha and mu difficult to distinguish in traditional sensor-space EEG analysis
- Waveform shape reflects underlying physiological and pathophysiological characteristics (Cole et al., 2019)
- **Quantifying difference in waveform shape of alpha and mu may inform understanding of physiological distinctions between them**

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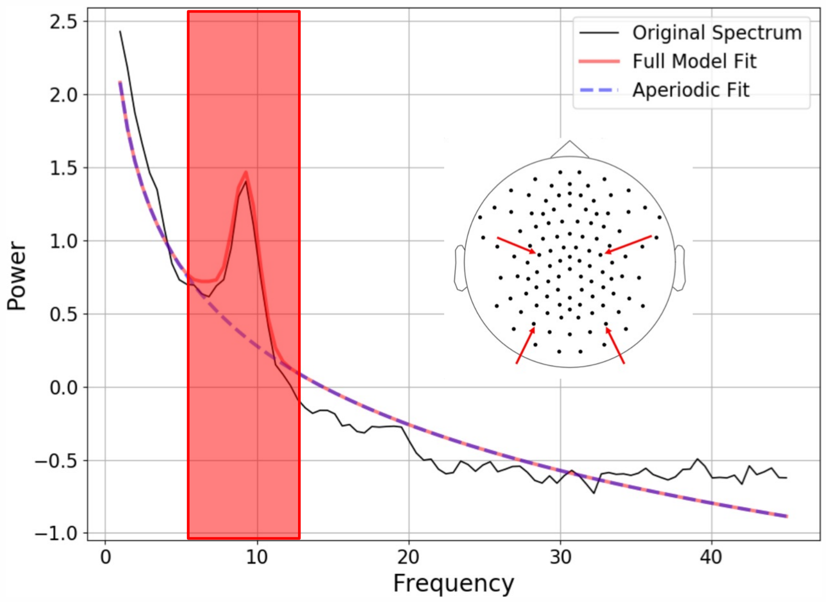
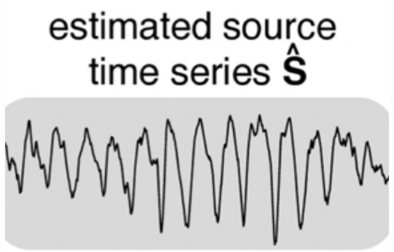
Figure Adapted from Schaworonkow & Nikulin (2021)

Methods

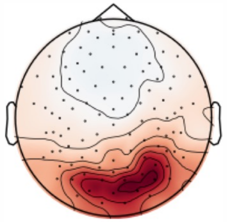
Isolating Alpha and Mu Oscillations from Large EEG Dataset

- 1. Minimal preprocessing: interpolate channels with variance 3 SDs away from the mean for each raw EEG from large dataset of children ages 5-21 (Alexander et al., 2017)
- 2. Find peak in 6-13 Hz range using spectral parameterization package in 2 occipital and 2 sensorimotor channels
- 3. Perform spatio-spectral decomposition (SSD) (Nikulin et al., 2011) to find oscillatory sources with high alpha SNR, each source with its own time series and spatial pattern





estimated source spatial pattern



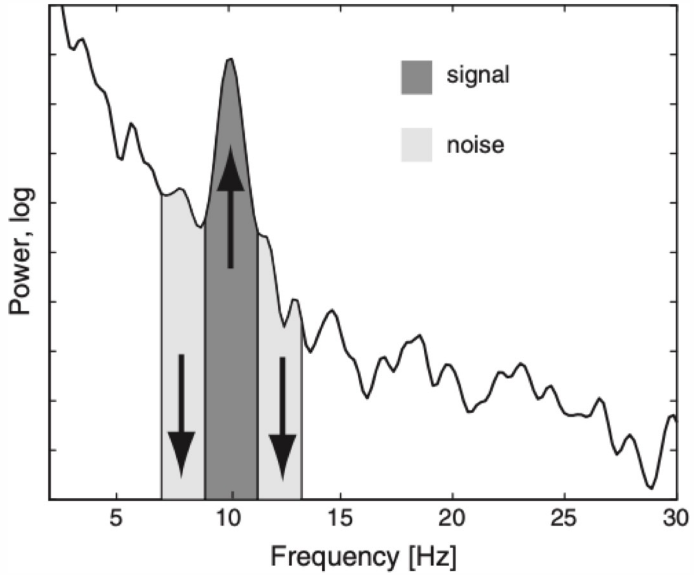


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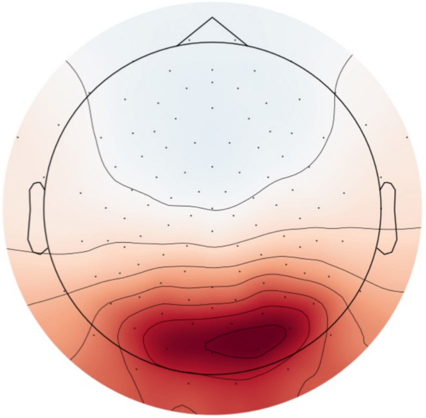
Figure Adapted from Schaworonkow & Nikulin (2021)

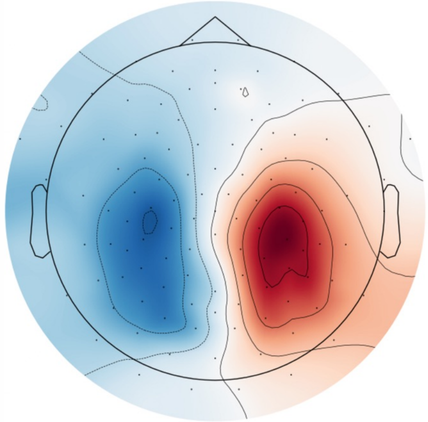
Methods

Isolating Alpha and Mu Oscillations from Large EEG Dataset

- 4. Find peak in 6-13 Hz range using spectral parameterization package for each SSD component
- 5. Keep components with alpha peak SNR > 5
- 6. Calculate absolute cosine distance for each component to alpha and mu templates
- 7. Classify all components within threshold distance of alpha template as alpha components and within threshold distance of mu template as mu components
- 8. Calculate waveform shape features from time series of alpha and mu components using bycycle package



Alpha template



Mu template

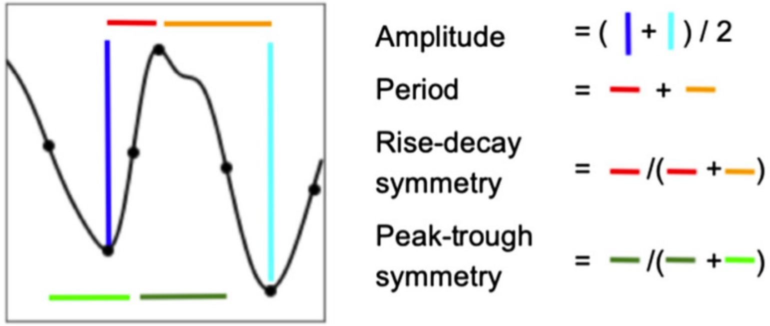


Figure Adapted from Cole & Voytek (2019)

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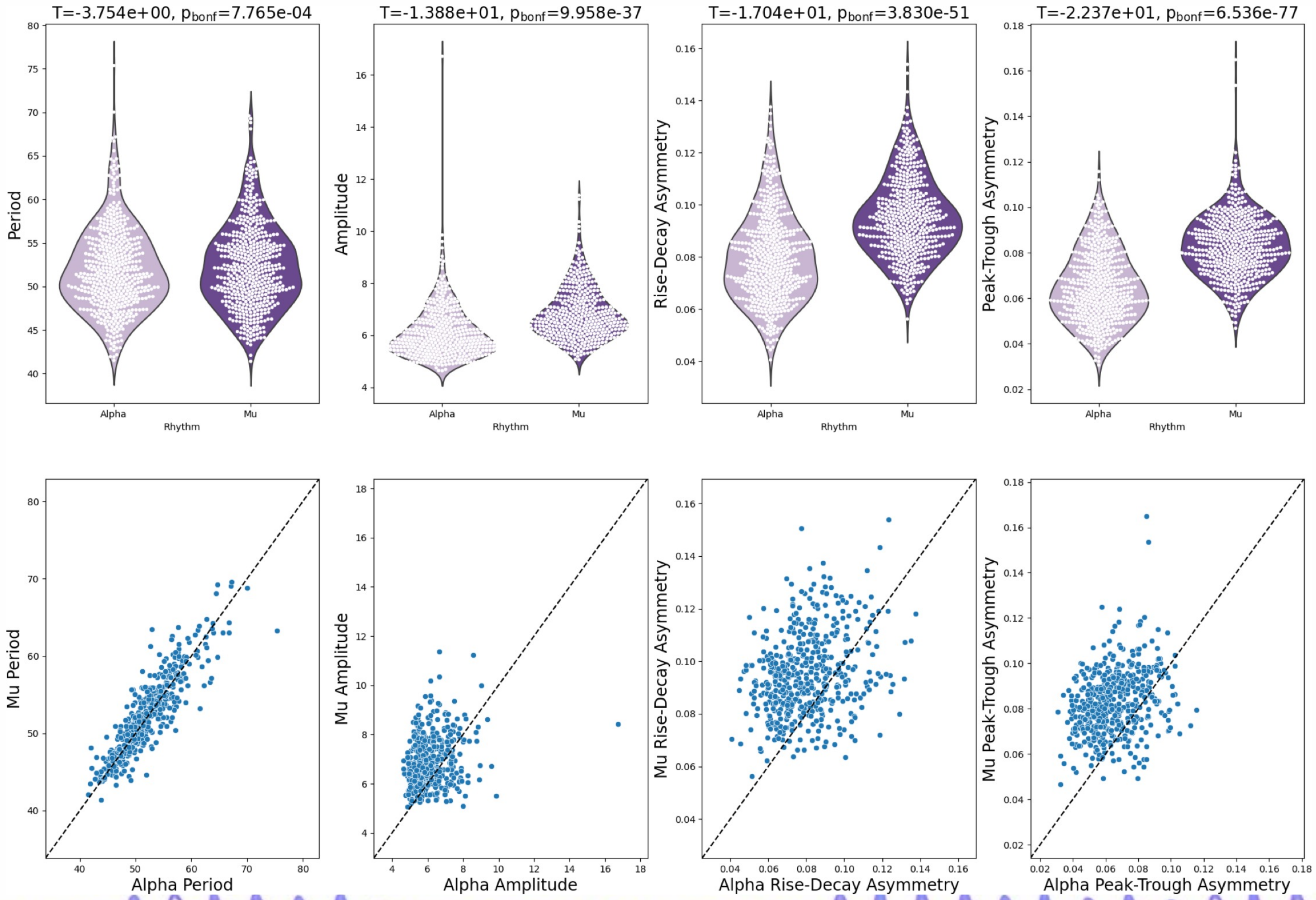
Results

Alpha and mu significantly differ in all waveform shape features



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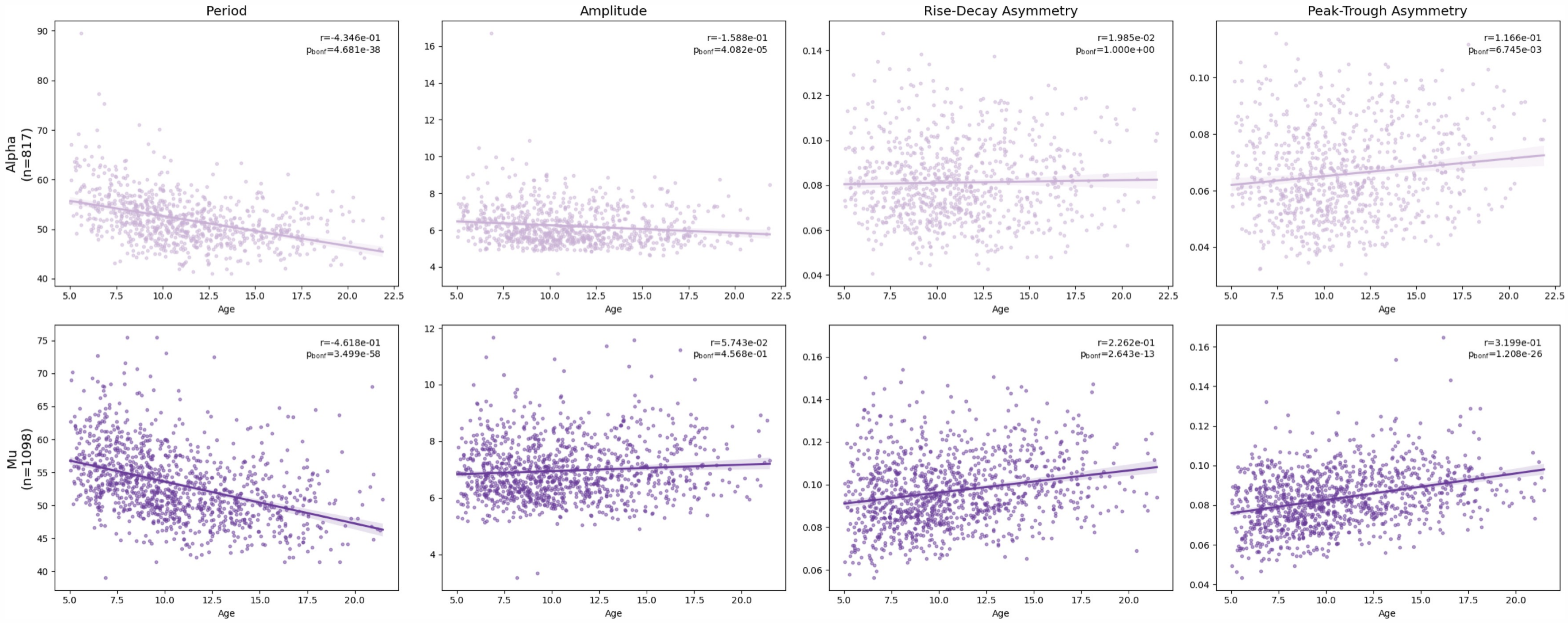
Results

Waveform shape of alpha and mu change differently across development



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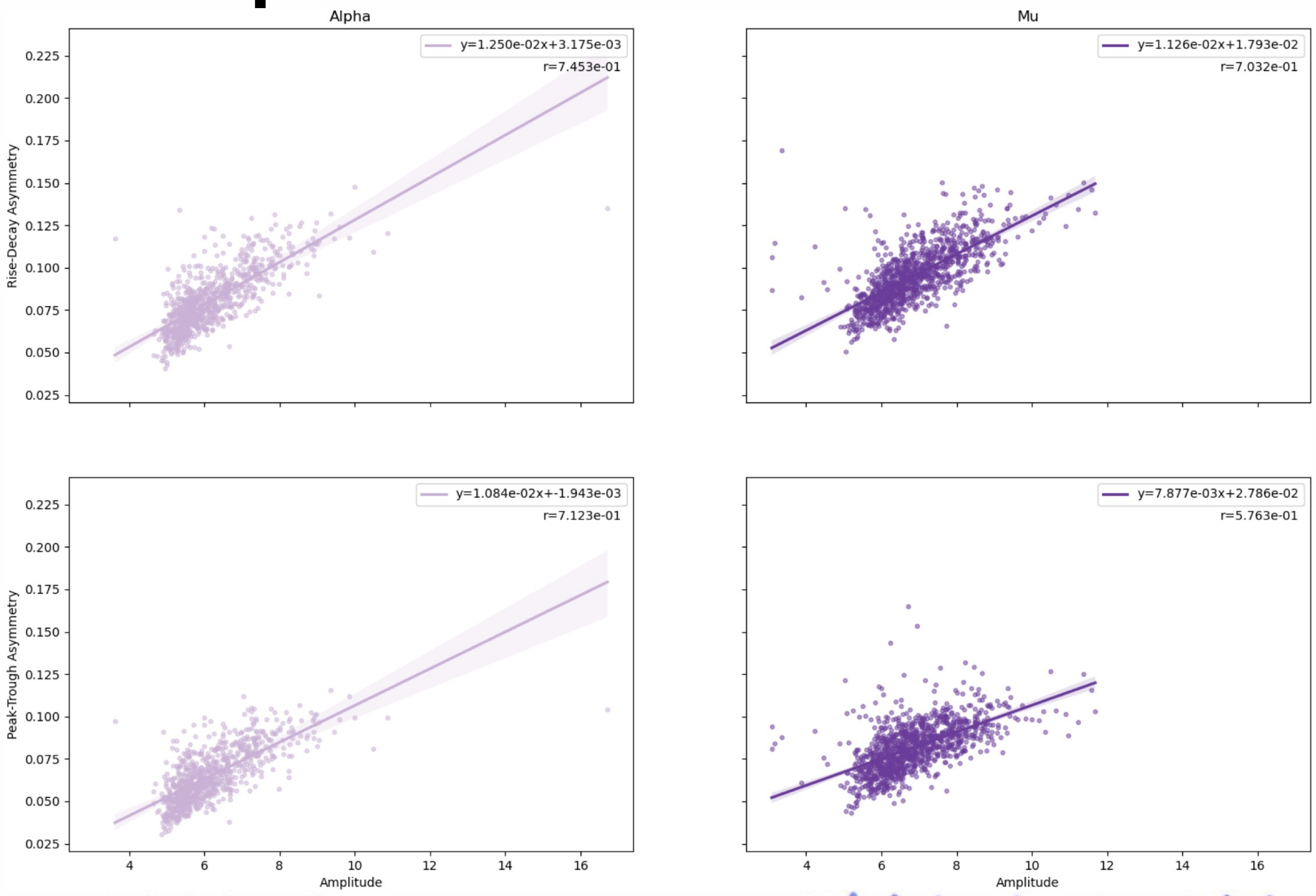
Results

Asymmetry measures increase with waveform amplitude for alpha and mu



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Future Directions

- 1. Account for SNR differences between alpha and mu in examination of waveform shape features
- 2. Examine interaction of asymmetries between and within subjects
- 3. Average waveform shape from phase-aligned instantaneous frequency profiles

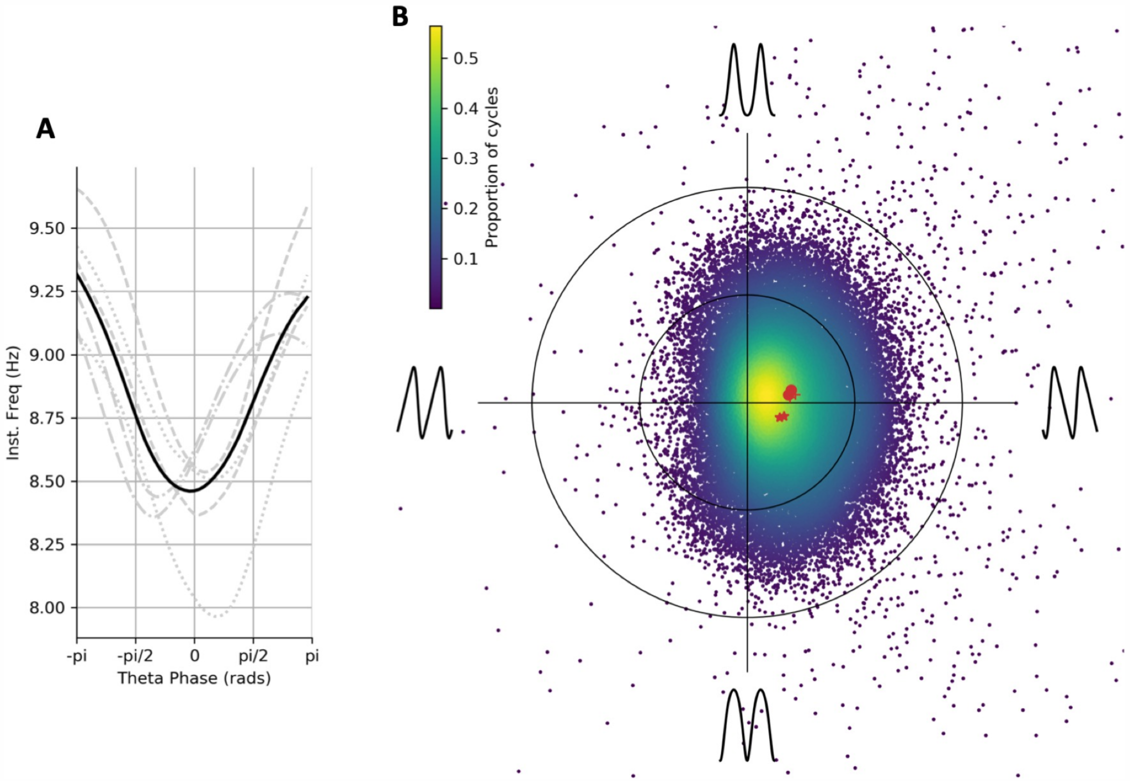

Figure from Quinn et al. (2021)

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