EEG- Derived Spectral Processing and the Development of Working Memory through Adolescence

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INTRODUCTION

- From adolescence to adulthood there are significant improvements in executive function, notably in working memory, believed to be underlined by refinements in brain process that optimize whole brain function[1]
- Previous developmental EEG studies show age-related decreases in mean resting state transient brain rhythms across frequencies and band power[5,6]
- Single-cell studies, however, indicate that average brain rhythms cannot measure trial level transient activity, which is more directly associated with neural activation supporting higher-order cognitive tasks[7,8]
- Thus, we do not understand what aspects of age-related changes in neural function underlie improvements in executive function

STUDY AIMS

- To assess age-related changes in transient EEG activity through adolescence into adulthood in the frontal, occipital, and parietal lobes, as well as the entire cortex.
- To investigate the relationships between age-related changes in EEG activity and age-related improvements in working memory

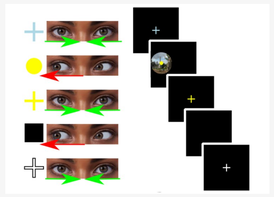
METHODS

Participants:

- 140 healthy 10- 30 years olds (60 subjects evenly distributed between 10-17, and 80 participants distributed between 18-30) (73 = females)

Memory Guided Saccade (MGS) Task:

- Visuospatial working memory task (Fig)
- Participants look at a peripheral target and after a varied fixation delay period (6-10 sec), move their eyes to the remembered location



EEG Acquisition:

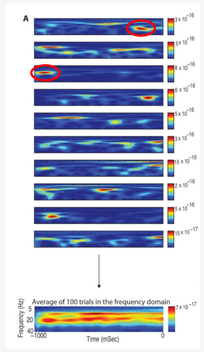
- Biosemi ActiveTwo 64- channel EEG system

EEG Preprocessing:

- Utilized a revised Makoto pipeline:
  - Removed flatline channels, low frequency drifts, noisy channels, short spontaneous bursts, and incomplete segments of data
- Independent Component Analysis (ICA) was preformed to identify eye-blink and eye- movement artifacts

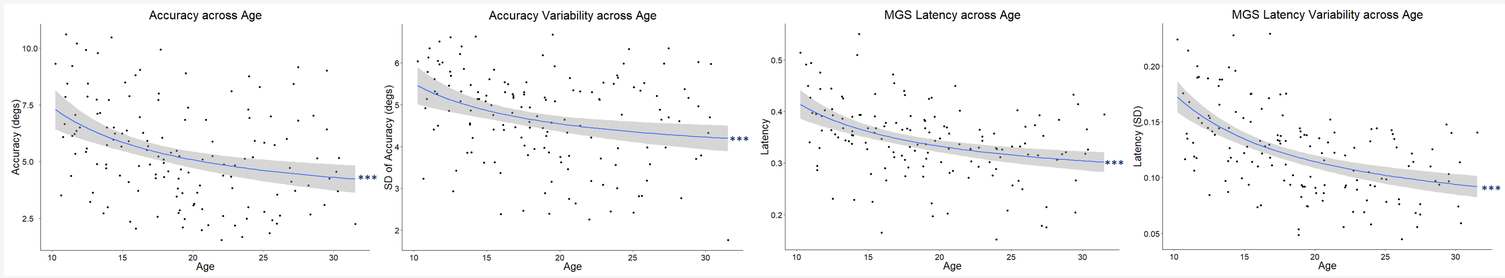
Spectral Event Processing

- Computed from 1s data windows
  - Delay and fixation epochs
- Gamma (30- 75 Hz), theta (4- 7 Hz), beta (13- 30 Hz), and alpha (8- 12 Hz) frequency bands were analyzed using an established protocol in *Shin et al*[8]
- Time frequency representations of the data were calculated using the complex Morlet wavelet and normalized to the median power value for each frequency band
- Events were extracted at the individual trial level within each frequency band, and were used to compute the average power, duration, and number of events per subject

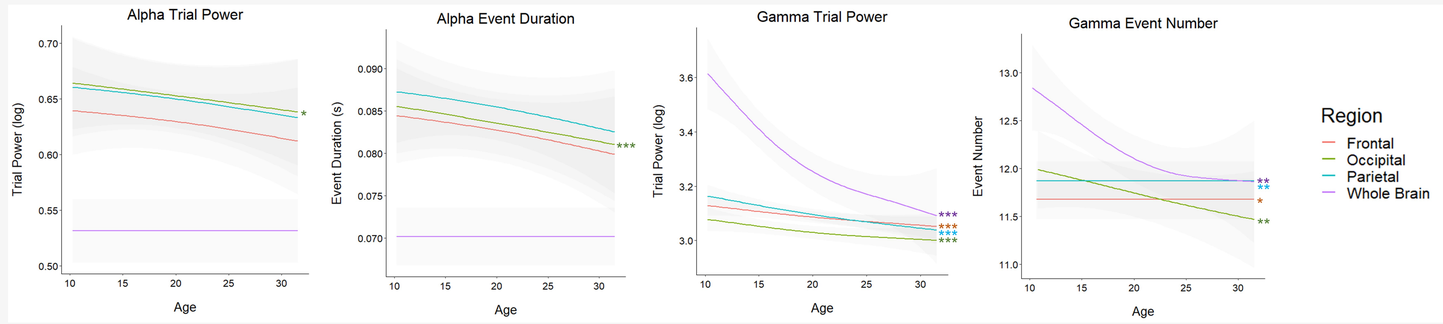


Averaging EEG signals over trials creates the appearance of sustained activity

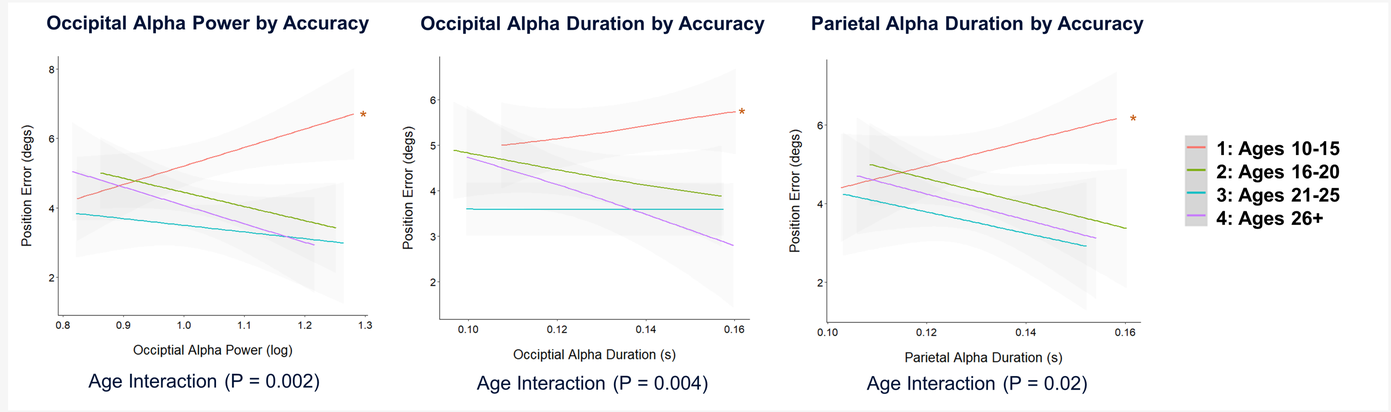
WORKING MEMORY PERFORMANCE IMPROVES INTO ADULTHOOD



TRANSIENT DELAY-PERIOD EEG ACTIVITY DECREASES THROUGH ADOLESCENCE



AGE IMPROVEMENTS IN WORKING MEMORY ARE ASSOCIATED WITH ALPHA-BAND SPECTRAL EVENTS



CONCLUSIONS

- Age-related trial level decreases in whole brain mean gamma and alpha power and variability in gamma, alpha, and beta bands suggest developmental improvements in the degree of neural activation supporting the ability to retain information on-line (gamma), controlling and integrating neural signals (alpha), and engaging top-down control (beta). Age related changes in gamma and beta bands may be underlined by developmental changes in GABA inhibitory and glutamate excitatory processing
- Age-related decreases in the number of spectral bursts in gamma and alpha bands and its association with performance suggest that improvements in WM may be supported by the optimization of neural spiking. Decreases in power may support this process.
- Higher alpha power in the occipital lobes and higher alpha event duration in the occipital and parietal lobes may reflect age related enhancements in accessing mnemonic information that is known to be stored in these regions in spatial working memory tasks[9].

ACKNOWLEDGEMENTS

This project was supported by Grant Number R01MH067924, the Staunton Farm Foundation, and the bioengineering department at the University of Pittsburgh

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