Day-to-Day Individual Alpha Frequency Stability Correlates with Trait Anxiety

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Introduction

Individual Alpha Frequency (IAF)
- Alpha brain waves have a frequency band of 8-12 Hz and are associated with a variety of cognitive functions such as creativity, sensory input gating, etc.
- Within this band, every person has a frequency with the highest power called the individual alpha frequency (IAF)
- IAF is currently being evaluated as a biomarker for pain and intellectual disabilities. It is also a target for neurostimulation studies targeting endogenous alpha waves
- Understanding the stability of this trait is critical for evaluating it as a biomarker and as a target of treatment

Mobile Electroencephalography (EEG)
- High density electroencephalography (HD EEG) devices allows for the detection of electrical activity across the scalp
- In recent years, mobile EEG devices have been created and sold to consumers
- Several mobile EEG devices were tested as part of preliminary work and the most effective was the Muse 2 Headband
- This device has been used in previous research such as for predicting stroke severity and assessing meditation quality. However, most studies took place under the supervision of study personnel which does not take advantage of the at-home data collection potential these devices uniquely offer.

Methods

20 participants were recruited who did not report a neurological disorder diagnosis or meet the criteria for a mental health condition as assessed using the Mini International Neuropsychiatric Interview. 2 participants withdrew over the course of the study and the present analyses examines the remaining 18. The study consisted of two in-lab sessions separated by 4 weeks of daily at-home recordings using the Muse device. At each of these sessions, self-report questionnaires were collected including the Beck Depression Inventory (BDI), State Trait Anxiety Inventory (STAI), Behavioral Inhibition System/Behavioral Activation System (BIS/BAS), and the Edinburgh Handedness Inventory (EHI).

Figure 1. Study Design. In the first session, self-report questionnaires were administered in addition to a clinical interview, followed by a Muse recording, an HD EEG recording, and a final Muse recording. All recordings were resting state recordings. 4 weeks of at-home resting state recordings using the Muse device followed. A final lab session then occurred with self-report questionnaires, a Muse recording, HD EEG recording, and a final Muse recording.

Figure 2. Electrode layout of EGI and Muse. (a & b) The Muse device has four recording electrodes: AF7, AF8, TP9, and TP10. Above are the locations of these electrodes and the reference electrodes. When recording, participants placed electrode gel on each of these electrodes. (c) EGI electrode layout with AF7, AF8, TP9, and TP10 highlighted.

Figure 3. Spectral Correlations. (a) EGI electrode layout with AF7, AF8, TP9, and TP10 highlighted. (b) Muse layout with recording electrodes highlighted. (c) EGI spectral correlations across sessions for TP9, TP10, AF7, and AF8. (d) Muse-EGI spectral correlations across recordings for TP9, TP10, AF7, and AF8. (e) Muse spectral correlations across days for TP9, TP10, AF7, and AF8.

Figure 4. Example Power Spectra from EGI and Muse. (a) Example EGI power spectra for all 128 electrodes with extracted IAF designated. (b) Example Muse TP10 power spectra across all days with extracted IAF designated.

Figure 5. Comparisons between EGI and Muse IAFs. (a) IAF extracted from first session Muse TP9 vs. first session EGI TP9. (b) IAF extracted from first session Muse TP10 vs. first session EGI TP10. (c) IAF extracted from last session Muse TP9 vs. last session EGI TP9. (d) IAF extracted from first session.

Figure 6. IAF Comparisons between First and Last Session. (a) Extracted IAF from Muse TP9 first session vs. last session. (b) IAF from Muse TP10 first session vs. last session. (c) IAF from EGI TP9 first session vs. last session. (d) IAF from EGI TP10 first session vs. last session. (e) IAF change in TP9 Muse vs. change in TP9 EGI. (f) IAF change in TP10 Muse vs. change in TP10 EGI. TP10 IAF standard deviation.

Figure 7. Behavioral Correlates with IAF Stability. (a) First session STAI trait anxiety score vs. Muse TP9 IAF standard deviation. (b) Last session STAI trait anxiety score vs. Muse TP9 IAF standard deviation. (c) First session BIS/BAS behavioral inhibition score vs. Muse TP10 IAF standard deviation. (d) Last session STAI trait anxiety score vs. Muse TP10 IAF standard deviation.

Figure 8. EGI IAF Distribution. (a) First session EGI TP9 IAF vs. global IAF. (b) First session EGI TP10 IAF vs. global IAF. (c) Last session TP9 IAF vs. global IAF. (d) Last session TP10 IAF vs. global IAF. (e) Distribution of IAF frequency across the scalp.

Conclusion

- Muse and EGI are comparable at TP9 and TP10 for identifying IAF. Furthermore, both devices found that the IAF was stable over a month
- Day-to-day stability of the IAF over four weeks measured by the Muse device correlates with trait anxiety and behavioral inhibition
- Trait anxiety and behavioral inhibition have been previously related as behavioral inhibition is thought to be the neurological basis of trait anxiety
- There is not a singular IAF per person as a spectrum of IAF frequencies exists across the scalp. IAF needs to be better defined given its spatial distribution.

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