When assessing frontal EEG asymmetry, Individualized Alpha Frequency approaches do not differ much from the standard, nomothetic approach in reliability or validity.

A Comparison of Nomothetic and Individualized Alpha Frequency Approaches

Diheng Zhang[1], **John J.B. Allen**[1]
[1] *Department of Psychology, University of Arizona*

Introduction

Frontal asymmetry (FA) is considered to be a reliable marker of affective processing and psychopathology **(Reznik and Allen 2018)**. Traditionally, the magnitude of alpha is calculated by taking average over a nomothetic fixed frequency window (e.g. 7.5 to 13.5 hz). Methods have been proposed to extract individualized alpha frequency (IAF) peaks and windows in hopes of improving the reliability and validity of signal detection. However, no study has compared the nomothetic to IAF approaches in a large well-characterized data set. In this study, we:

1. Assessed the psychometric performance of the standard fixed window approach, a PZ-alpha based IAF **(Quaedflieg et al. 2015)** and a global-alpha based IAF windows detection **(Corcoran et al. 2018)** approach on a previously collected EEG data set.
2. Compared the stability over repeated assessments of these three methods for calculating single-site alpha and pair-wise alpha asymmetry.
3. Compared the validity of these three methods with respect to differentiating subjects with different depression histories.

Methods

To compare the performance of two different IAF approach, we calculated alpha and alpha asymmetry with three different approaches on a dataset of 2431 resting EEG recordings, collected from 313 subjects (8 recordings per subject collected on four occasions across two weeks).

- Standard: The alpha window was pre-selected as [7.5 13.5] and fixed across subjects, recordings and channels **(Stewart et al. 2010)**.
- Global IAF: The alpha windows were selected by a Matlab library proposed by **Corcoran et al. (2018)**, which automatically detect alpha peak to anchor individual lower bound and upper bound per channel.
- PZ IAF: The IAF was determined as the dominant frequency rhythm between 5 and 15 Hz at the posterior electrode (Pz) on 8 mins of resting eyes closed data. The IAF bandwidth was defined as the IAF±0.20×IAF **(Quaedflieg et al. 2015)**.

In all cases, we examined log alpha power at individual sites and the difference of log alpha power (ln(R)-ln(F)) for asymmetry scores. See Figure 1 for the windows selected by different approaches.

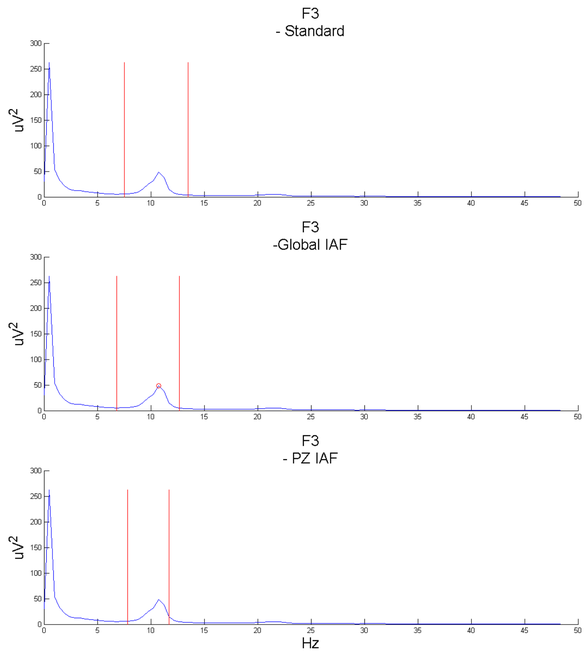

Figure 1: Power spectral density plots of channel F3 from Subject 27, Recording 3, with alpha windows selected by standard approach (top), global alpha based IAF (middle), and PZ-based IAF (buttom).

Results

- Our results revealed that FA calculated with these three different methods are highly correlated at all frontal channels (F2-F1, F4-F3, F6-F5, and F8-F7; r_mean = 0.98).
- The stability across the 8 recordings over the two weeks also showed no substantial difference between approaches as indicated by Intra-class correlations (ICCs: Standard F4_F3: 0.72; PZ-based IAF F4_F3: 0.72; Global-alpha based IAF F4_F3: 0.72). (See Figure 2 for ICCs of pair-wise alpha asymmetry and single-site alpha)

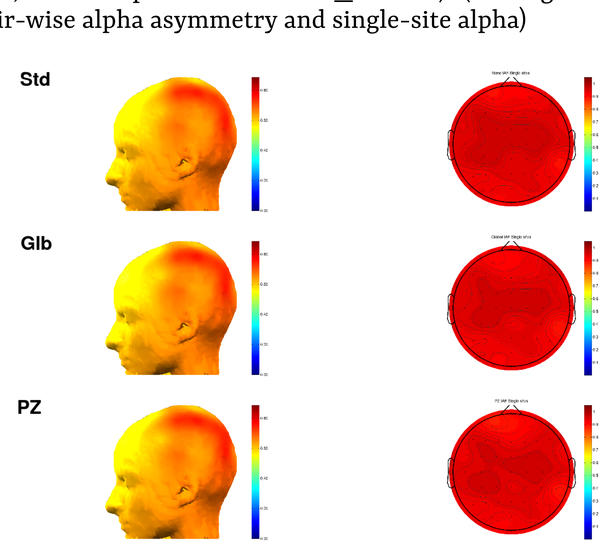

Figure 2: Alpha asymmetry ICCs (left) and single cites alpha ICCs (right) across methods, plotted against sites. Std = standard AF approach; Glb = global alpha based IAF; PZ = PZ-based IAF

- To examine the relationship between lifetime MDD status and frontal EEG asymmetry calculated by these three different approaches, a full-factorial mixed linear model tested the relationship between lifetime MDD status and frontal EEG asymmetry. For all three methods, replicating the findings of **Stewart et al. (2010)**, main effects of lifetime MDD status were found (Current MDD V.S. Never/Past MDD; t = 3.886, P < 0.001); no main effects of methods or interaction between lifetime MDD status was found. (See Figure 3)

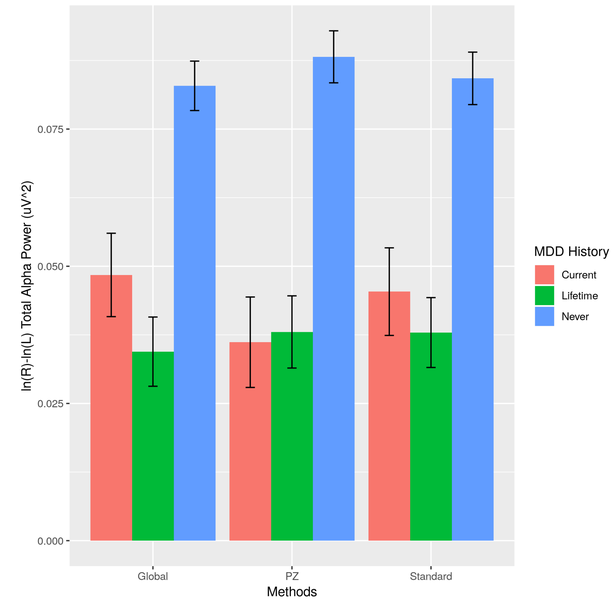

Figure 3: Frontal alpha asymmetry scores (collapsed across F2-F1, F4-F3, F6-F5, F8-F7) as a function of MDD history. Error bars reflect standard error. Global = global alpha based IAF; PZ = PZ-based IAF; Standard = standard AF approch

Conclusion

- Based on our dataset, the global-alpha based and the PZ-alpha based IAF approaches yielded overall trait-like stability that is at least as good as the standard, nomothetic (fixed alpha windows approach) approach.
- Both IAF approaches yielded similar validity with respect to subjects' depression history, compared to the standard approach.
- No substantial improvement on reliability and validity in measuring frontal EEG alpha asymmetry was found with either the global-alpha based or the PZ-based IAF approaches, compared to the standard approach.
- Currently, all the data analyses done are based on resting data and reference-free current source density (CSD) estimation. It is still unknown whether IAF approaches could provide superior reliability or validity in terms of task related data (e.g. emotion manipulation paradigm) or data calculated with respects to other references (AVG, LM, etc.).

References

Corcoran, Andrew W, Phillip M Alday, Matthias Schlesewsky, and Ina Bornkessel-Schlesewsky. 2018. "Toward a Reliable, Automated Method of Individual Alpha Frequency (Iaf) Quantification." *Psychophysiology* 55 (7): e13064.

Quaedflieg, CWEM, T Meyer, FTY Smulders, and T Smeets. 2015. "The Functional Role of Individual-Alpha Based Frontal Asymmetry in Stress Responding." *Biological Psychology* 104: 75–81.

Reznik, Samantha J, and John JB Allen. 2018. "Frontal Asymmetry as a Mediator and Moderator of Emotion: An Updated Review." *Psychophysiology* 55 (1): e12965.

Stewart, Jennifer L, Andrew W Bismark, David N Towers, James A Coan, and John JB Allen. 2010. "Resting Frontal Eeg Asymmetry as an Endophenotype for Depression Risk: Sex-Specific Patterns of Frontal Brain Asymmetry." *Journal of Abnormal Psychology* 119 (1): 502.

THE UNIVERSITY OF ARIZONA