

Spectral EEG distributions in generalized anxiety disorder using a large hospital-based clinical EEG database

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1 ABSTRACT

Quantitative EEG features in psychiatric conditions vary with acquisition, preprocessing, montage and clinical context, and laboratory-grade population thresholds for clinical use are lacking. Larger clinical EEG datasets now permit context-specific characterisation of EEG features against a real-world reference population. We asked whether generalized anxiety disorder (GAD) is associated with selective shifts in spectral features relative to a broad hospital-based clinical EEG population without recorded GAD.

2 BACKGROUND

Anxiety-related EEG findings are widely reported, however, their population behaviour in real-world clinical EEG is unclear. Rather than comparing GAD with healthy controls, we benchmark GAD-associated EEG features against a broad clinical EEG population, a stricter test of feature specificity, since both groups share acquisition, referral and preprocessing pipelines.

3 AIM

To characterise population distributions of EEG spectral parameters in participants with GAD compared with a broader clinical EEG reference population.

4 METHODS

102,908

Broader clinical EEG population (no GAD)

859

GAD primary Dx with EEG

14

qEEG pre-selected features

Cases were 859 participants with EEG within -3 to +12 months of a primary GAD diagnosis. Comparators were 102,908 participants from the broader clinical EEG population without recorded GAD. Conditions included eyes-open, eyes-closed, with heterogeneous acquisition (>70 montages, 19-128+ channels; 200-4,096 Hz; recording lengths from 1 min to >10 hours). A standardized in-house pipeline was applied: 0.5-100 Hz bandpass, 50/60 Hz notch, common-average re-referencing, resampling to 250 Hz, bad-channel interpolation, IQR normalization, and segment-level artefact rejection via a LightGBM classifier (no ICA, by design). Features were pre-specified from prior GAD literature before analysis; no data-driven feature selection was performed.

5 COHORT

The GAD cohort showed a female predominance, with women comprising approximately 65% of cases (~35% male), consistent with the well-established ~2:1 female-to-male prevalence ratio reported for generalized anxiety disorder.

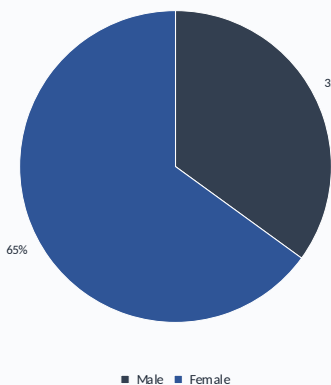


Figure 1. GAD cohort: Sex distribution

6 RESULTS

14 quantitative EEG features across six groupings were pre-specified from peer-reviewed GAD literature, then derived from resting-state EEG: theta (4-8 Hz) power (relative and absolute, global and frontal), beta-2 (20-30 Hz) power (relative and absolute, frontal and central), alpha asymmetry (frontal and temporal), theta coherence (fronto-temporal and temporal-parietal), midline theta connectivity (Fz-Cz-Pz), and theta clustering coefficient. Cohen's d was computed as the standardized mean difference using pooled standard deviation.

Effect sizes within the beta-2 power grouping were substantially greater than those observed across the five non-beta-2 groupings. The GAD-vs-non-GAD effect sizes within the beta-2 power grouping were 0.59 and 0.50 for relative and absolute power in the central region, and were 0.37 and 0.33 in the frontal region. Across the non-beta-2 groupings, the largest effect size was $d = 0.14$, less than half the minimum observed across the four beta-2 features ($d = 0.33$). Notably, the theta and asymmetry features, despite being frequently cited in GAD literature, show negligible effect sizes in this real-world clinical sample.

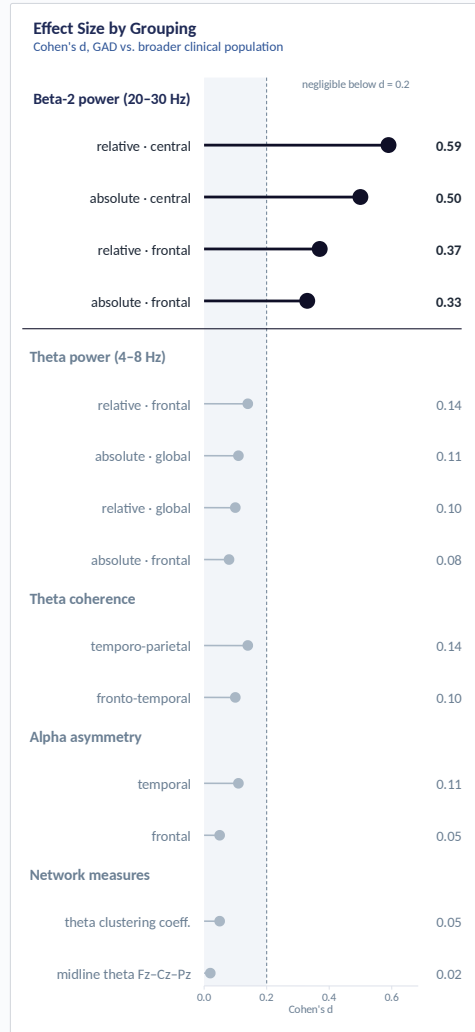


Figure 2. Cohen's d across all 14 quantitative EEG features

7 KEY FINDINGS

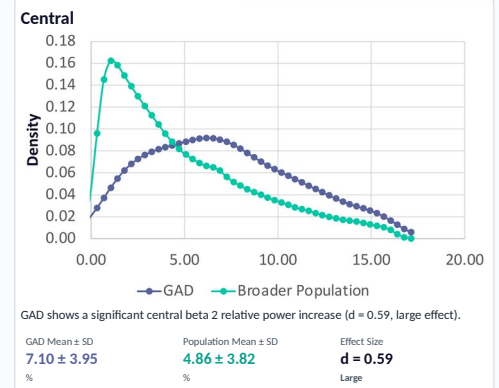
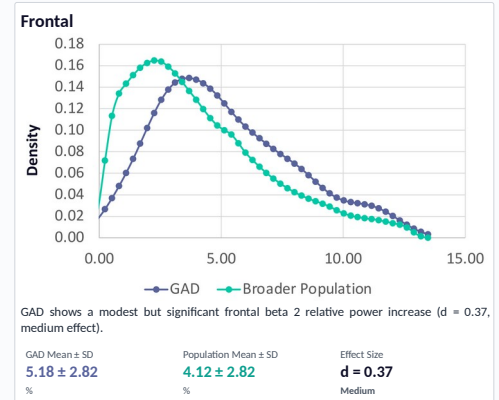


Figure 3. Beta-2 (20-30 Hz) relative power: GAD vs. broader clinical population

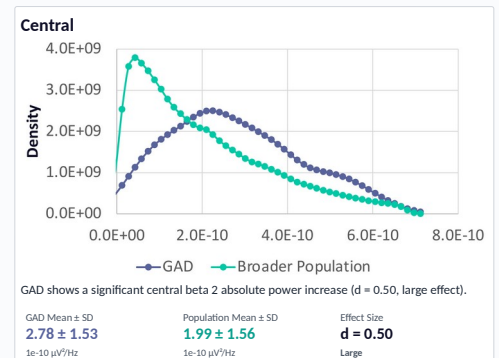
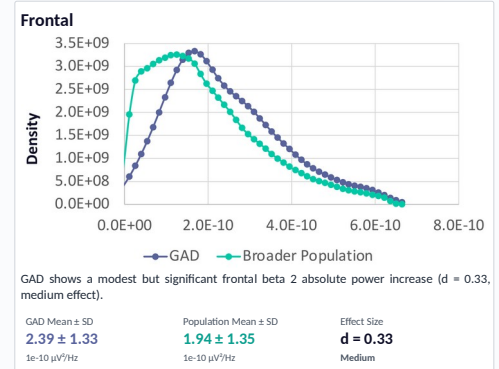


Figure 4. Beta-2 (20-30 Hz) absolute power: GAD vs. broader clinical population

CONCLUSION

In a large real-world clinical EEG dataset, beta-2 power showed selective distributional separation in GAD, while commonly discussed theta and alpha-asymmetry features did not. Increased beta-2 power is consistent with the established literature linking cortical hyper-arousal and elevated high-beta oscillations to anxious states. The selectivity of this shift, against negligible displacement across alpha, theta, asymmetry, connectivity and clustering measures is not readily explained by a global database artefact and supports further evaluation of beta-2 power as a candidate GAD-associated EEG feature.

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DISCLOSURE

S. C. Hopkins and F. Bolognani are employees and/or shareholders of Newleos Therapeutics. I. Mishanin, P. Pshonkovskaya, T. Adamovich, A. Matveev and M. Khayretdinova are employees and/or shareholders of Brainify.AI. The authors declare no other conflicts of interest.