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Half Awake
A Within-Brain Comparison of Aperiodic and Oscillatory EEG During Unilateral Methohexital Anesthesia

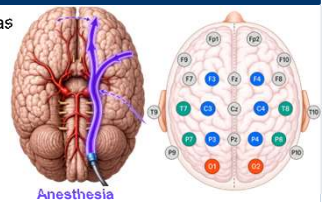
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PROBLEM & OBJECTIVE

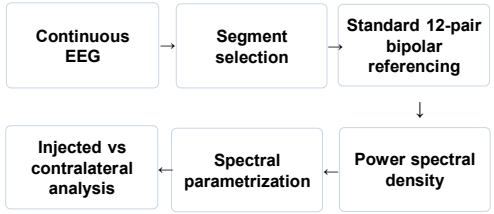
- **Motivation**: Aperiodic EEG activity was traditionally treated as background noise, but growing evidence suggests it contains meaningful information about brain state.
- **Opportunity**: The Wada procedure temporarily anesthetizes one hemisphere while the other serves as an internal control, creating a rare within-brain experiment.
- **Problem**: Movement and behavioral testing can produce bilateral EEG changes that obscure the localized effects of anesthesia.
- **Objective**: We tested whether the aperiodic spectral exponent provides a more robust and spatially specific marker of unilateral methohexital anesthesia than conventional oscillatory measures.



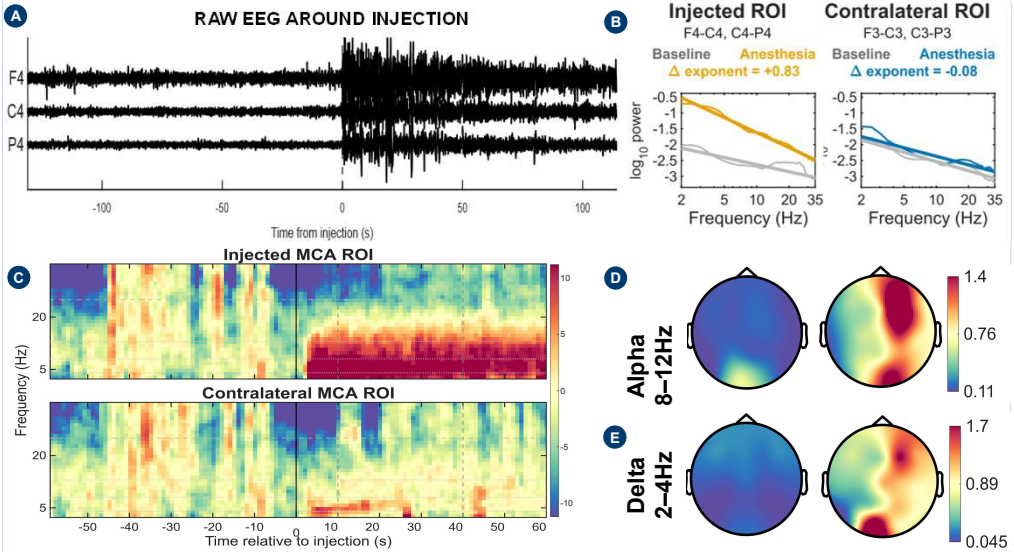
ABSTRACT

EEG from 27 patients undergoing Wada testing were spectrally parameterized across matched pre- and post-injection windows to separate aperiodic and periodic activity. Each participant served as their own control by comparing changes in the injected and contralateral hemispheres. The aperiodic exponent steepened more in the injected hemisphere in 20 of 27 participants (p = 0.019). In contrast, distinct theta oscillations (4–8 Hz) were detected in only 6 of 27 participants, limiting their utility for single-subject analysis. Making the exponent the more specific candidate biomarker of hemispheric anesthesia. These findings support the aperiodic exponent as a robust marker of hemispheric anesthesia and add to growing evidence that the EEG background contains meaningful information about cortical states. More broadly, incorporating aperiodic activity may improve how EEG is used to characterize changes in brain function.

METHODS

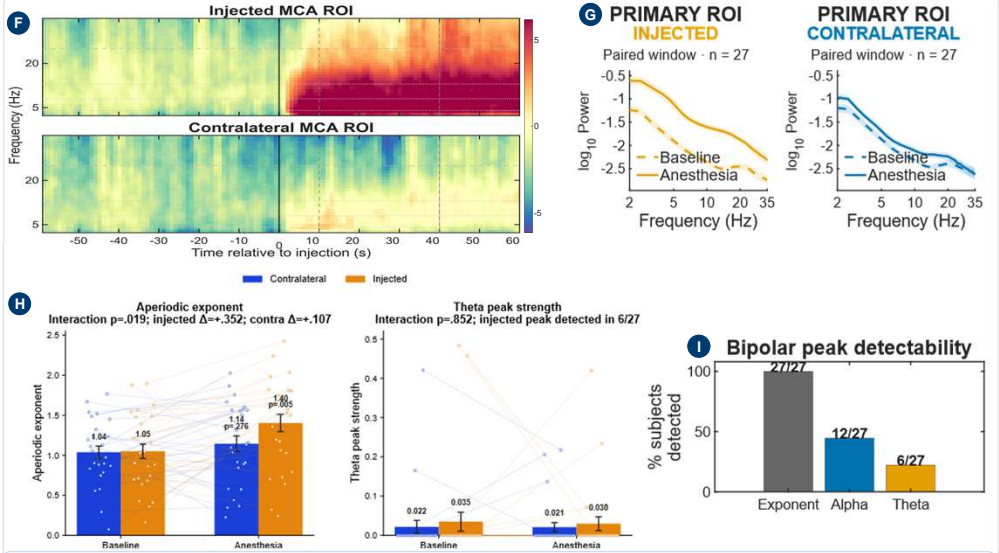


SINGLE-SUBJECT EXAMPLE



(A) Raw EEG traces of the electrodes at the medial carotid artery region of interest demonstrate slowing following methohexital injection at time zero. (B) Spectral parameterization reveals greater exponent steepening in the injected hemisphere than the contralateral hemisphere, consistent with the literature on anesthesia-related cortical slowing. (C) Spectrograms show a sustained post-injection increase in low-frequency power, strongest in the injected MCA ROI. The contralateral ROI shows a much weaker, narrower increase. (D–E) Following administration of methohexital, there is a rise in broadband power seen above in Alpha and delta power. The topographies show their spatial distribution, providing anatomical context for the unilateral spectral changes.

GROUP-LEVEL BIPOLAR RESULTS N=27



(F) Group-level spectrograms show a sustained post-injection increase in low-frequency power, strongest in the injected MCA ROI, consistent with the single-subject data. (G) Group-averaged spectra show a larger baseline-to-anesthesia change in the injected hemisphere than in the contralateral hemisphere. (H) The aperiodic exponent increased more in the injected hemisphere (Δ = +0.352) than in the contralateral hemisphere (Δ = +0.107), lateralizing to the correct anesthetized hemisphere. Theta peak strength showed no corresponding interaction (p = 0.852) and did not correctly lateralize to the injected hemisphere. (I) The aperiodic exponent was measurable in all participants (27/27), compared with distinct alpha peaks in 12/27 and theta peaks in 6/27. Across participants, the aperiodic exponent captured the unilateral anesthetic effect more consistently than oscillatory peak measures.

TAKEAWAY

The aperiodic exponent emerged as the most robust marker of unilateral methohexital anesthesia. It was measurable in all participants (27/27), whereas a distinct theta peak was detected in only 6/27 (22%), limiting its value for single-subject interpretation. **Following injection, exponent steepening was consistently greater in the injected hemisphere than in the contralateral hemisphere, a statistically significant difference (p = 0.019), supporting a localized anesthetic effect rather than a bilateral recording artifact.** Although spectral offset also changed with anesthesia, it may be strongly influenced by movement, making the aperiodic exponent the more specific biomarker of hemispheric anesthesia.

CLINICAL RELEVANCE

- A biomarker that is consistently measurable and reflects the anesthetized hemisphere may improve confidence in distinguishing true anesthetic effects from nonspecific EEG changes during presurgical evaluation.
- These findings support further evaluation of the aperiodic exponent as an objective EEG biomarker of hemispheric anesthesia and motivate validation in larger, prospective Wada cohorts.
- Broader significance: Demonstrating that the exponent reliably tracks a controlled change in brain state strengthens the case for using aperiodic EEG to understand brain function rather than dismissing it as background activity.

ACKNOWLEDGMENTS

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