Increased Intracranial EEG Power and Duration in Medial Temporal Lobe Seizures with Impaired Consciousness

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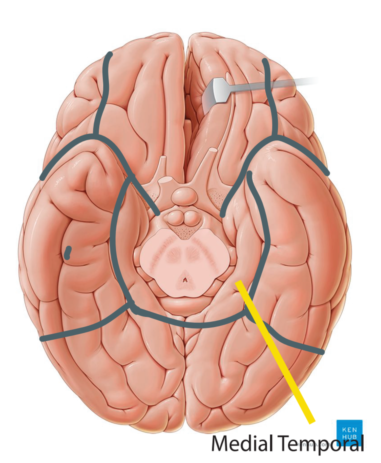
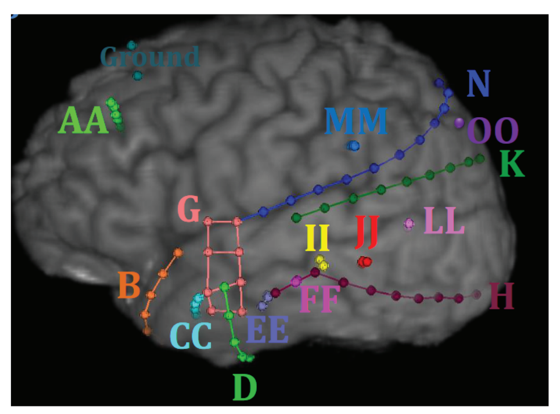
1. Introduction

Consciousness is essential to normal human life, and its transient loss can have severe effects on quality of life and mortality. In this study, we used intracranial EEG to determine differing characteristics between medial temporal lobe seizures with and without impaired consciousness defined by behavioral responsiveness. Our goal was to obtain mechanistic insights, and to elucidate signal characteristics that could potentially be used to prevent impaired consciousness using neurostimulation.

2. Methods

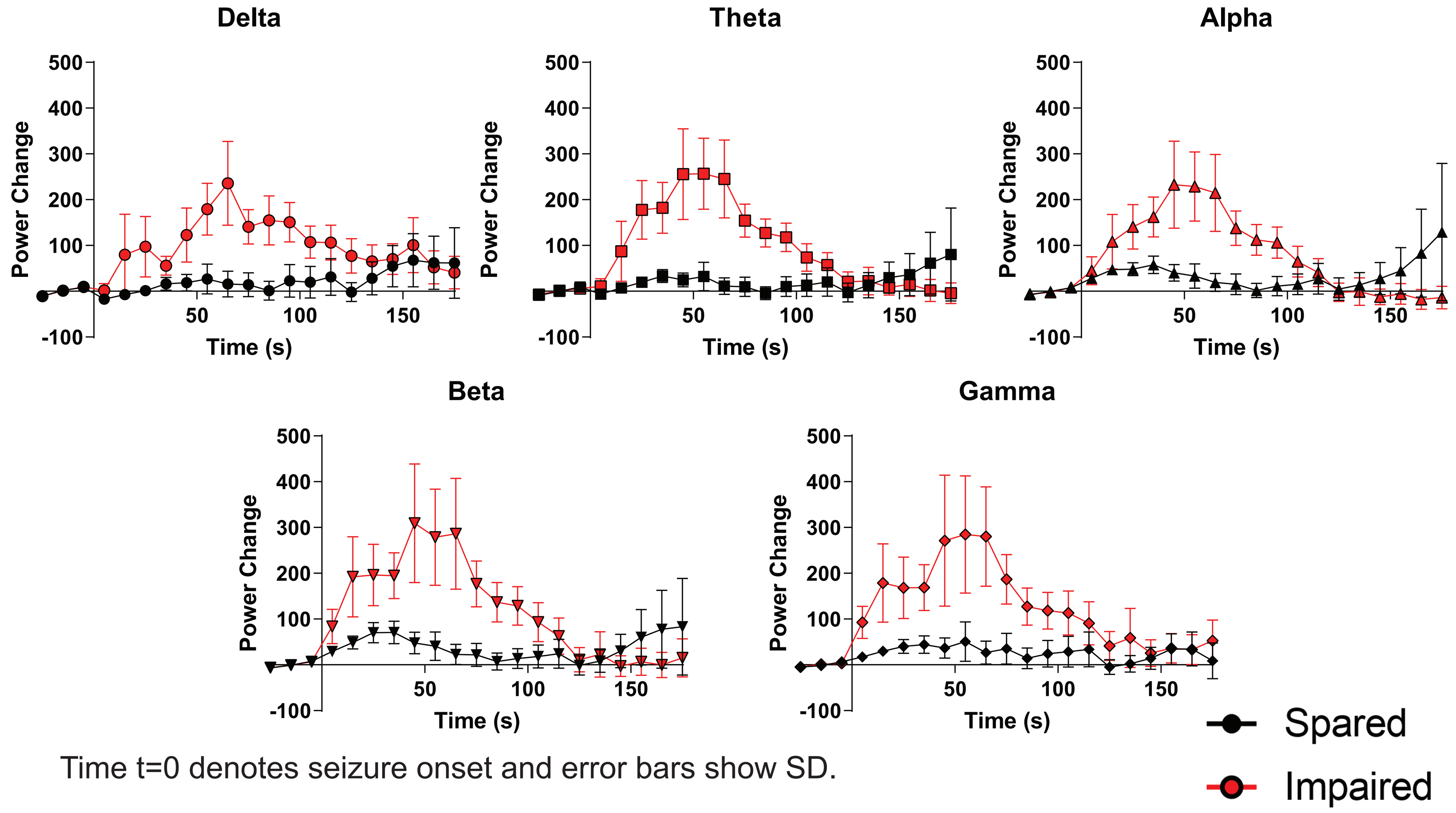
Intracranial EEG from 8 patients with a total of 76 medial temporal lobe seizures were analyzed. Behavioral responsiveness was independently rated by two video reviewers and classified into impaired and spared responsiveness to external stimuli. EEG signals from each electrode contact were processed using fast Fourier transform to calculate the signal power at different frequencies. Signals were synchronized to time of seizure onset and averaged across electrodes within mesial temporal regions. The change in power from preictal baseline was compared between seizures with impaired and spared behavioral responsiveness. High frequency oscillations and noise classified as artifacts in the icEEG data were marked and removed prior to analysis.





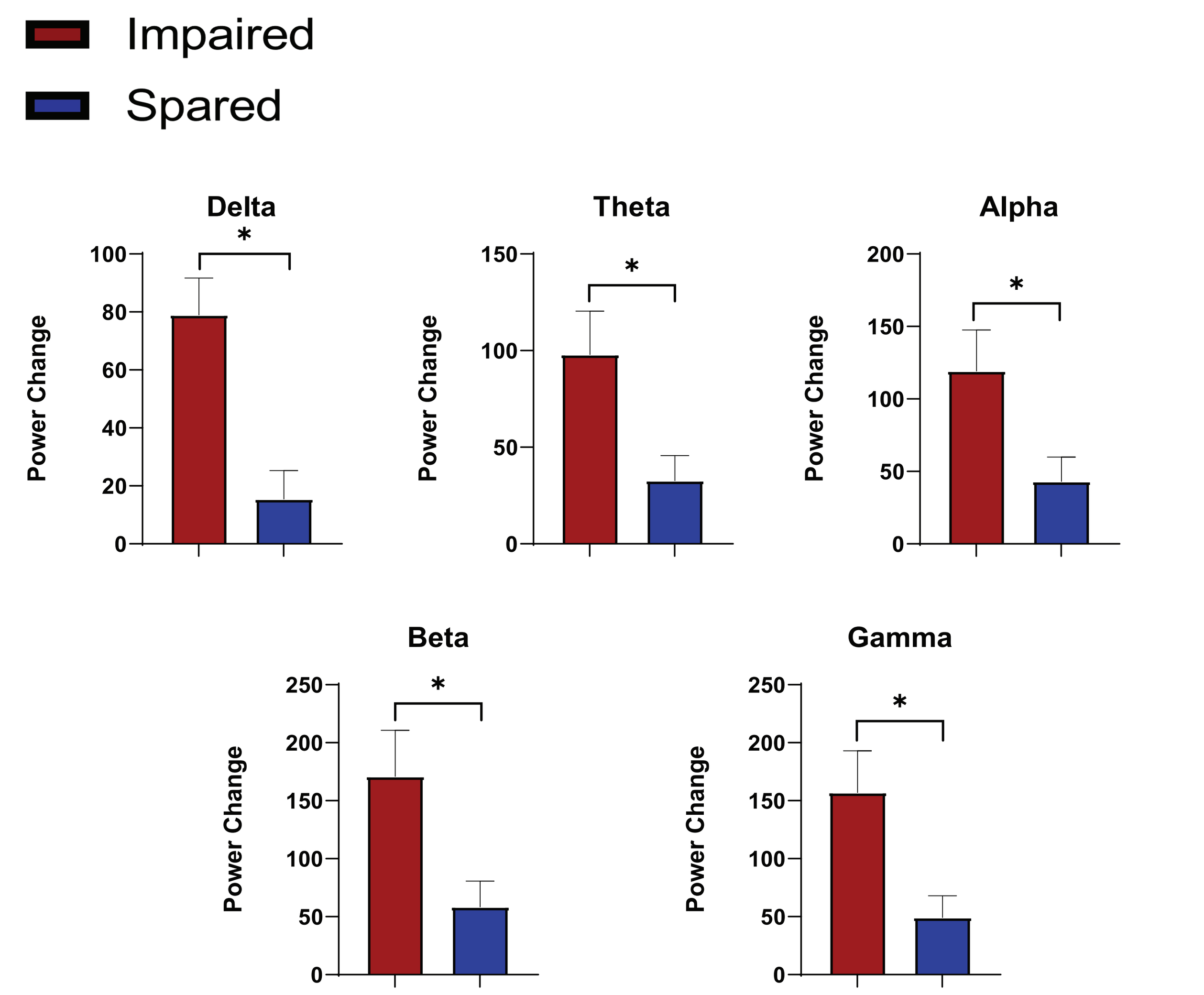
Schematic of brain anatomy depicts the location of the mesial temporal lobe region that was analyzed.

3. Time course plots of intracranial EEG changes during temporal lobe seizures with spared (n=58) and impaired (n=18) behavioral responses



Time t=0 denotes seizure onset and error bars show SD.

4. Mean power change (SEM) in different frequency bands (delta, theta, alpha, beta, and gamma) during seizure compared with 30 s pre-seizure baseline



Delta Frequency: 0.5 Hz – 4 Hz

Theta Frequency: 4 Hz – 8 Hz

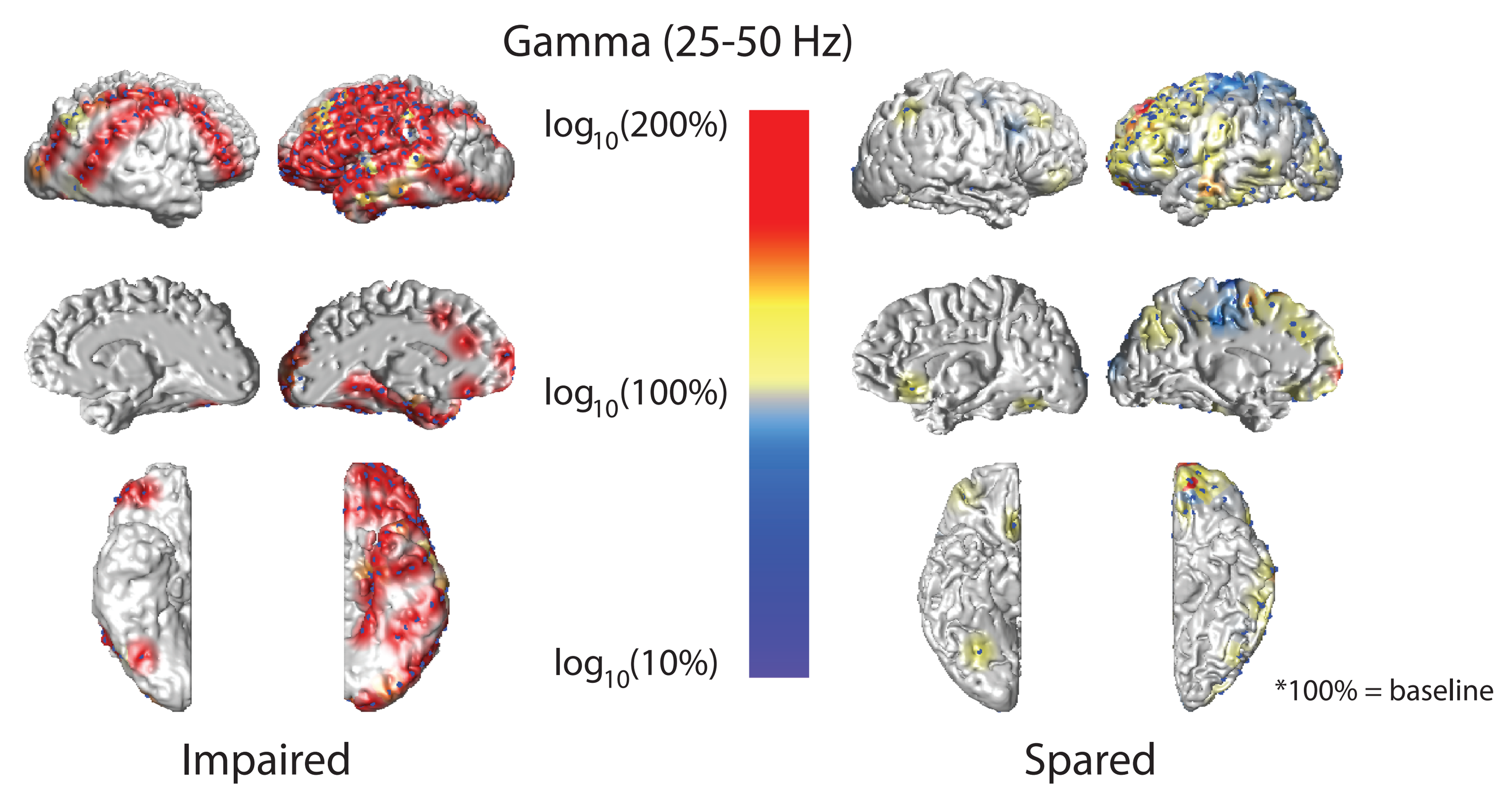
Alpha Frequency: 8 Hz – 13 Hz

Beta Frequency: 13 Hz – 25 Hz

Gamma Frequency: 25 Hz – 50 Hz

Bar graphs show mean and standard error of mean of the power change averaged across the duration of the seizure.

5. Three dimensional colour maps of gamma activity changes during simple and complex partial seizures



This is on log based 10 scale for 0.1 to 2 (10% to 200%) where 100% is equal to baseline.
Large elevations in fast gamma activity are seen bilaterally in widespread brain regions during the event in complex partial seizures, representing propagation of fast activity in all brain cortices bilaterally while simple partial seizures are more confined to the onset region.

6. Conclusion

These results suggest that medial temporal lobe seizures with impaired consciousness have greater physiological severity corresponding to medial temporal signal power and seizure duration.

Prior work has demonstrated a broad network of cortical and subcortical dysfunction outside the temporal lobe associated with impaired consciousness.

Our findings indicate that more severe local changes in the temporal lobe could trigger impairment in this larger network.

In addition, the identified intracranial signal markers may be useful to trigger neurostimulation therapies to restore consciousness in temporal lobe seizures and improve quality of life for people with epilepsy (see **STARTepilepsy.com** for ongoing clinical trial).

7. References

1. Englot, D.J., et al., Impaired consciousness in temporal lobe seizures: role of cortical slow activity. Brain, 2010. 133(Pt 12): p. 3764-77.
2. Gummadavelli, A., et al., Neurostimulation to improve level of consciousness in patients with epilepsy. Neurosurg Focus, 2015. 38(6): p. E10.