Pre-surgical High-density EEG and Atlas Electrical Head Models Provide Low-error Epileptic Foci Predictions in Patients that Received Favorable Resective Surgery

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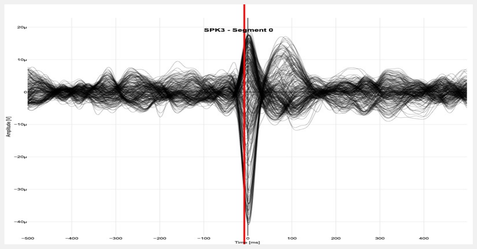
Introduction

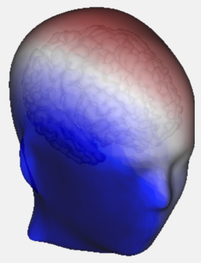
- Invasive icEEG is a routine part of pre-surgical planning for resective surgery
- Recent innovations in high-density scalp EEG (hdEEG) source localization using atlas electrical head models suggests non-invasive early-stage pre-surgical planning may be feasible with low error
- ***Does a novel source localization algorithm (Bayesian Multiple Sparse Priors; MSP [1]) provide a significant seizure localization accuracy improvement over conventional algorithms (LORETA & sLORETA) when applied with atlas head models?***

Methods

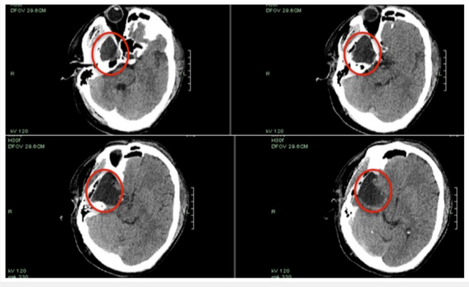
41 patients with epilepsy ages 7-45 recruited, 25 retained for analysis (16 rejected for poor DQ)

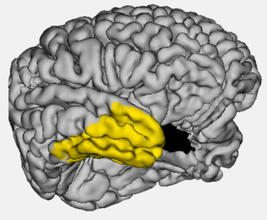
- Pre-op 256-channel hdEEG was recorded from all patients
- Inter-ictal spikes were hand-selected by a specialist and averaged by spatial similarity





- All patients received favorable resective surgery (Engel = 1 post-op)
- Surgeon hand-drew resected area on pre-op structural MRI for each patient
- Resection drawings were digitized and registered to atlas electrical head models



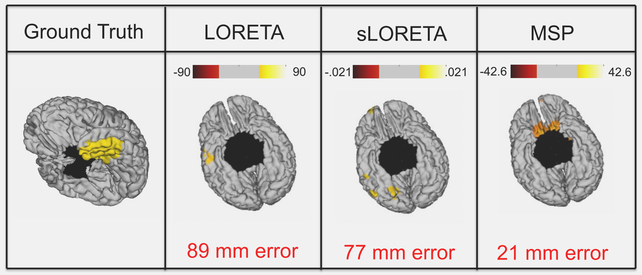


Source Localization

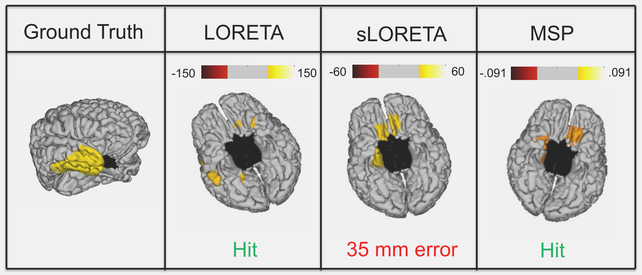
- Inter-ictal spikes were localized in Sourcerer (BEL, Eugene, OR) to the cortical surface of an age-matched atlas head model for each patient using 3 algorithms: LORETA, sLORETA, and novel MSP [1]
- Euclidean distance from the maximum intensity value to the boundary of the resection (ground truth) were computed for all patients and all algorithms

Source Localization Results (Representative Samples)

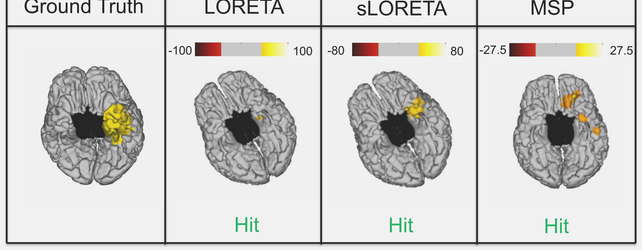
Patient 1



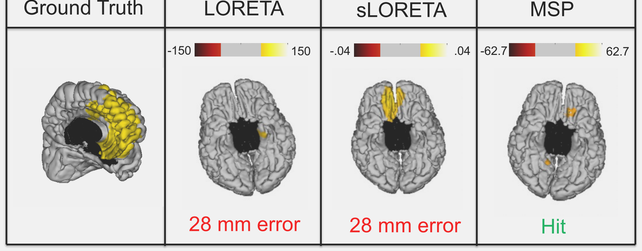
Patient 2



Patient 3



Patient 4



^Intensity scales are in uA/mm²

Statistics

	LORETA	sLORETA	MSP
Ave Error (mm)	30.87	25.73	11.90**
Total Hits	9	10	15

- ** RM-ANOVA revealed MSP provided a statistically lower error distance when compared to LORETA and sLORETA ($F = 3.65$, $p > .001$)
- MSP provided more localizations inside of the resected areas, though not significant (MSP vs LORETA $\chi^2 = 0.1$; MSP vs sLORETA $\chi^2 = 2.5$ – critical $\chi^2 = 3.843$, NS)

Conclusions

- The maximal localized intensity value of inter-ictal spikes recorded with hdEEG was accurately localized within the resected boundary in 15 out of 25 cases when using Bayesian Multiple Sparse Priors (MSP) as the inverse solution
- MSP provided statistically lower error rates (in mm) than traditional LORETA and sLORETA algorithms
- An atlas head model allows reasonably accurate source localization upon initial evaluation without an individual MRI
- hdEEG may be a viable option for non-invasive pre-surgical planning for resective surgery candidates

References

[1] Fernandez-Corazza, M., Feng, R., Ma, C., Hu, J., Pan, L., & Luu, P. (2021). Source localization of epileptic spikes using Multiple Sparse Priors. *Clinical Neurophysiology, 132*(2), 586-597. https://doi.org/10.1016/j.clinph.2020.10.030

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