Received: 12 September 2023 | Accepted: 22 November 2023

DOI: 10.1002/epd2.20183

Epileptic Disorders

CLINICAL VIGNETTE

# Paradigm found: Epileptogenic zone identified by fMRI in ictal fixation off sensitivity

**Douglas R. Nordli III**[1] | **John Collins**[2] | **Peter Warnke**[3] | **Douglas R. Nordli Jr**[1]

[1]Department of Neurology, University of Chicago, Chicago, Illinois, USA

[2]Department of Radiology, University of Chicago, Chicago, Illinois, USA

[3]Department of Neurological Surgery, University of Chicago, Chicago, Illinois, USA

**Correspondence**
Douglas R. Nordli III, Department of Neurology, University of Chicago, 5841 S Maryland Ave, Chicago IL, USA.
Email: douglas.nordli2@uchicagomedicine.org

A young right-handed woman was evaluated for intractable focal epilepsy. Daily seizures began at age 10 characterized by bilateral blurred vision with central bright spots and an uncomfortable feeling that her eyes were deviating to the right. The seizures occurred multiple times per day and were refractory to efficacious doses of levetiracetam, oxcarbazepine, topiramate, lamotrigine, and lacosamide. Scalp EEG demonstrated ictal fixation off sensitivity with left occipital spikes (Figure 1A,B). MR brain revealed bilateral periventricular nodular heterotopia with a transmantle sign (Figure 2).

The patient was evaluated for candidacy of epilepsy surgery. We hypothesized that a localizing signal could be obtained if the patient underwent fMRI while capturing ictal fixation off sensitivity using a simple eyes open/eyes closed paradigm instead of bilaterally implanting both heterotopias to capture seizure with SEEG. During the fMRI, the patient would be asked to close her eyes and open them to determine whether she experienced the typical ictus while in the scanner. The patient experienced her typical event while in the fMRI scanner using the proposed paradigm. The fMRI brain successfully localized the patient's ictal fixation off sensitivity using the simple eyes open/eyes closed paradigm (Figure 3). Unilateral, targeted SEEG implantation comprised of five depth electrodes bracketing the identified heterotopia (Figure 4) captured the ictal FOS for confirmation (Figure 5). Following, the patient underwent a laser ablation (Figure 6) of the combined electrophysiological and fMRI—identified epileptogenic area. She has remained seizure free following surgery without visual or neurologic deficits.

Prior literature has indicated the utility of fMRI in localizing the irritative zone in epilepsy.[1] Strong concordant data increases patient's seizure free rates in epilepsy surgery. fMRI identifies changes in blood flow and metabolism whereas EEG identifies epileptiform discharges.[2] Given the concordance of the patients scalp EEG and fMRI, the patient was spared bilateral implantation of the periventricular nodular heterotopia. Without this concordant information, planning a unilateral implantation from data on a routine EEG may be risky, especially considering the broad and complex epilepsy networks that can be present when faced with heterotopias.[3,4] This case highlights fMRI's ability to identify the putative epileptogenic zone in FOS using a simple eyes open/eyes closed paradigm. More specifically, this case demonstrated fMRI's unique ability to localize ictal fixation off sensitivity. This novel use of fMRI paradigm calls for further research.

**Abbreviations:** fMRI, functional magnetic resonance imaging; FOS, fixation off sensitivity; MRI, magnetic resonance imaging; SEEG, stereotactic electroencephalogram.

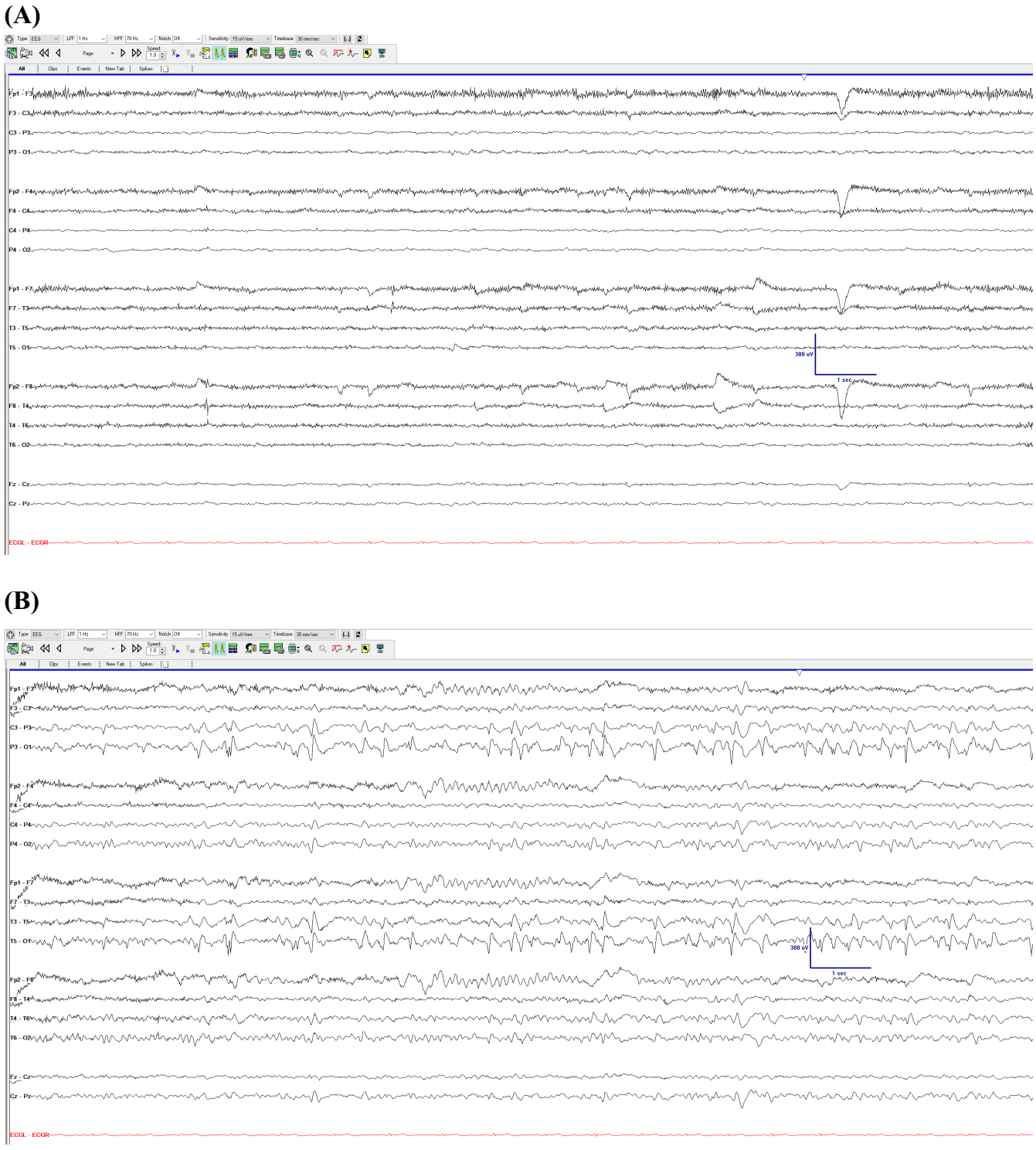



**FIGURE 1** (A) Longitudinal Bipolar EEG with eyes open. (B) Longitudinal bipolar EEG with eyes closed demonstrating FOS with left occipital spike and sharp wave discharges.

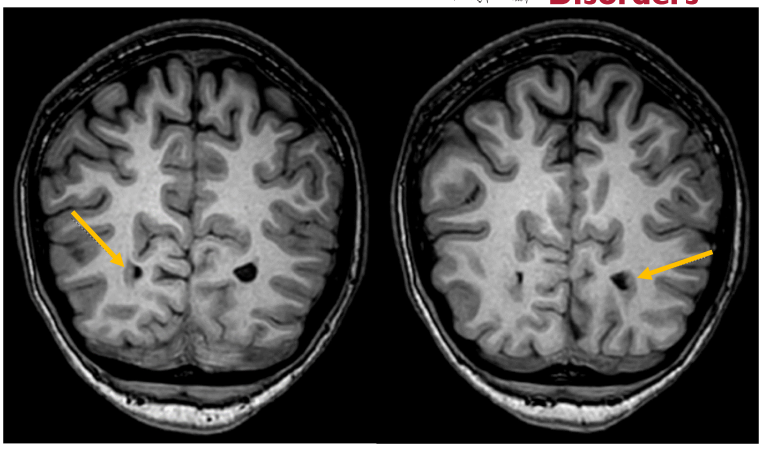


**FIGURE 2** T1 MRI brain showcasing bilateral periventricular nodular heterotopia (yellow arrows).

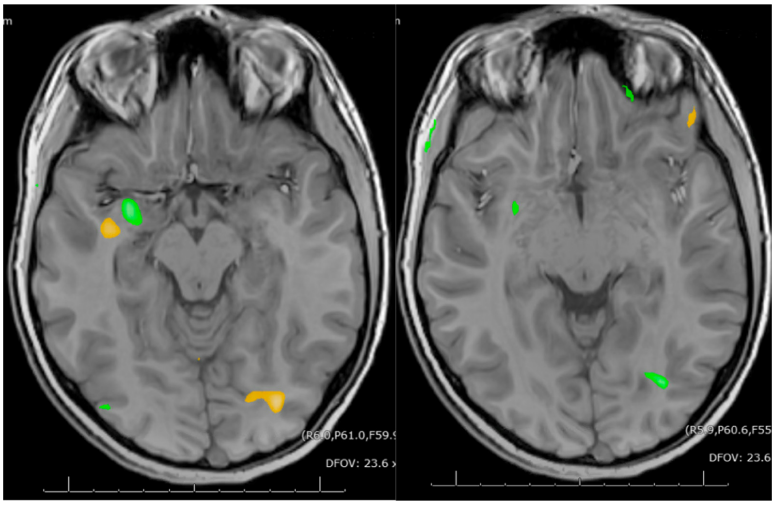



**FIGURE 3** fMRI using simple eyes open/eyes closed paradigm. Eyes open at baseline shows activation (gold) adjacent to heterotopia in left occiput and on either side of heterotopia. Note adjacent deactivation (green).

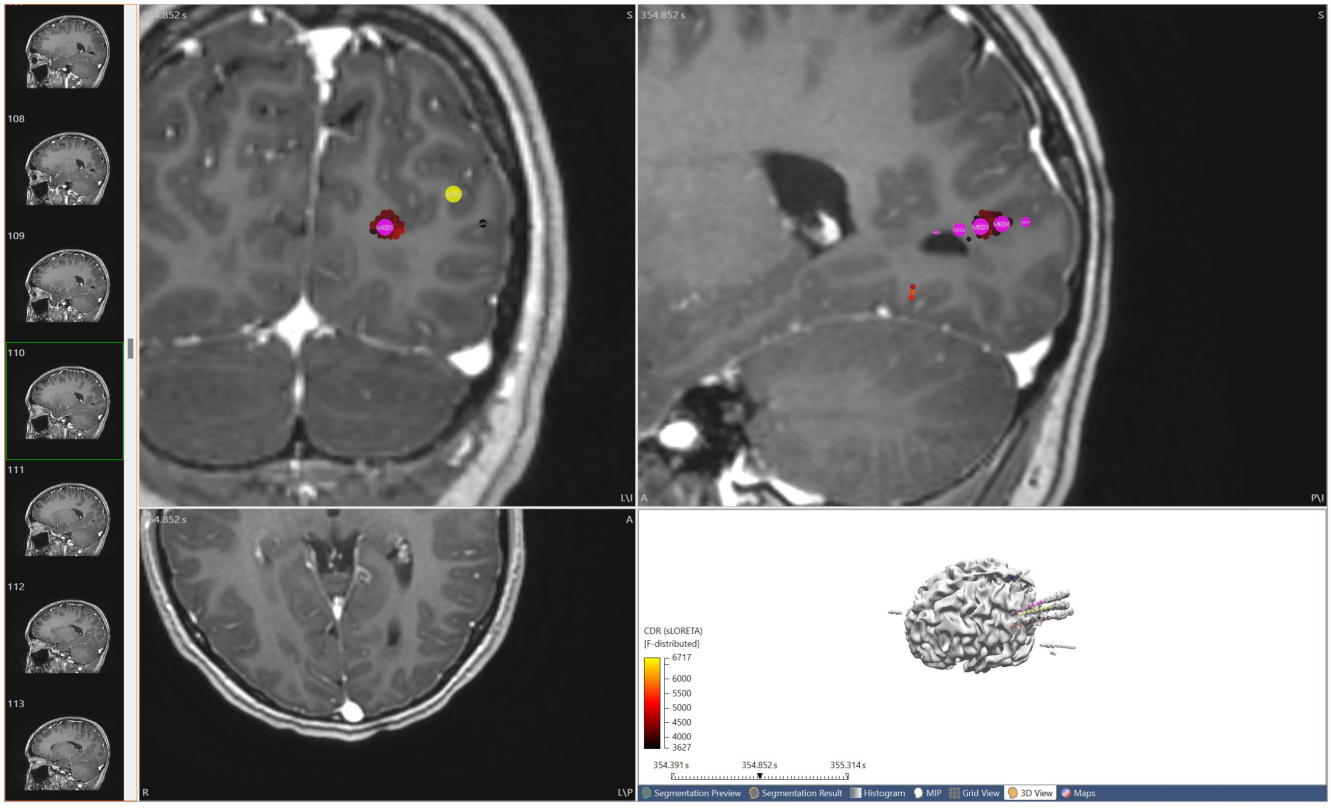



**FIGURE 4** Reconstructed SEEG MRI image with location of stereotactic EEG implants and electrodes of interest (pink) in MED 1–8.

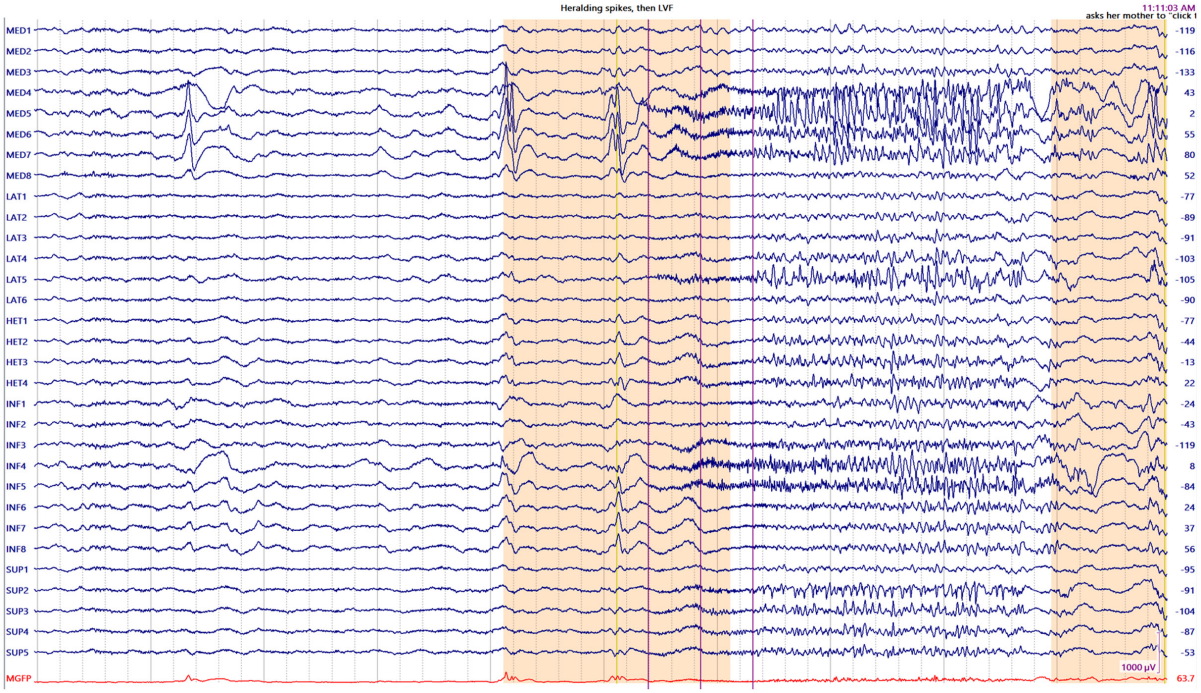



**FIGURE 5** Stereotactic ictal EEG during eye closure showcasing heralding spikes beginning in MED 5,6 followed by low voltage fast activity in MED 5–8. The location of this SEEG electrode is medial and closest to the heterotopia, confirming it as pathologic and epileptogenic tissue.

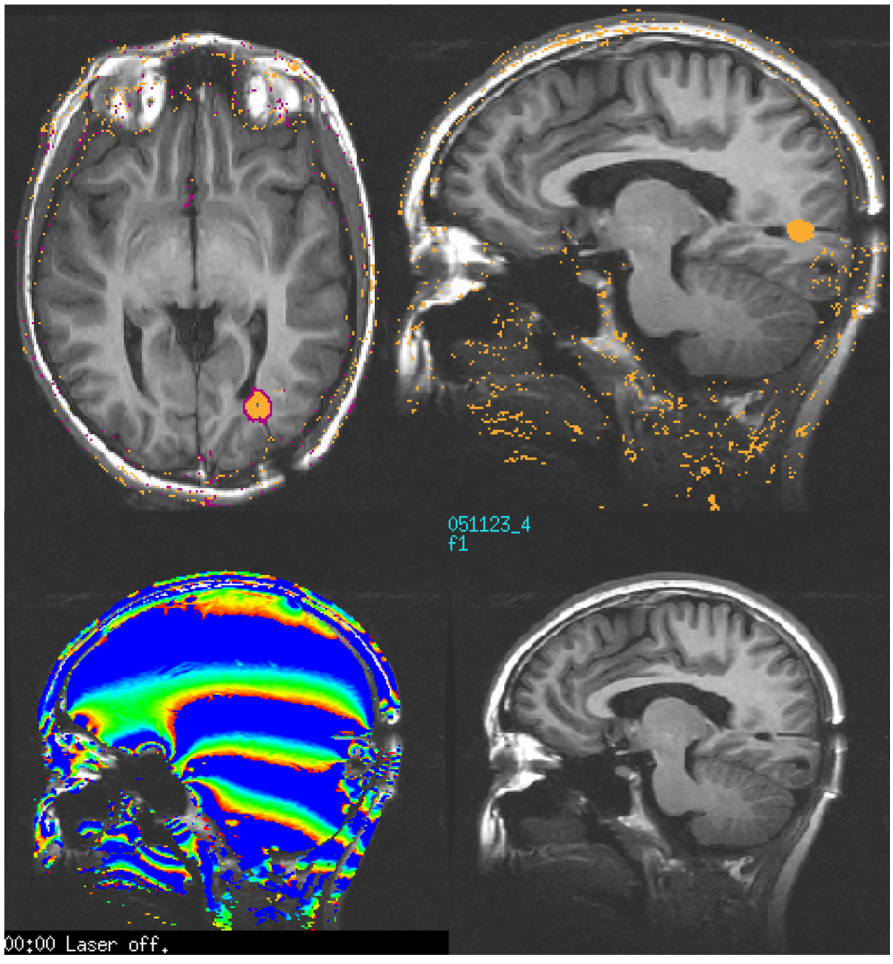



**FIGURE 6** Damage maps from the Arrhenius equation and video with simultaneous thermography and damage evolution.

## ORCID

*Douglas R. Nordli III* https://orcid.org/0000-0002-3995-5467

## REFERENCES

1. Formaggio E, Storti SF, Galazzo IB, Bongiovanni LG, Cerini R, Fiaschi A, et al. Reproducibility of EEG-fMRI results in a patient with fixation-off sensitivity. Clin EEG Neurosci. 2014;45(3):212–7. https://doi.org/10.1177/1550059413497946
2. Vulliemoz S, Lemieux L, Daunizeau J, Michel CM, Duncan JS. The combination of EEG source imaging and EEG-correlated functional MRI to map epileptic networks. Epilepsia. 2010;51(4):491–505.
3. Duncan JS. Selecting patients for epilepsy surgery: synthesis of data. Epilepsy Behav. 2011;20(2):230–2.
4. Pizzo F, Roehri N, Catenoix H, Medina S, McGonigal A, Giusiano B, et al. Epileptogenic networks in nodular heterotopia: a stereoelectroencephalography study. Epilepsia. 2017;58(12):2112–23.

## SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

**How to cite this article:** Nordli DR III, Collins J, Warnke P, Nordli DR Jr Paradigm found: Epileptogenic zone identified by fMRI in ictal fixation off sensitivity. Epileptic Disord. 2023;00:1–6. https://doi.org/10.1002/epd2.20183

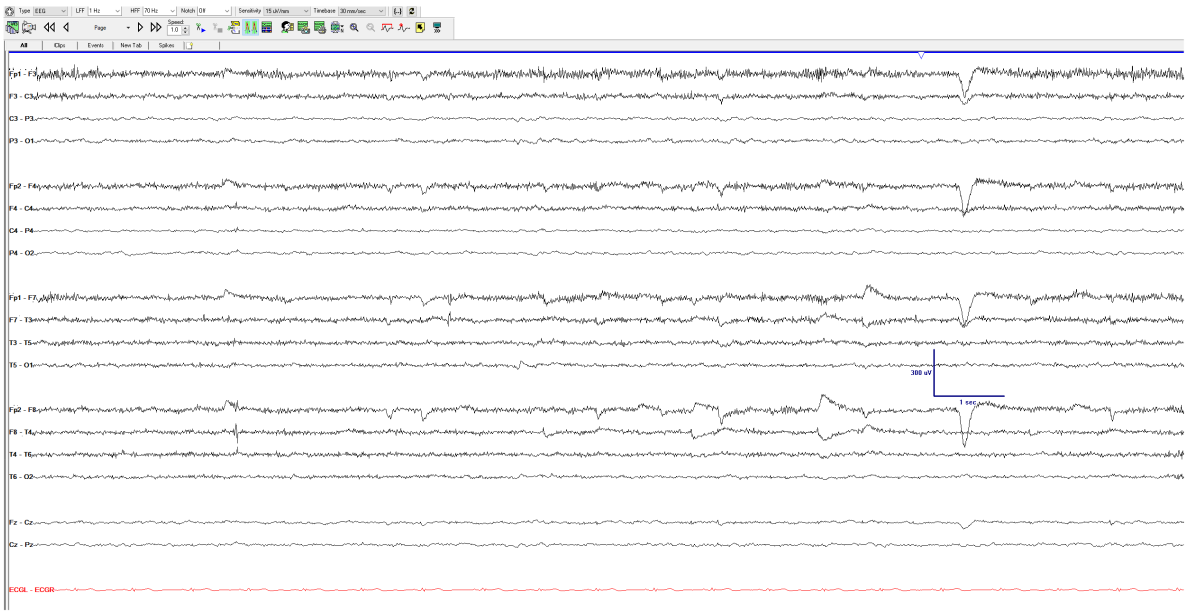
### Test Yourself

1. A young woman presents with bilateral blurred vision with central bright spots and an uncomfortable feeling that her eyes were deviating to the right. These events occur when she closes her eyes. EEG as shown below during eyes open (A) and eye closure (B) which triggers the typical event.

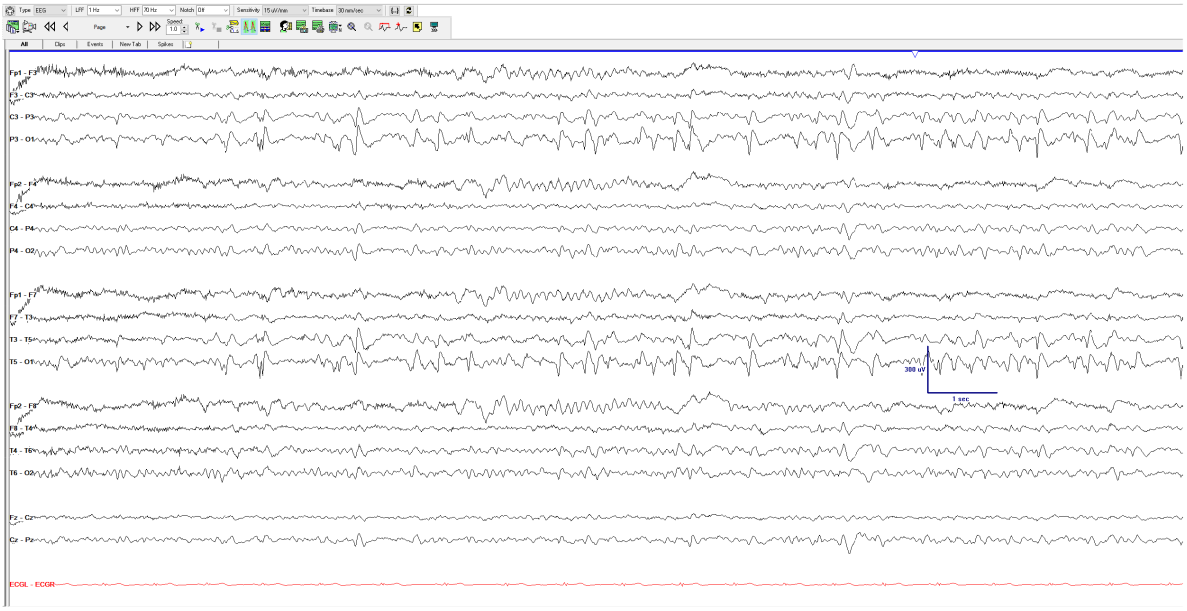
What EEG pattern is shown?

A. Positive occipital sharp transients of sleep (POSTS)
B. Fixation off sensitivity
C. Posterior dominant rhythm
D. 6 Hz phantom spike and wave

*A: Longitudinal bipolar EEG with eyes open*



B: *Longitudinal bipolar EEG with eyes closed*




2. fMRI identifies change in which of the following?
   A. Electricity
   B. Magnetic dipoles
   C. Blood flow
   D. Metabolism
   E. Both A and B
   F. Both C and D
3. True or False; concordant data increase success rates in epilepsy surgery?
   A. True
   B. False

*Answers may be found in the supporting information.*