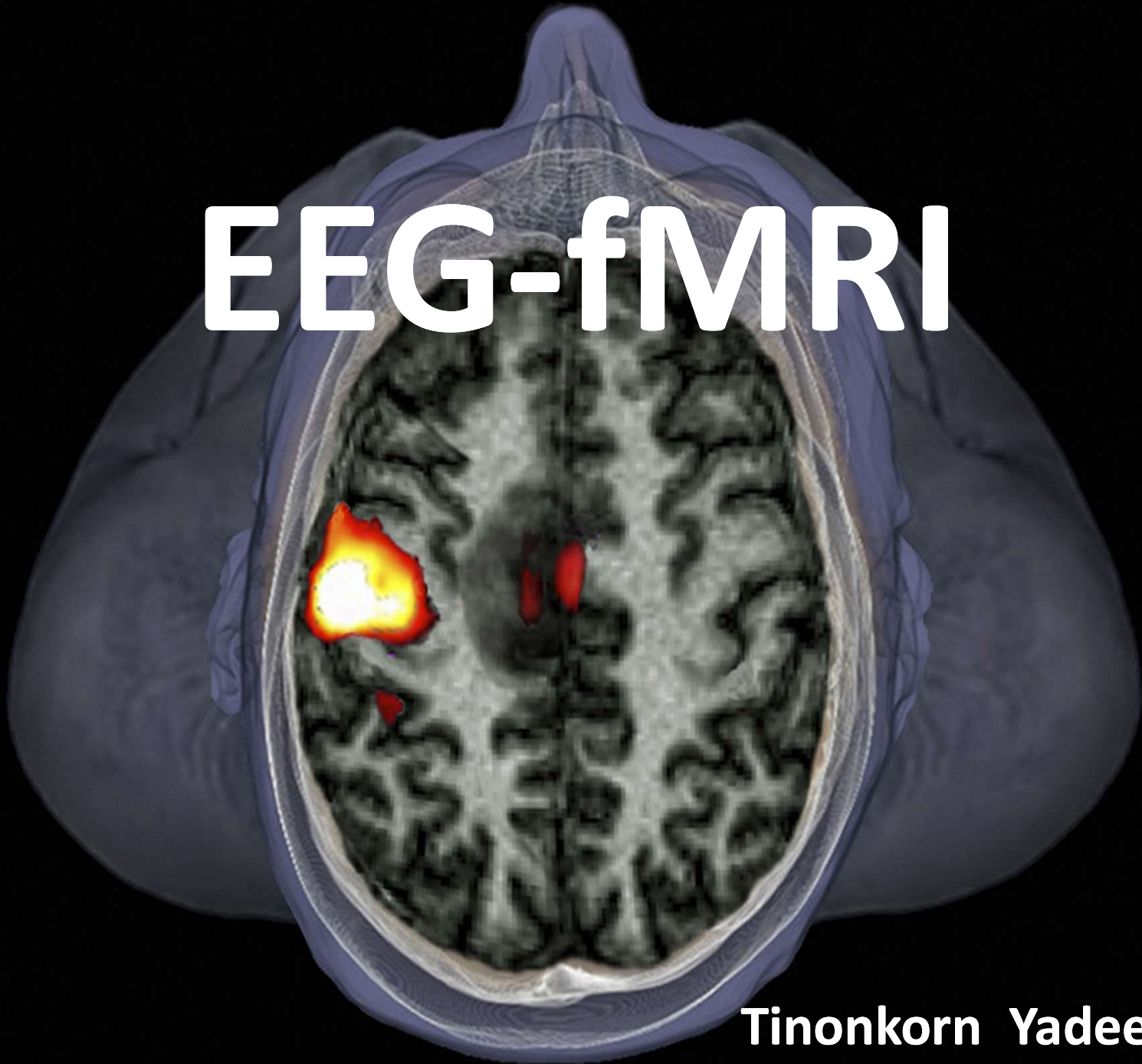
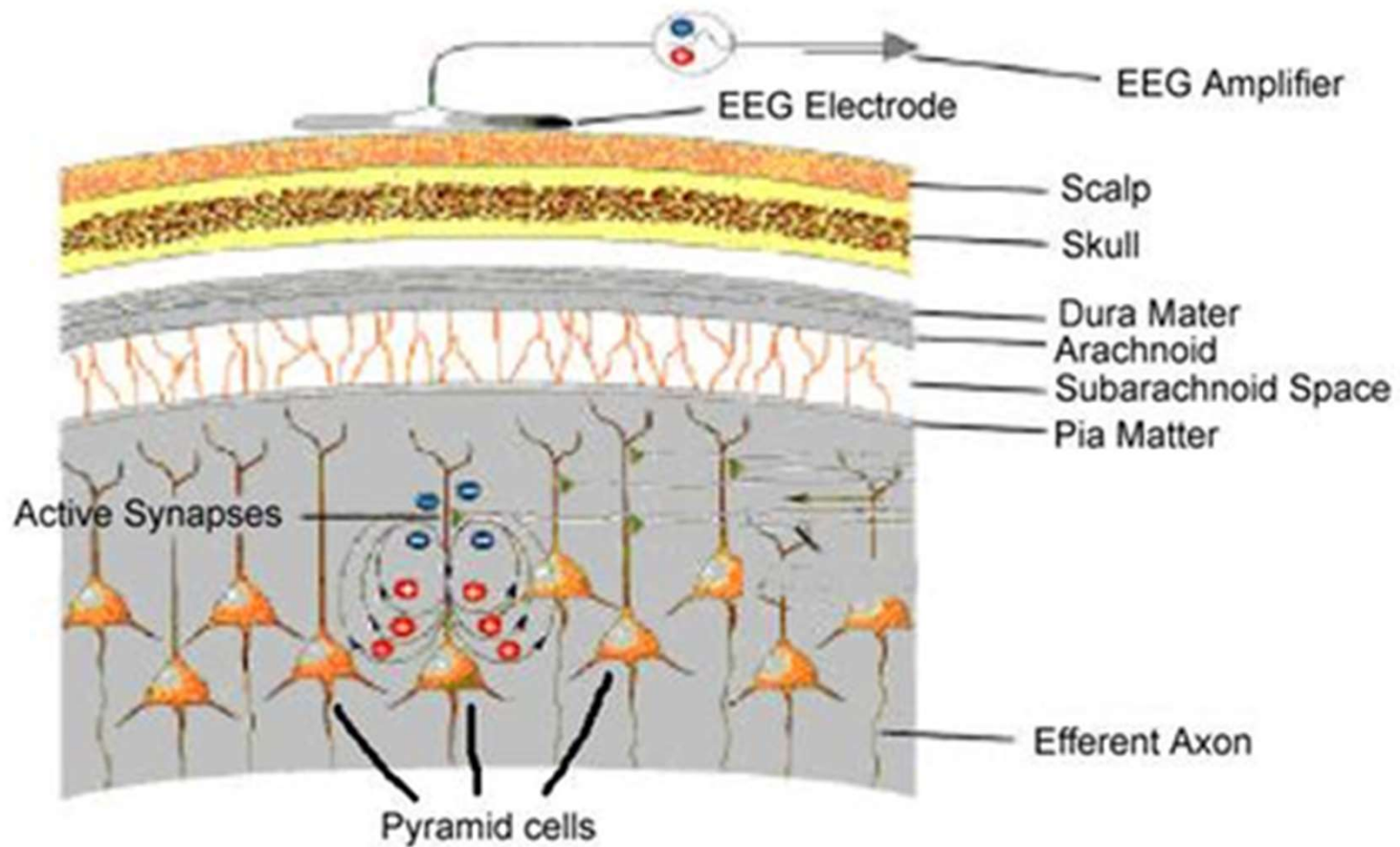


EEG-fMRI

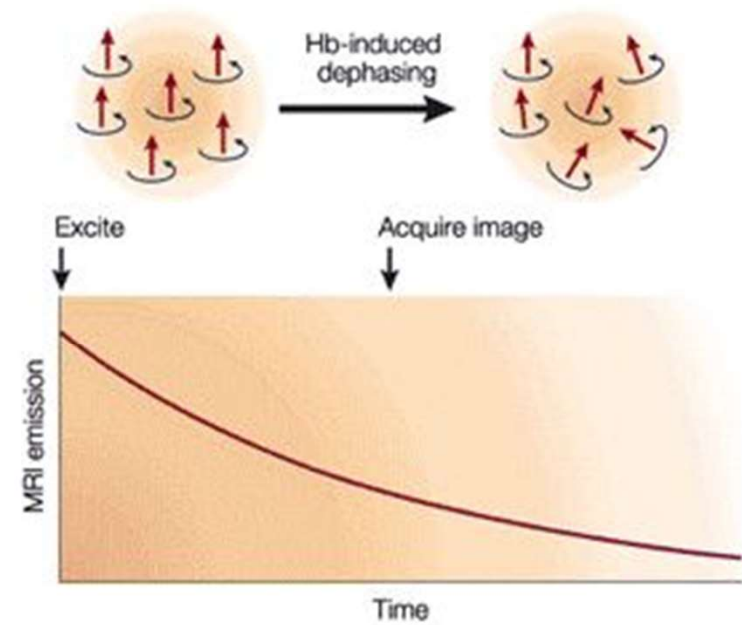
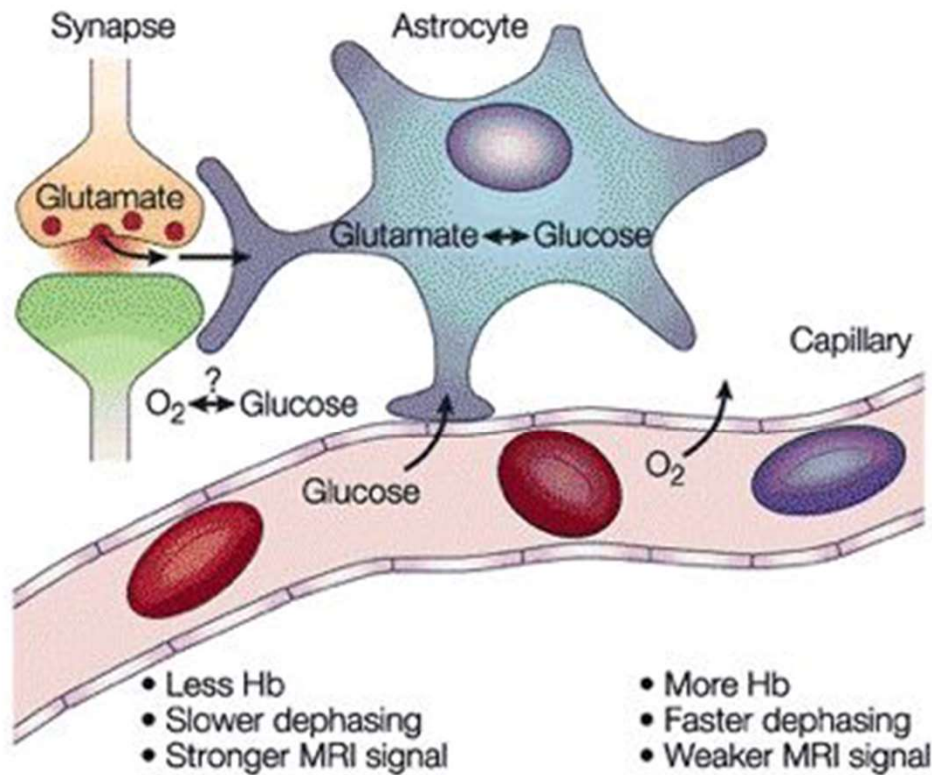


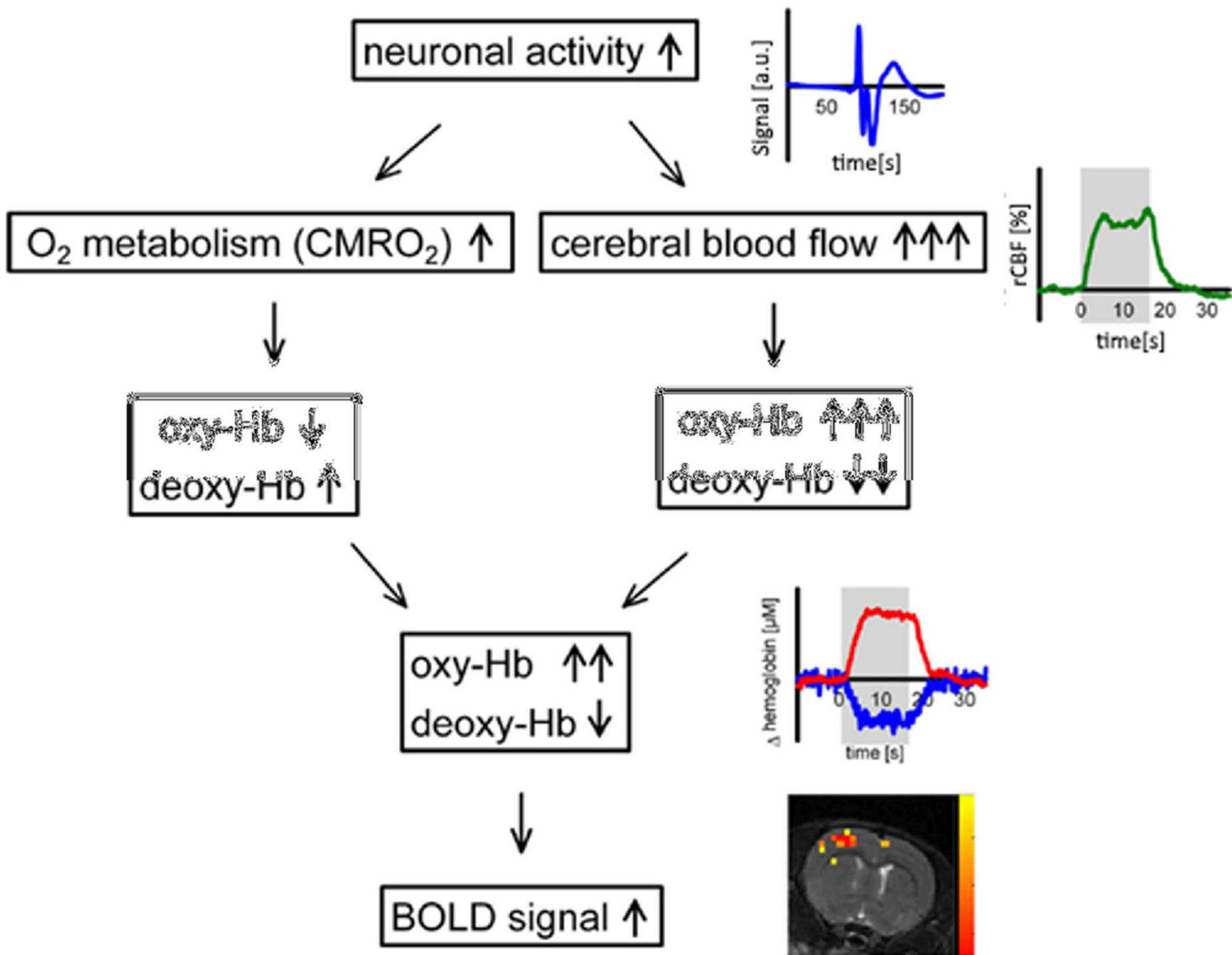
Tinonkorn Yadee, MD

EEG physiology

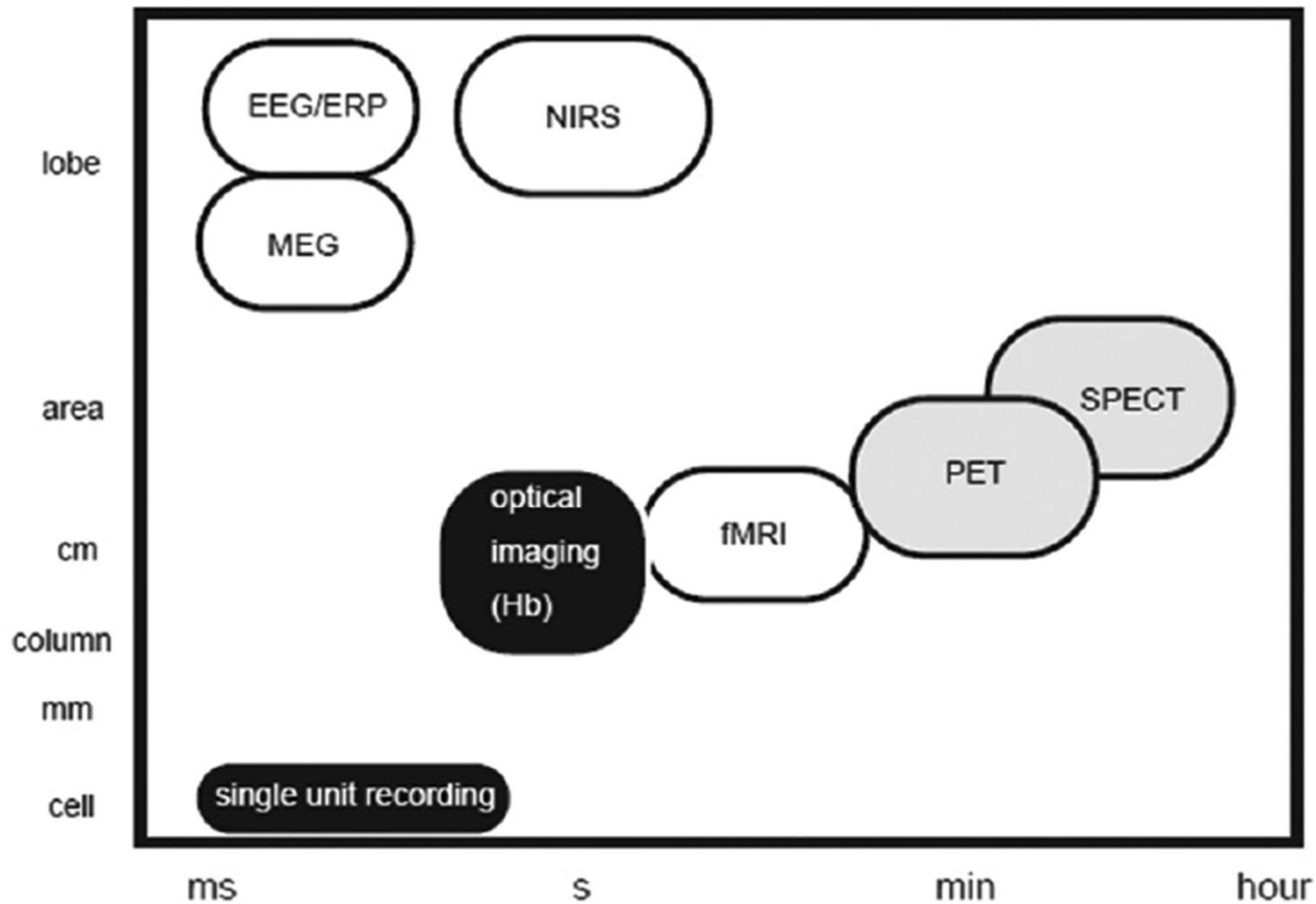


BOLD (blood oxygen-level dependent) signal

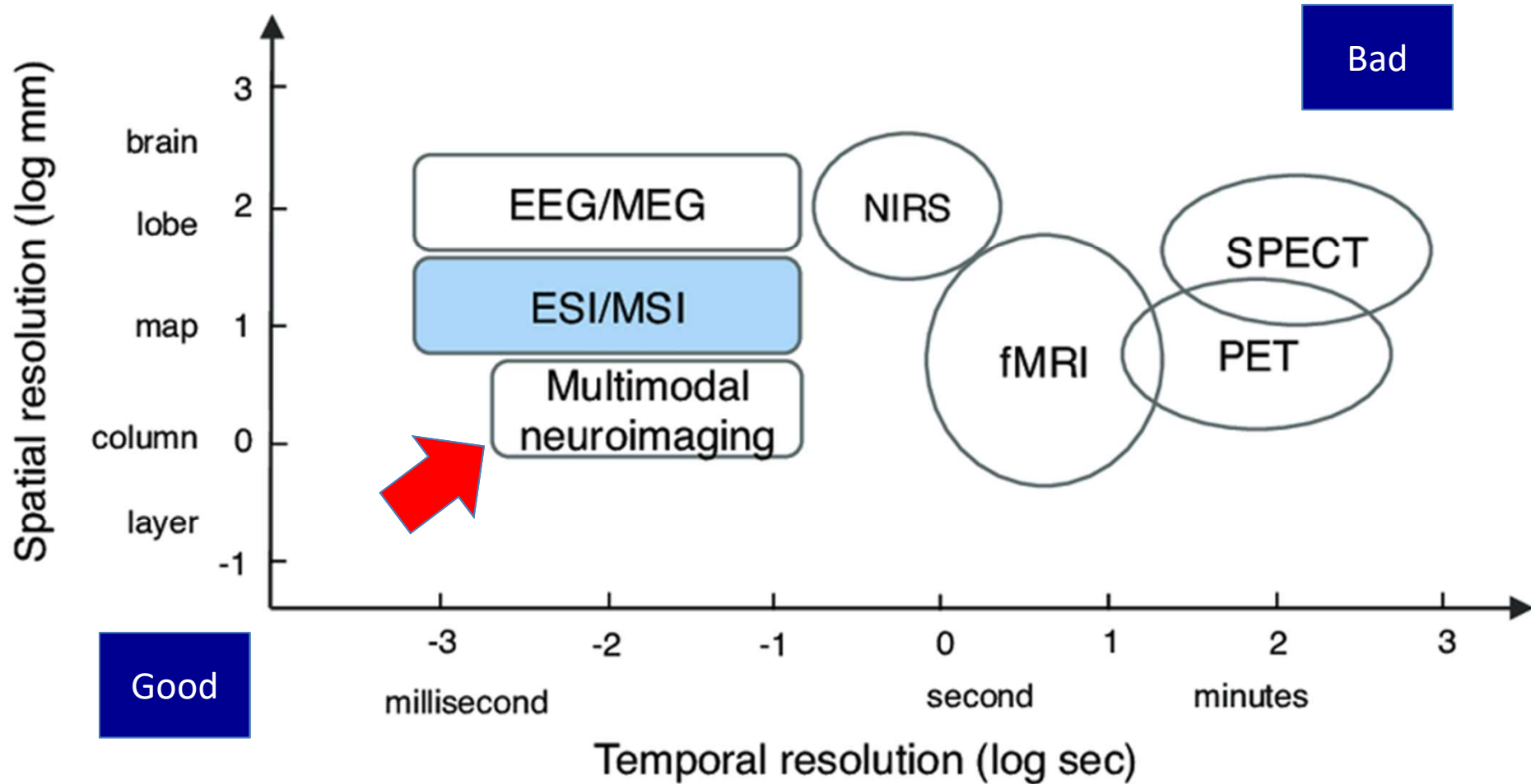


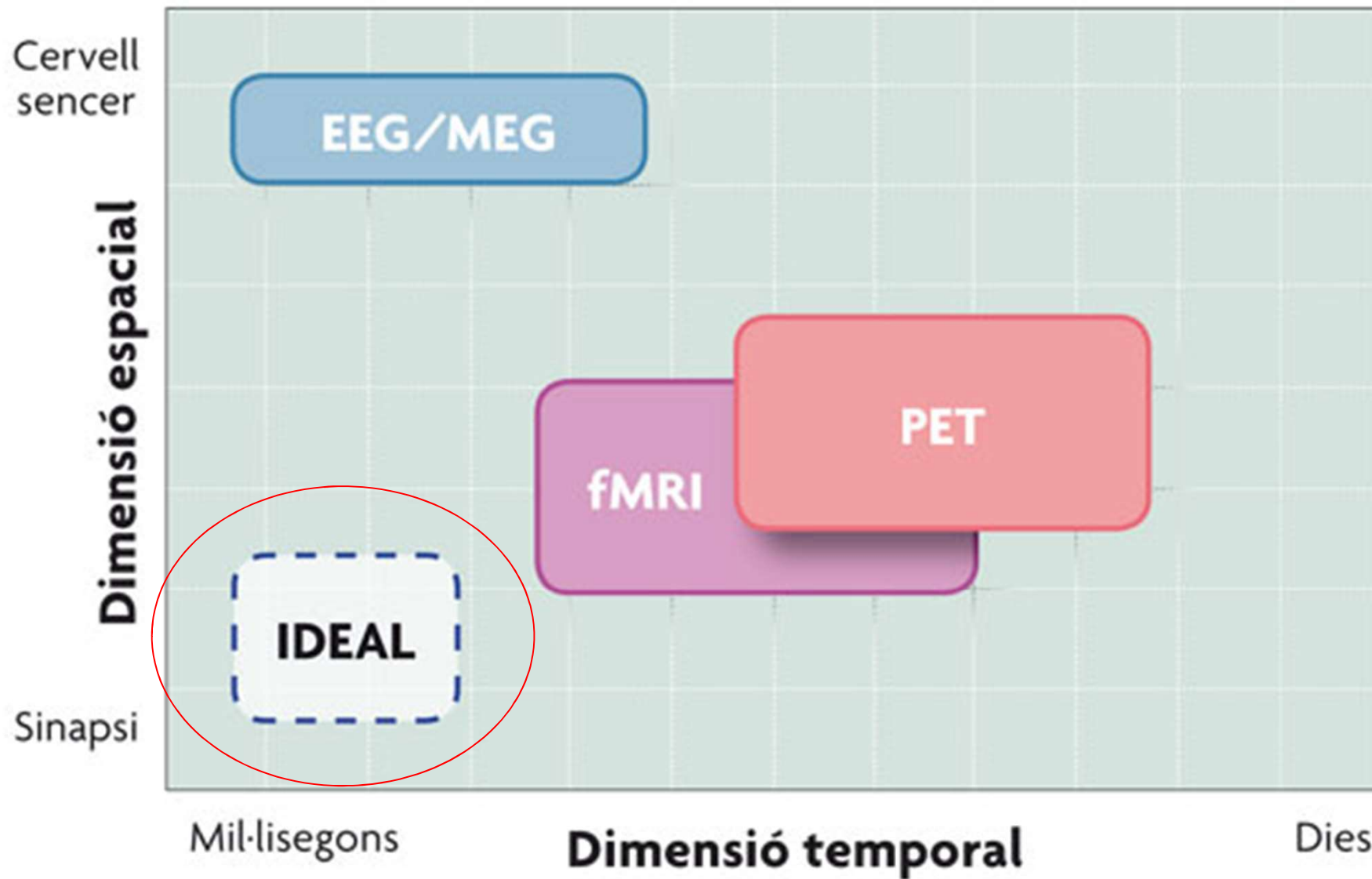


spatial resolution



temporal resolution



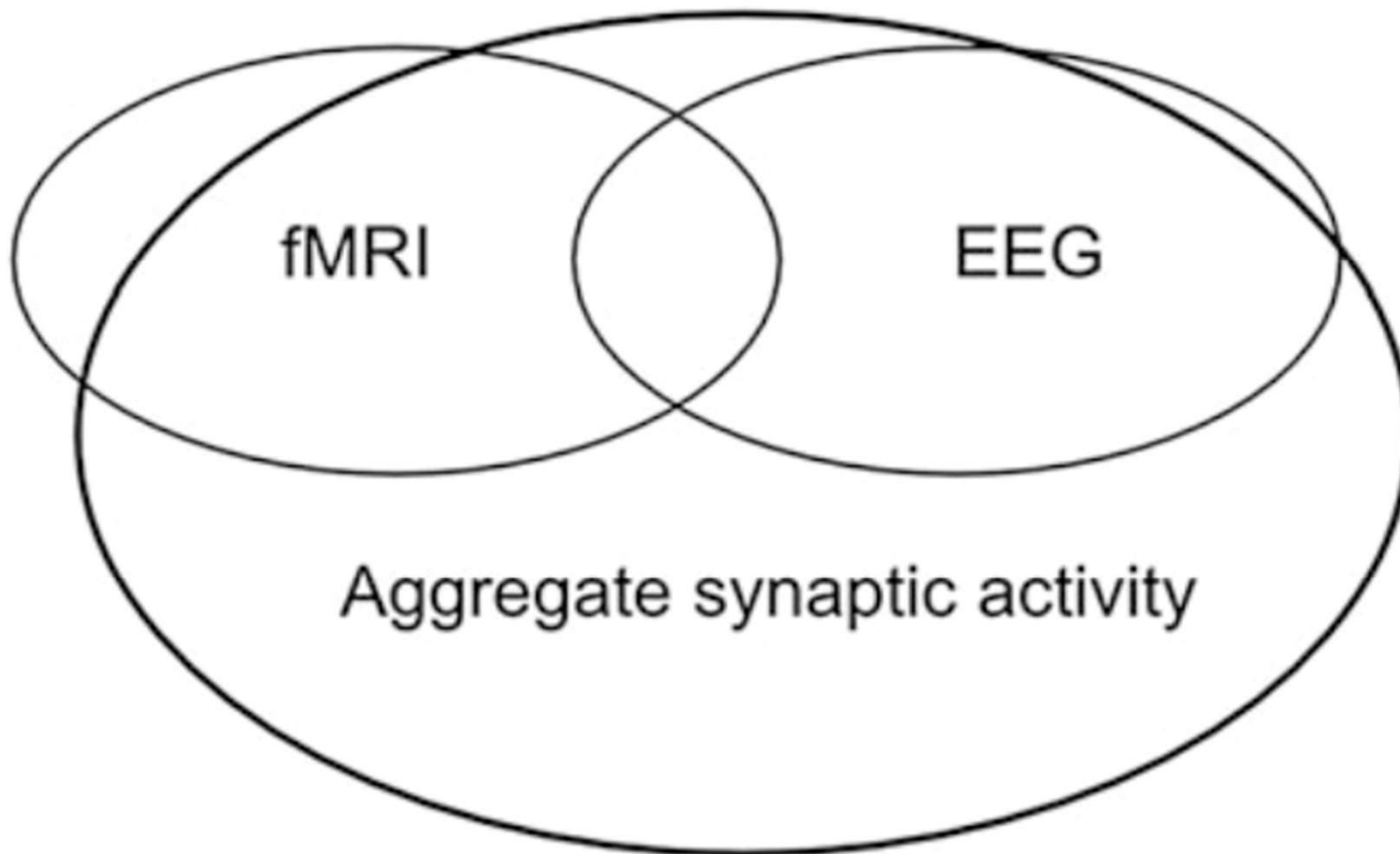


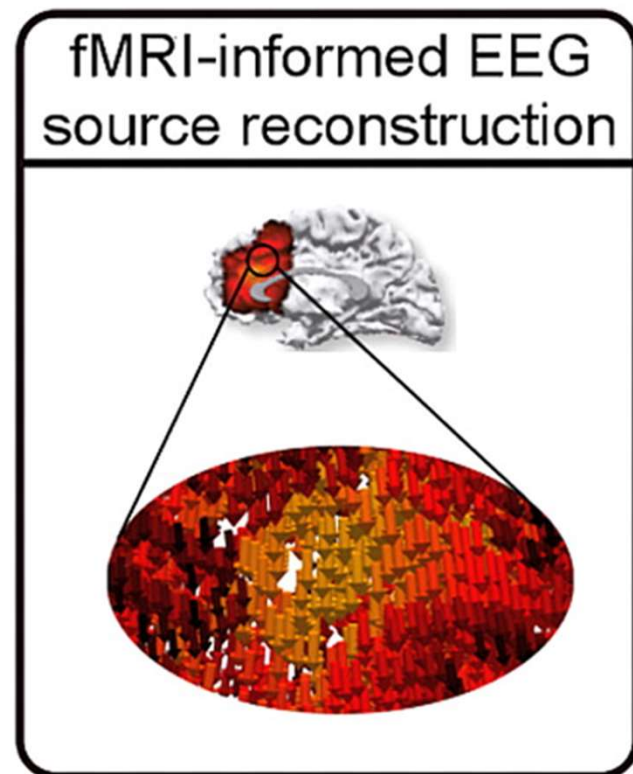
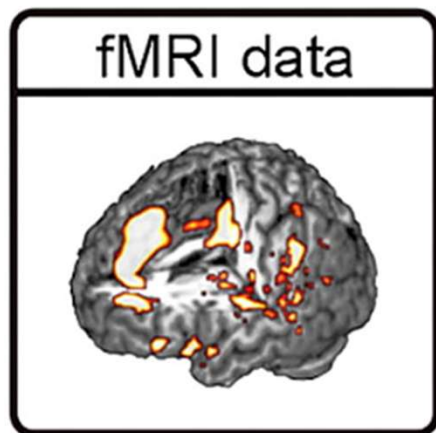
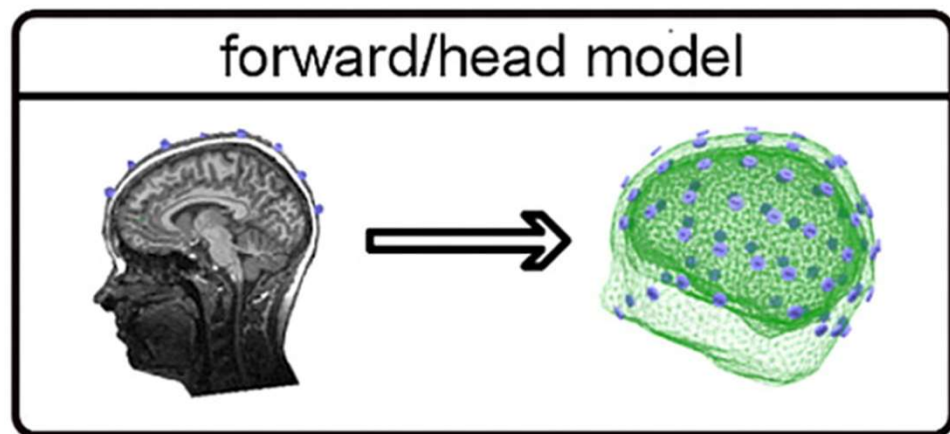
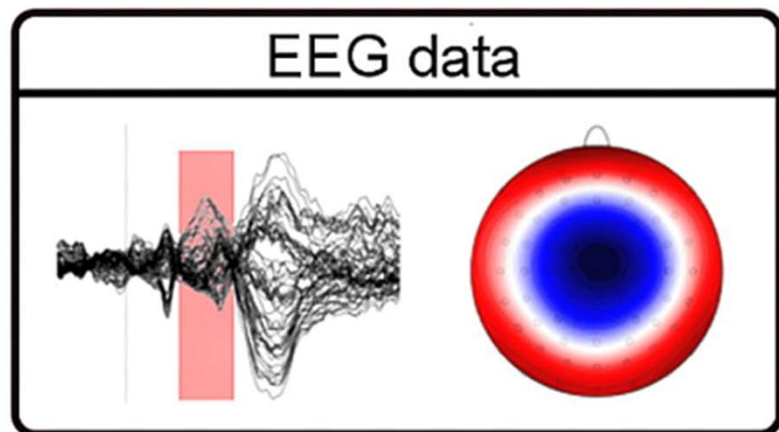
fMRI

- Activity coupled with metabolism
- Balance between inhibition and excitation
- Balance between CMRO₂ and CBF

EEG

- Sensitive to cortical activity
- Pyramidal cells
- Net charge perpendicular to scalp





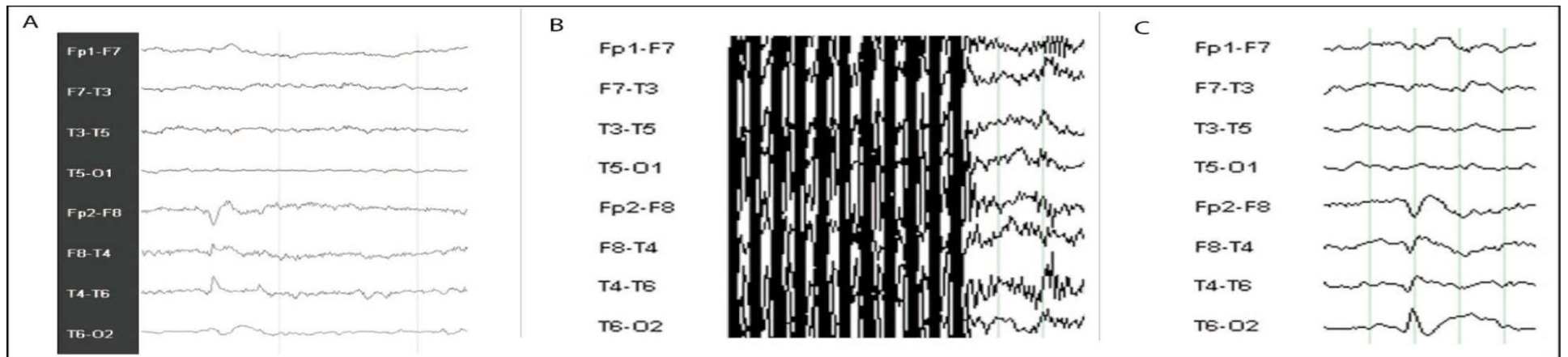
EEG-fMRI recording

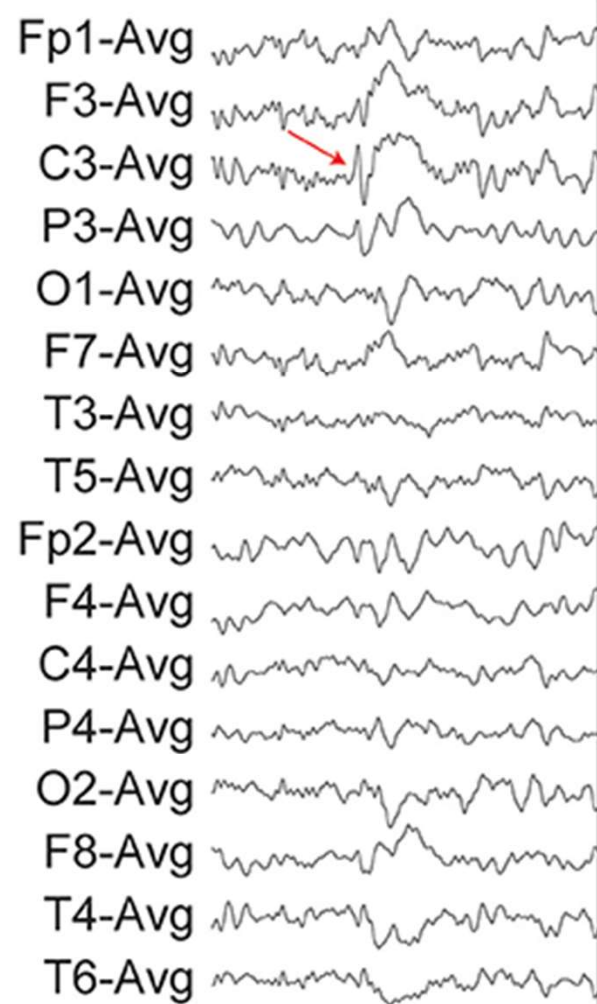
- EEG-recording outside scanner 20 mins
- Patients in scanner with EEG electrodes
- Scan 2 EPI (20 mins each)
- EEG heavily contaminated by MRI artifact



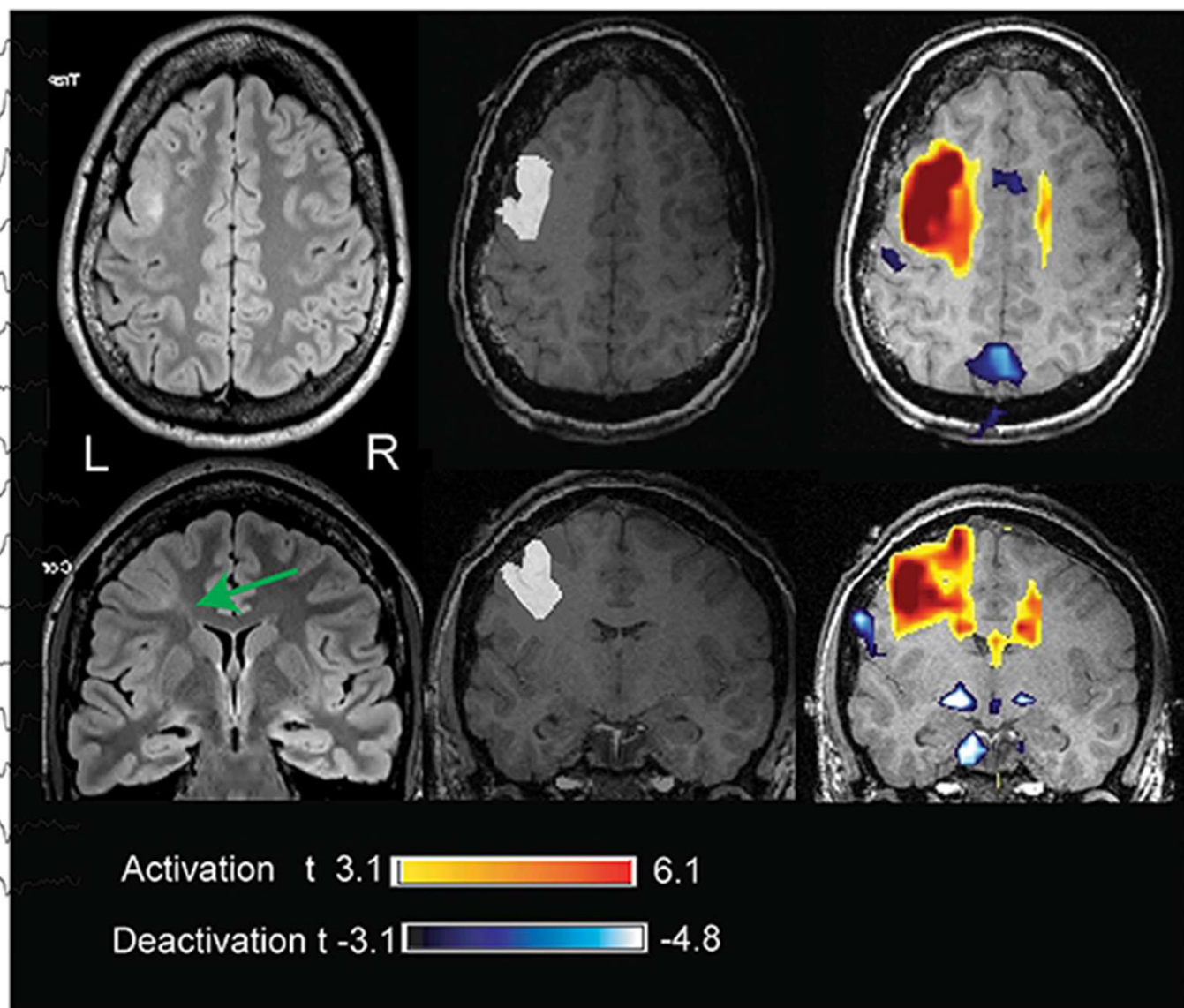
EEG-fMRI analysis

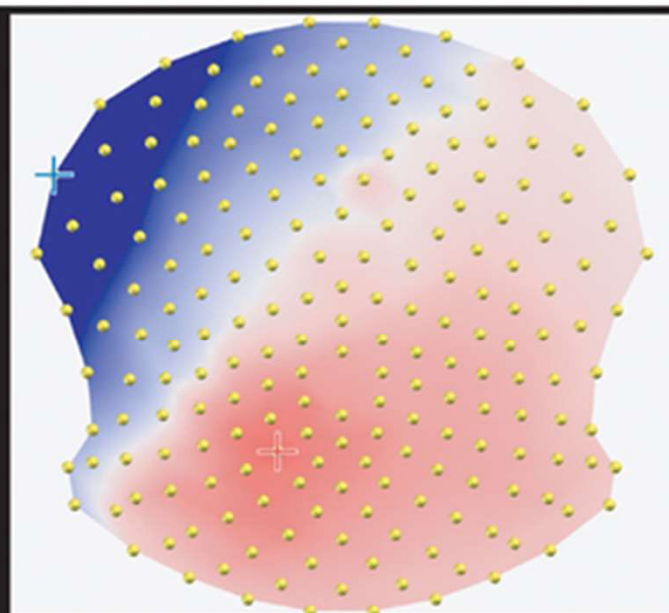
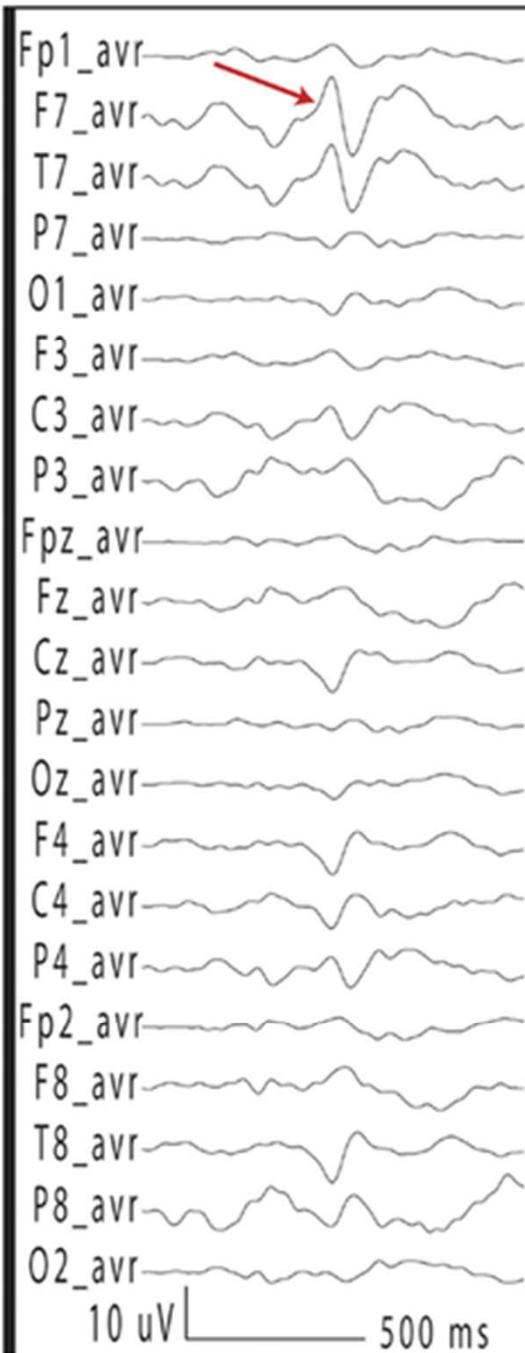
- Remove artifacts from EEG
- Mark Spike from EEG
- Determine the brain regions that show a significant BOLD change at the time of spike
- Superpose voxels with significant change on anatomical MRI





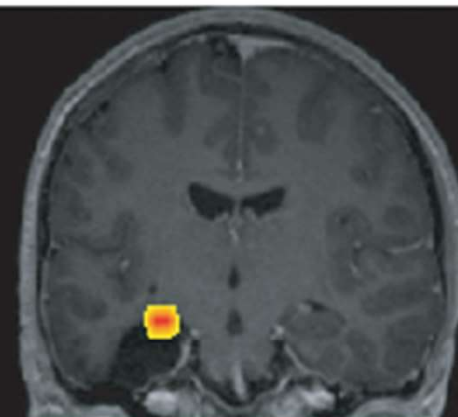
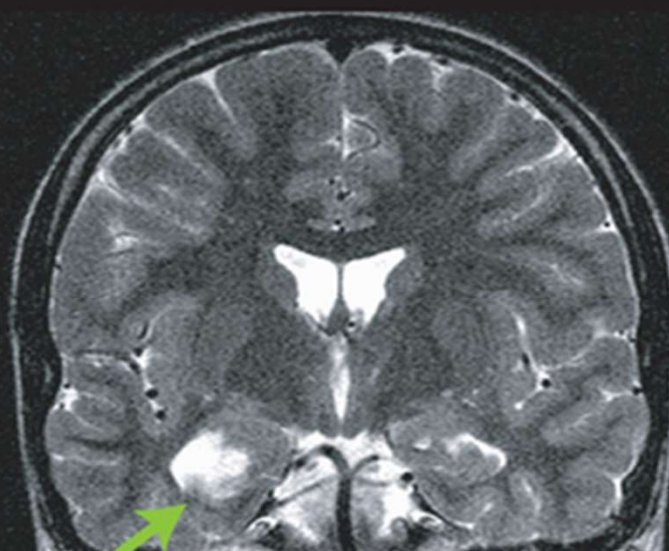
50 μ V | 1s





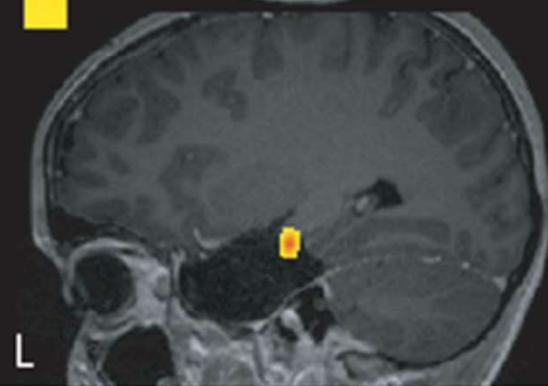
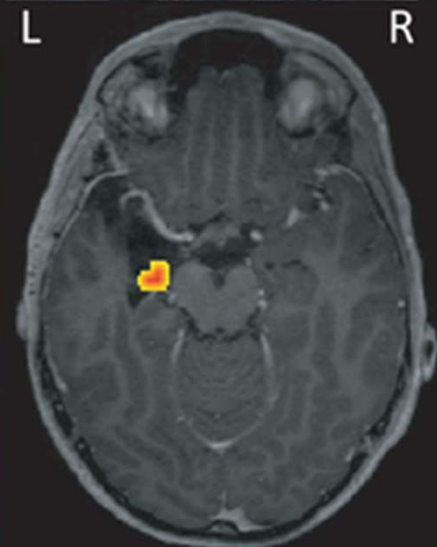
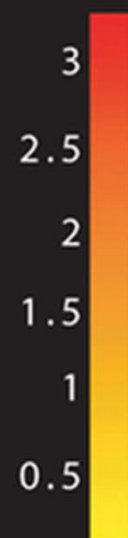
LEFT

RIGHT



L

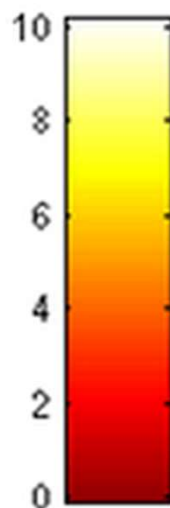
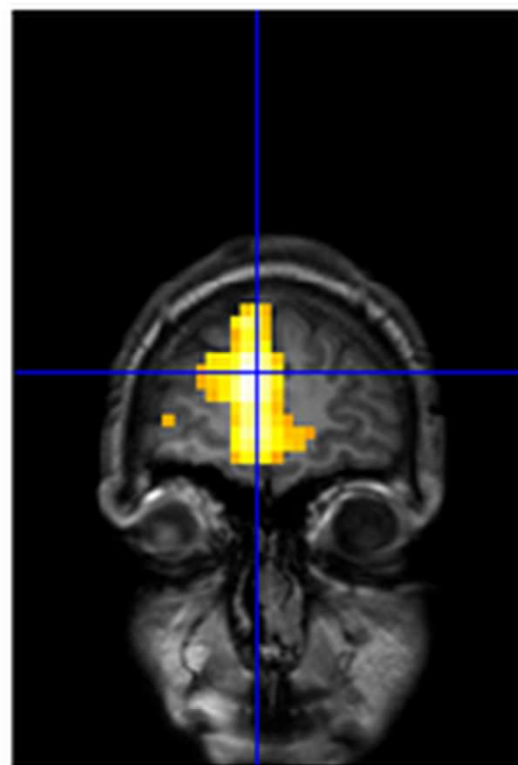
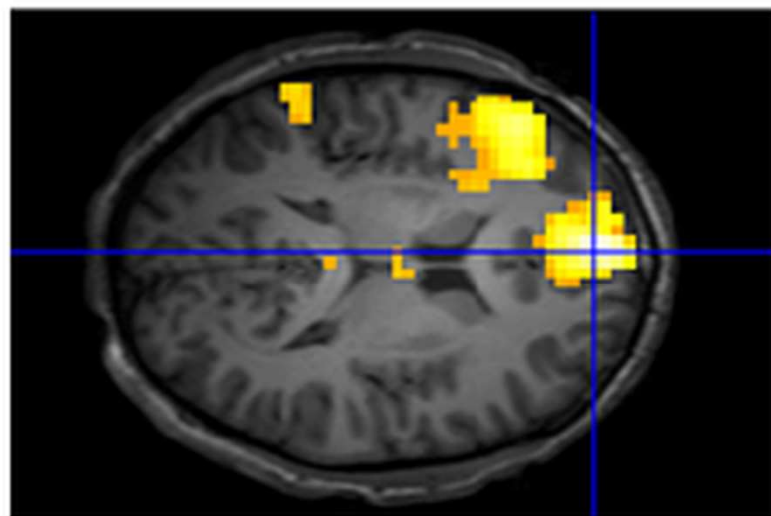
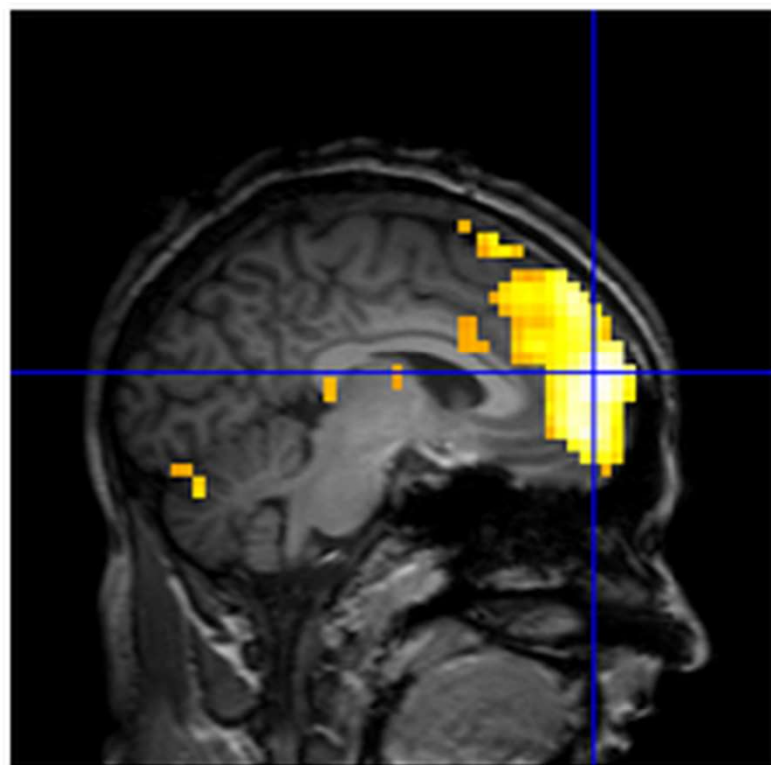
R



L

Fp2-F4
F4-C4
C4-P4
P4-O2
Fp2-F8
F8-T4
T4-T6
T6-O2
Fz-Cz
Cz-Pz
Fp1-F3
F3-C3
C3-P3
P3-O1
Fp1-F7
F7-T3
T3-T5
T5-O1

100 μ V
1 sec



Published in final edited form as:

Epilepsia. 2013 December ; 54(12): 2184–2194. doi:10.1111/epi.12434.

Electroencephalography/functional magnetic resonance imaging responses help predict surgical outcome in focal epilepsy

Dongmei An^{*,†}, Firas Fahoum^{*}, Jeffery Hall^{*}, André Olivier^{*}, Jean Gotman^{*}, and François Dubeau^{*}

^{*}Montreal Neurological Institute, McGill University, Montreal, Quebec, Canada

[†]Department of Neurology, West China Hospital, Sichuan University, Chengdu, China

- Patients having EEG-fMRI study →
Surgery → 12 months F/U
- Co-register post-op MRI with pre-op BOLD

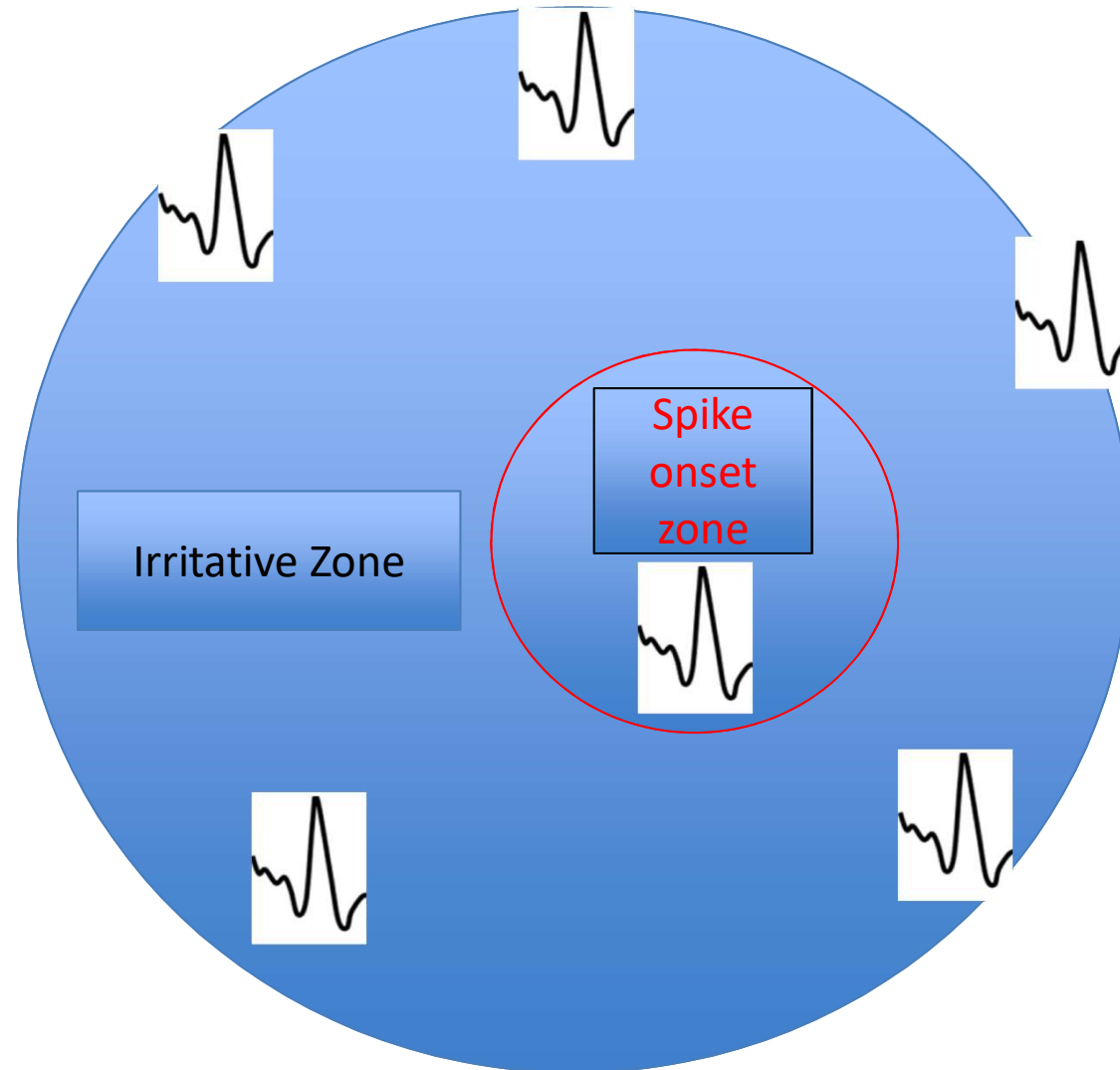


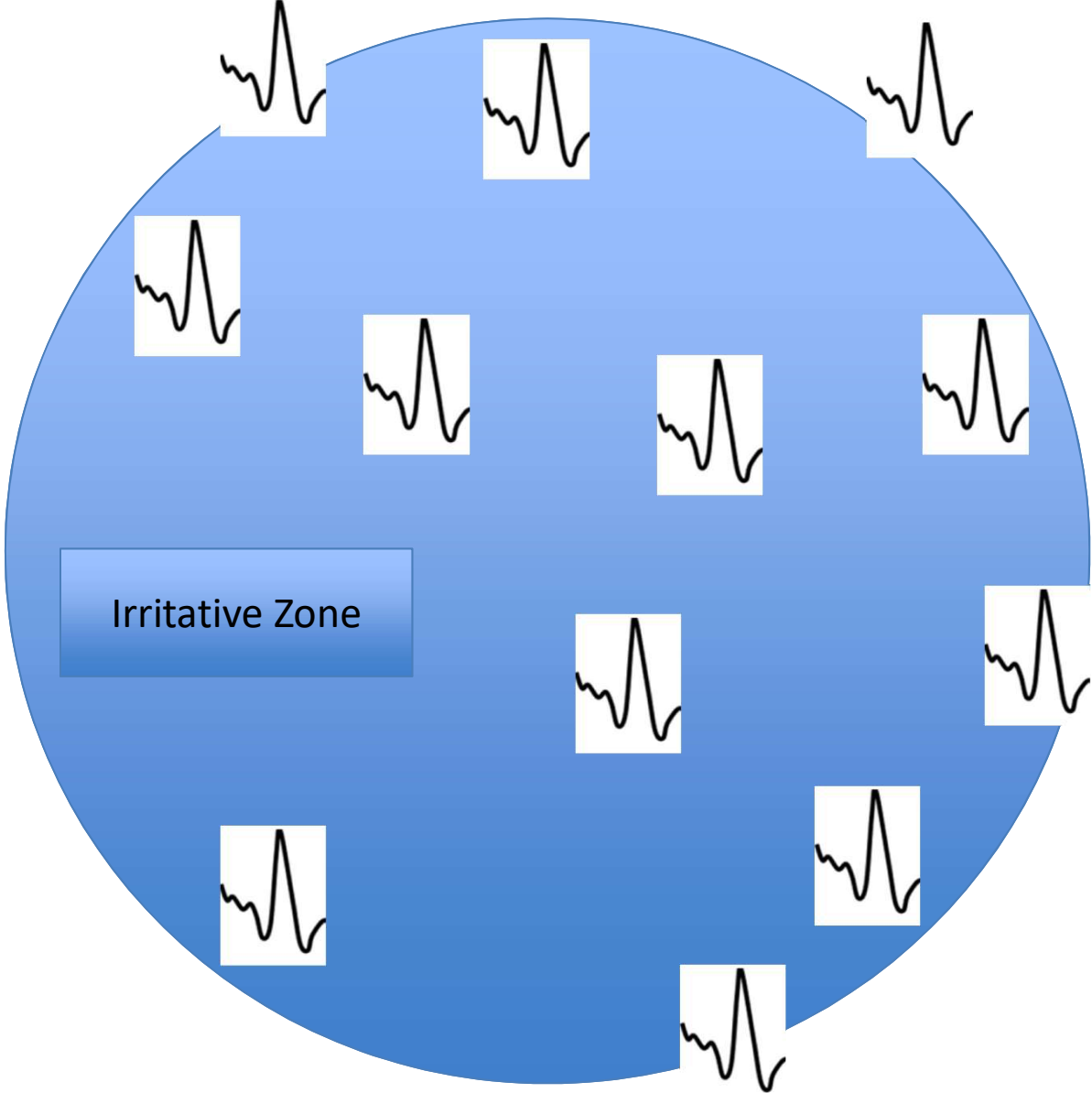
Predicting surgical outcome from interictal EEG-fMRI

- Four groups of patients according to concordance between BOLD response and resection

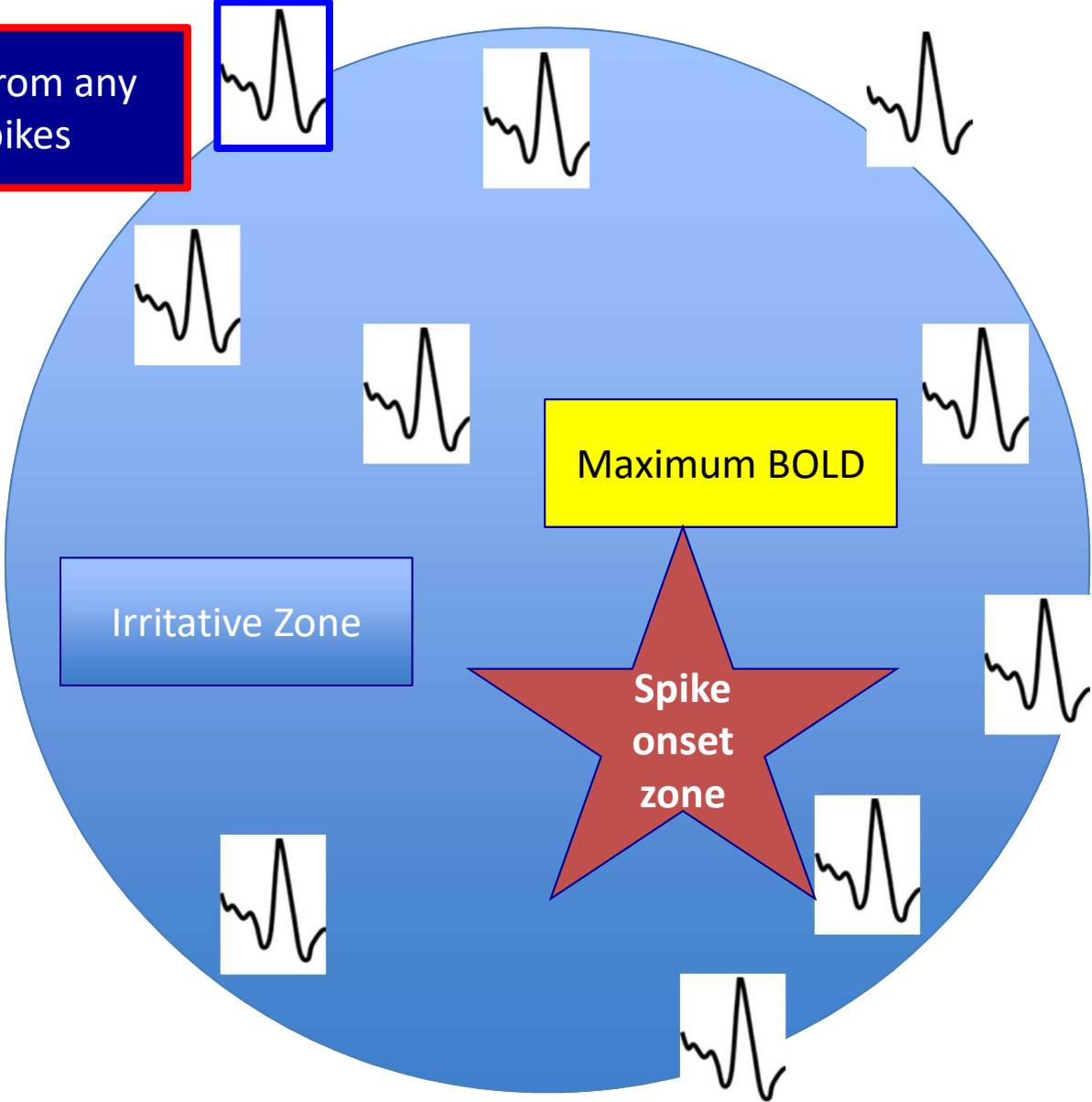
Full concordance	10	7 Sz free
Partial concordance	9	4 Sz free
Partial discordance	5	3 Sz free
Full discordance	11	1 Sz free

Is there a region where spikes originate and from which they propagate?





EEG-fMRI from any scalp spikes

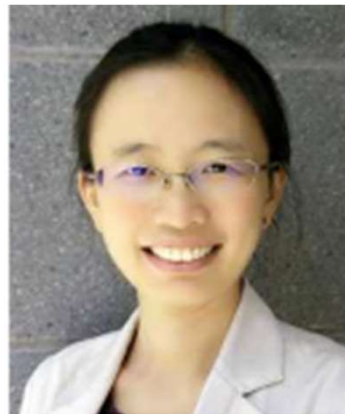


Is the Spike Onset Zone a good indicator of the Seizure Onset Zone?

The hemodynamic response to interictal epileptic discharges localizes the seizure-onset zone

*†Hui Ming Khoo, *Yongfu Hao, *Nicolás von Ellenrieder, *Natalja Zazubovits, *Jeffery Hall, *Andre Olivier, *François Dubeau, and *Jean Gotman

Epilepsia, 58(5):811–823, 2017
doi: 10.1111/epi.13717



Is the Spike Onset Zone a good indicator of the Seizure Onset Zone?

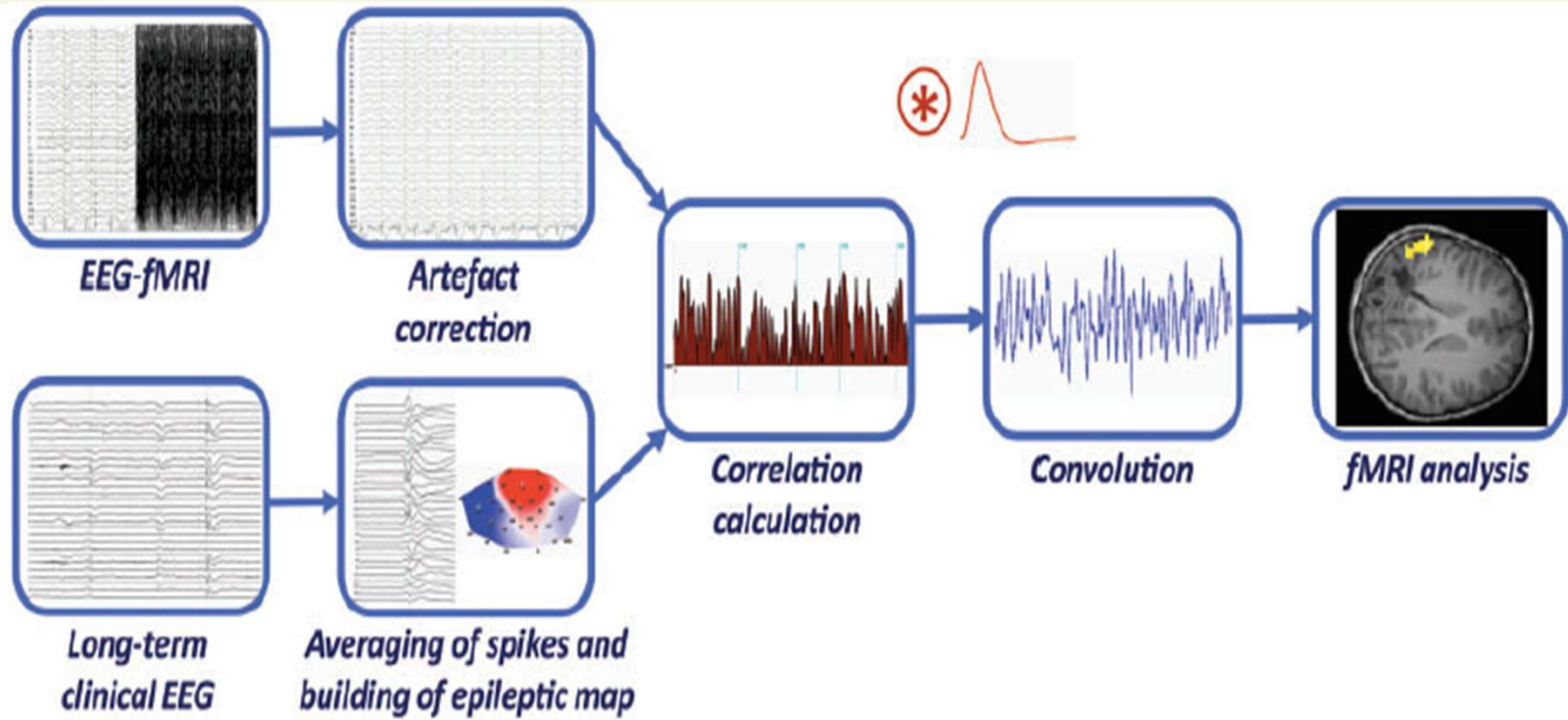
- In patient who had an EEG-fMRI study followed by electrode implantation
- Assess the correspondence between the region of maximum BOLD(Spike Onset Zone) and the Seizure Onset Zone
- Superimpose the pre-implantation BOLD map and the electrode position
- Defined “concordance” if contacts of seizure onset are within 2 cm of the peak BOLD

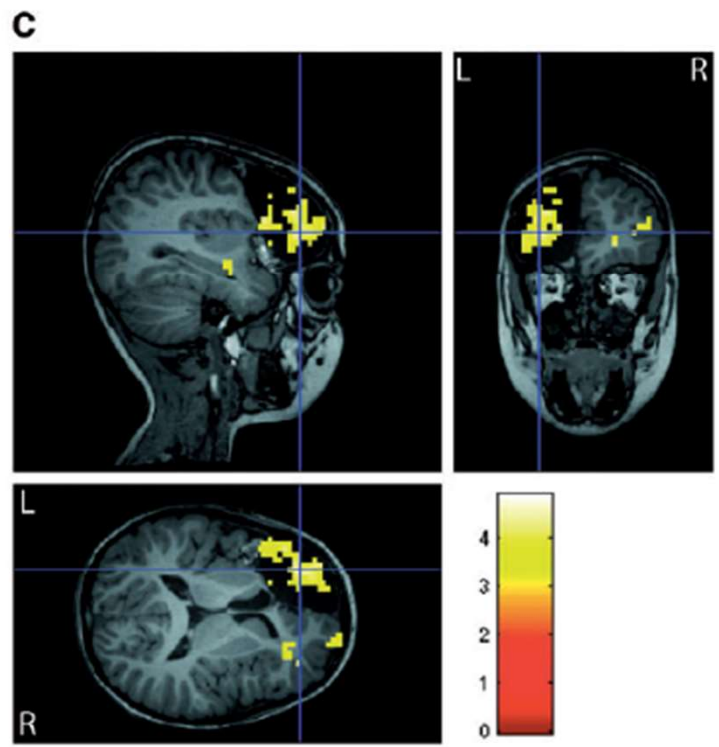
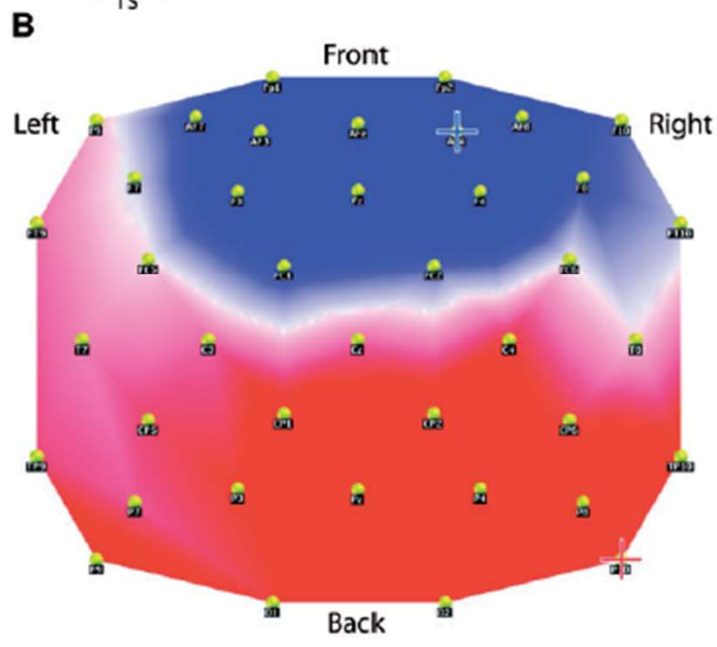
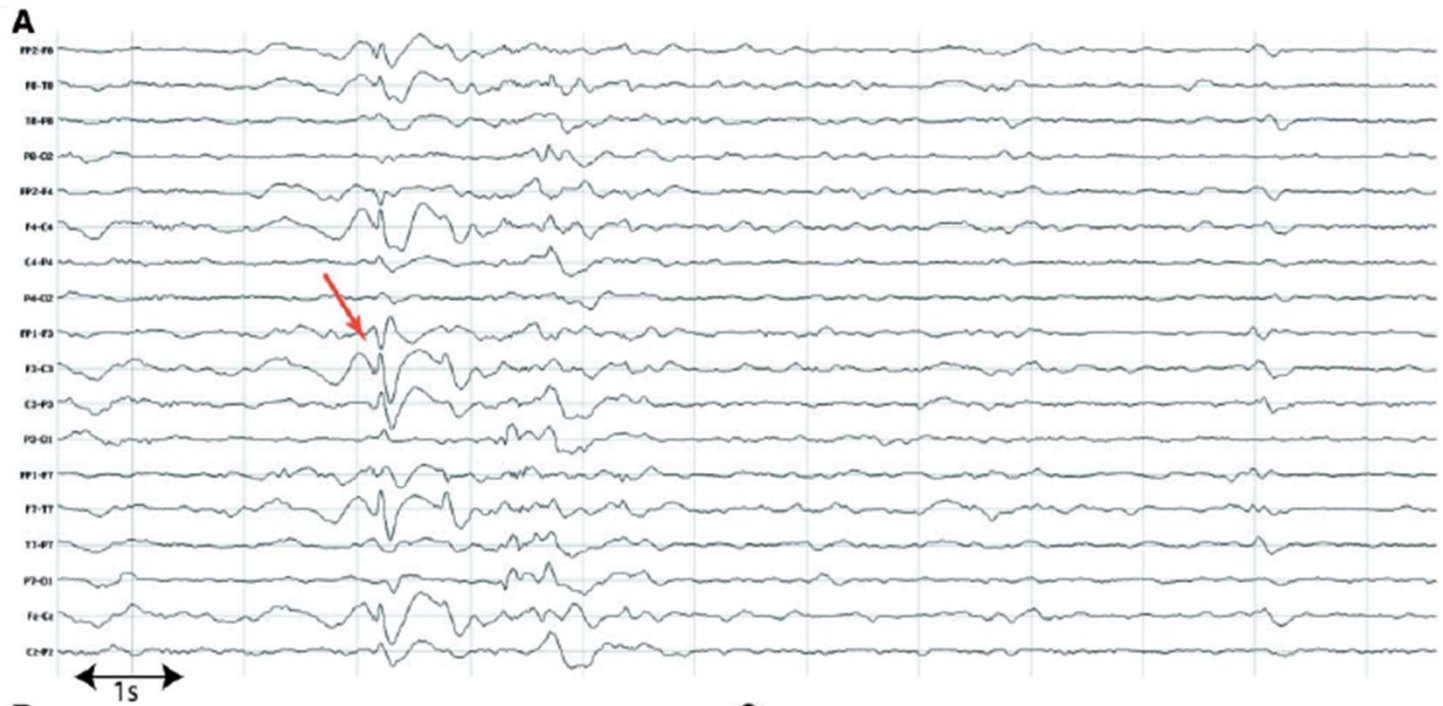
Spike Onset Zone defined by Maximum BOLD vs Seizure Onset Zone

- In 77% of 31 patients a Spike Onset Zone corresponds to the Seizure onset Zone
- In about a third of patients, with specific BOLD patterns, the Spike Onset Zone determines with almost certainty(93%) the Seizure Onset Zone

With or without spikes: localization of focal epileptic activity by simultaneous electroencephalography and functional magnetic resonance imaging

Frédéric Grouiller,¹ Rachel C. Thornton,² Kristina Groening,³ Laurent Spinelli,¹ John S. Duncan,² Karl Schaller,⁴ Michael Siniatchkin,^{3,5} Louis Lemieux,² Margitta Seeck,¹ Christoph M. Michel¹ and Serge Vulliemoz^{1,2}





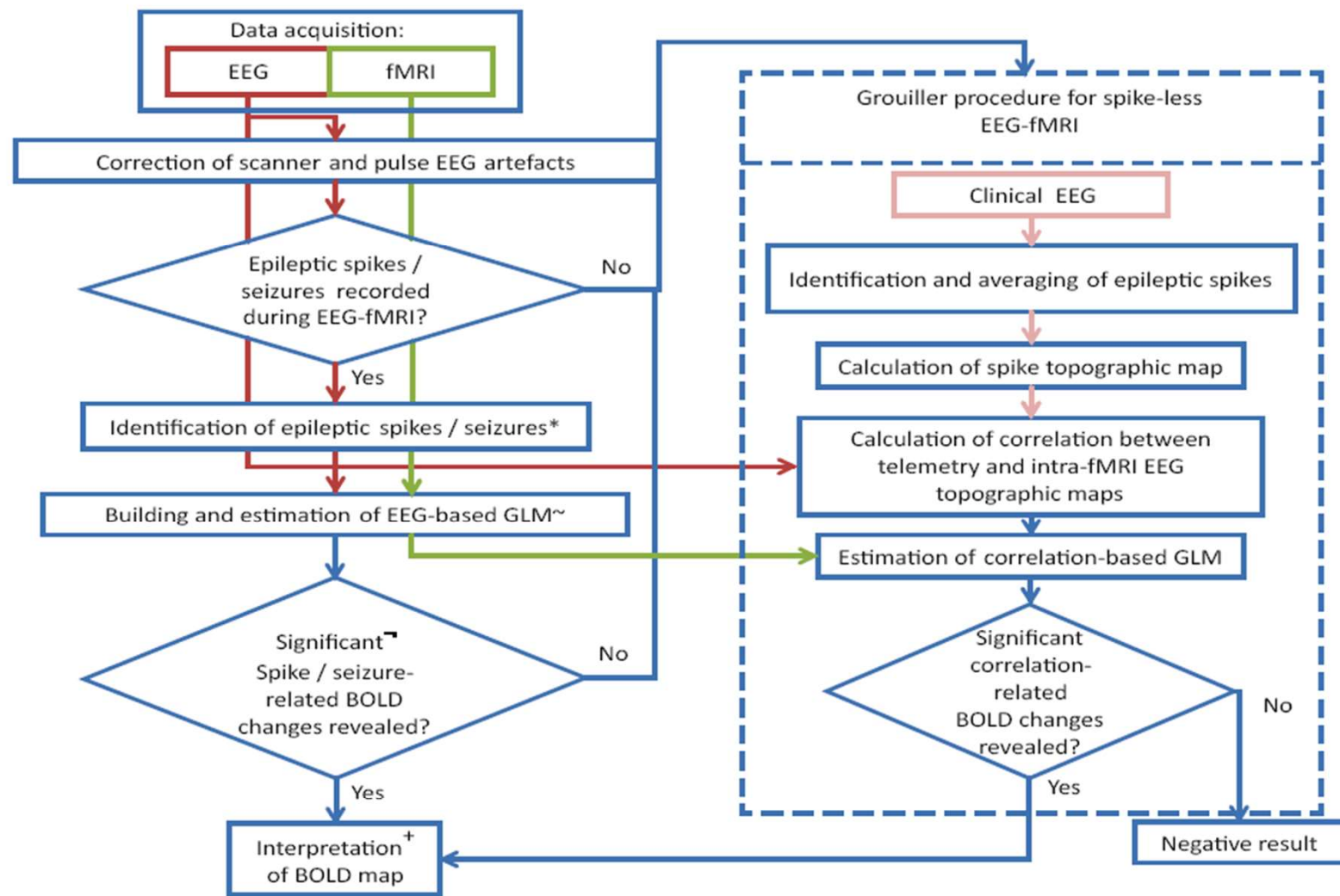


Figure 1: UCL interictal and ictal scalp EEG-fMRI analysis flowchart

*Seizures identified and divided into phases according to their spatiotemporal evolution

~One GLM for epileptic spikes and seizures which also includes additional regressors explaining effects of no interest such as: motion, pulse and physiological activities

^-Statistically significant at $p < 0.05$ family wise error corrected or $p < 0.001$ uncorrected

+Evaluation of concordance of global maximum and other BOLD clusters with the SOZ

Contribution of EEG/fMRI to the definition of the epileptic focus

Francesca Pittau, MD
François Dubeau, MD
Jean Gotman, PhD

Correspondence & reprint
requests to Dr. Gotman:
jean.gotman@mcgill.ca

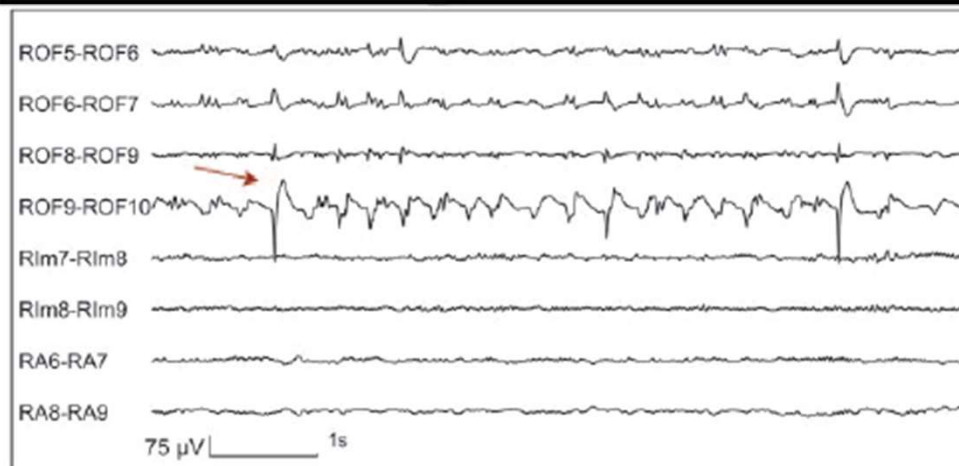
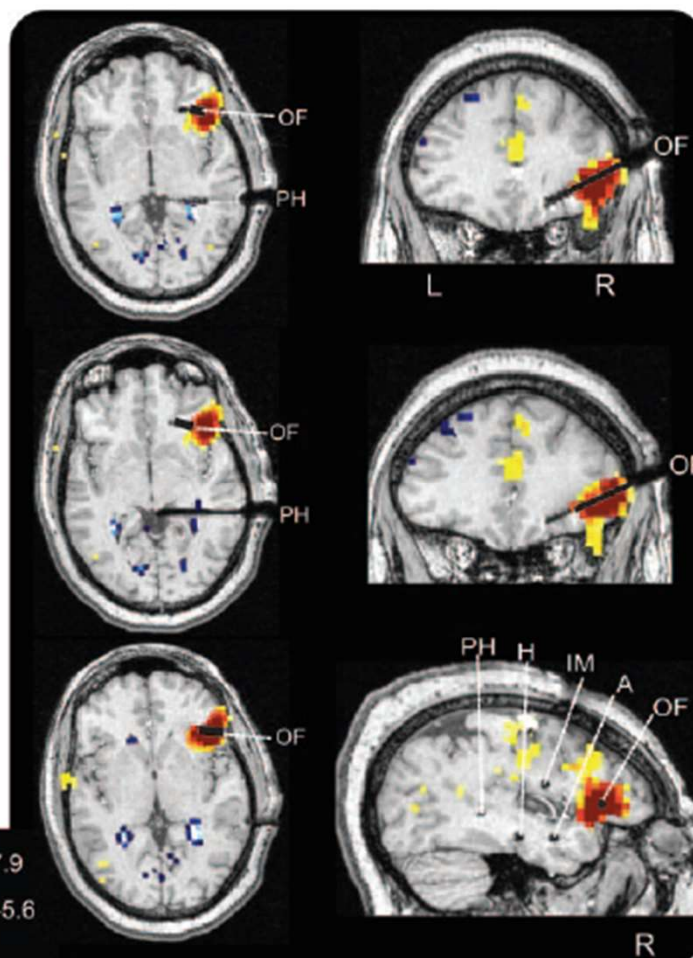
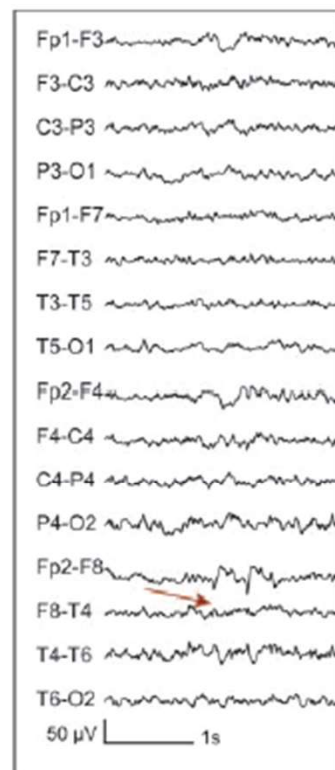
ABSTRACT

Objectives: To evaluate the clinical relevance of EEG/fMRI in patients with focal epilepsy, by assessing the information it adds to the scalp EEG in the definition of the epileptic focus.

Methods: Forty-three patients with focal epilepsy were studied with EEG/fMRI using a 3-T scanner. Blood oxygen level–dependent (BOLD) signal changes related to interictal epileptic discharges (IEDs) were classified as concordant or not concordant with the scalp EEG spike field and as contributory if the BOLD signal provided additional information to the scalp EEG about the epileptic focus or not contributory if it did not. We considered patients having intracerebral EEG or a focal lesion on MRI as having independent validation.

Results: Thirty-three patients had at least 3 IEDs during the EEG/fMRI acquisition (active EEG), and all had a BOLD response. In 29 of 33 (88%) patients, the BOLD response was concordant, and in 21 of 33 (64%) patients, the BOLD response was contributory. Fourteen patients had an independent validation: in 12 of these 14, the BOLD responses were validated and in 2 they were invalidated.

Conclusions: A BOLD response was present in all patients with active EEG, and more specific localization of the epileptic focus was gained from EEG/fMRI in half of the patients who were scanned, when compared with scalp EEG alone. This study demonstrates that EEG/fMRI, in the context of a clinical practice, may contribute to the localization of the interictal epileptic generator in patients with focal epilepsy. *Neurology*® 2012;78:1479-1487



RESEARCH PAPER

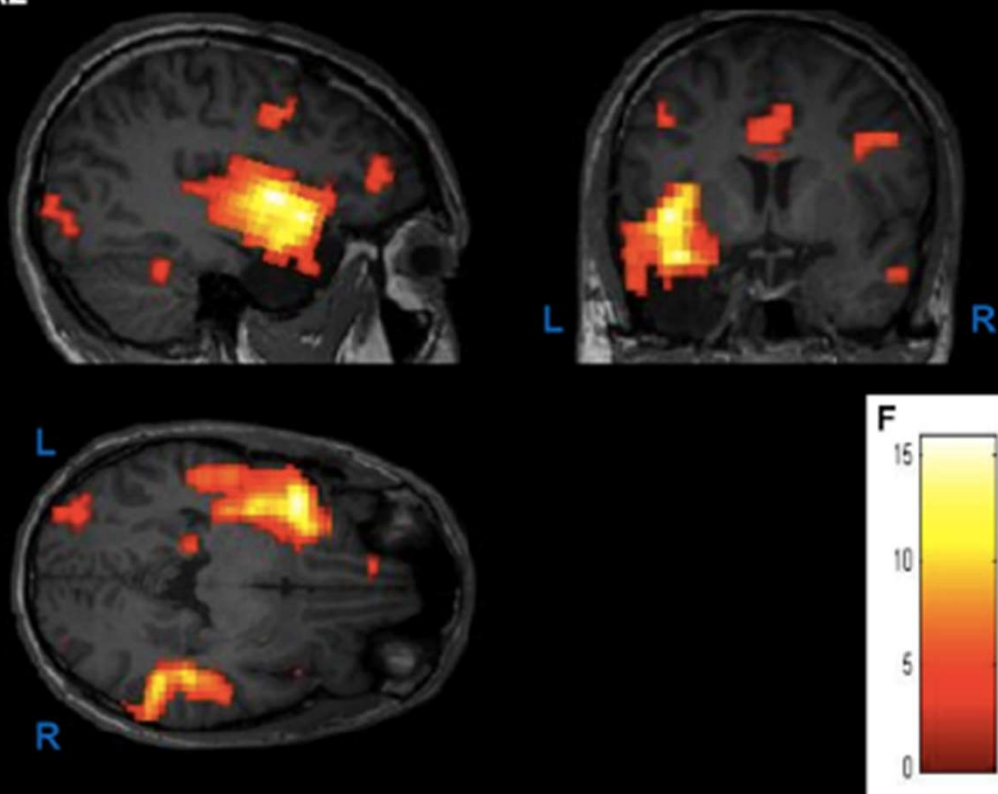
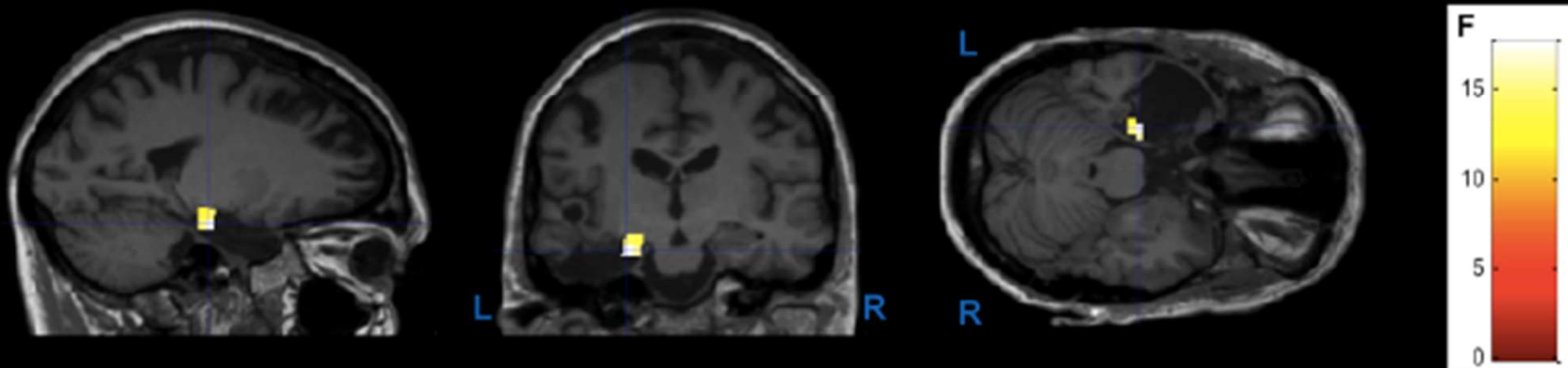
EEG-fMRI in the presurgical evaluation of temporal lobe epilepsy

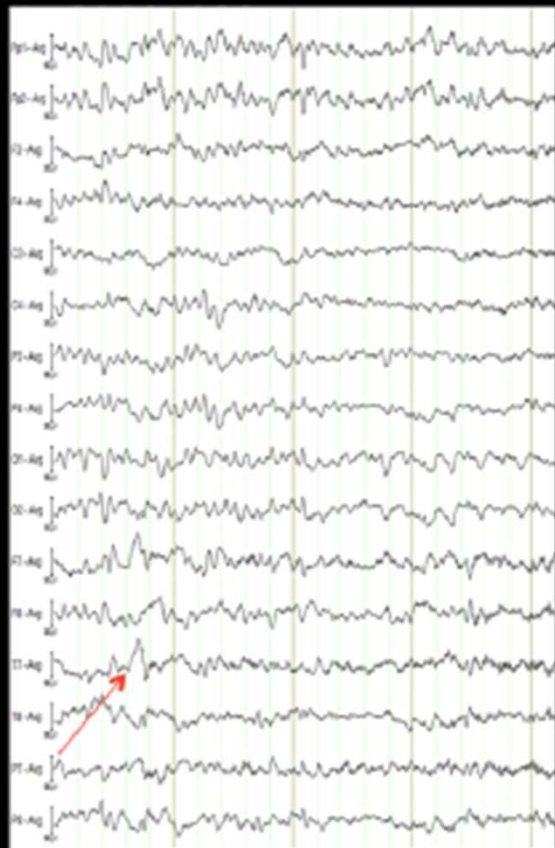
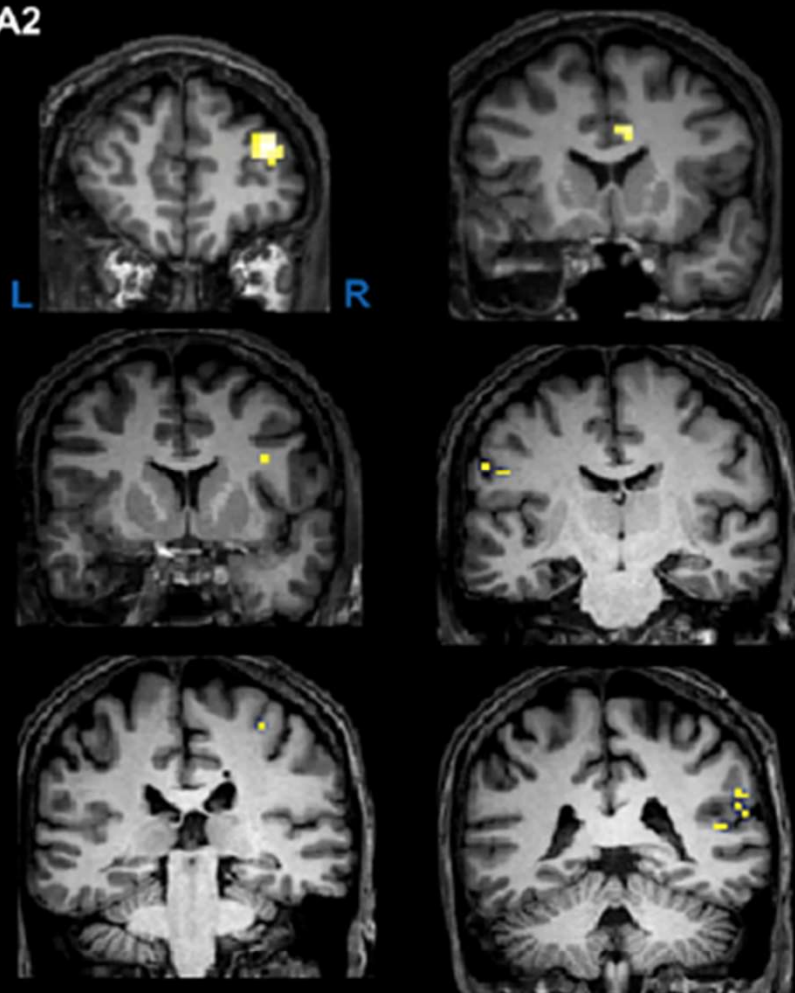
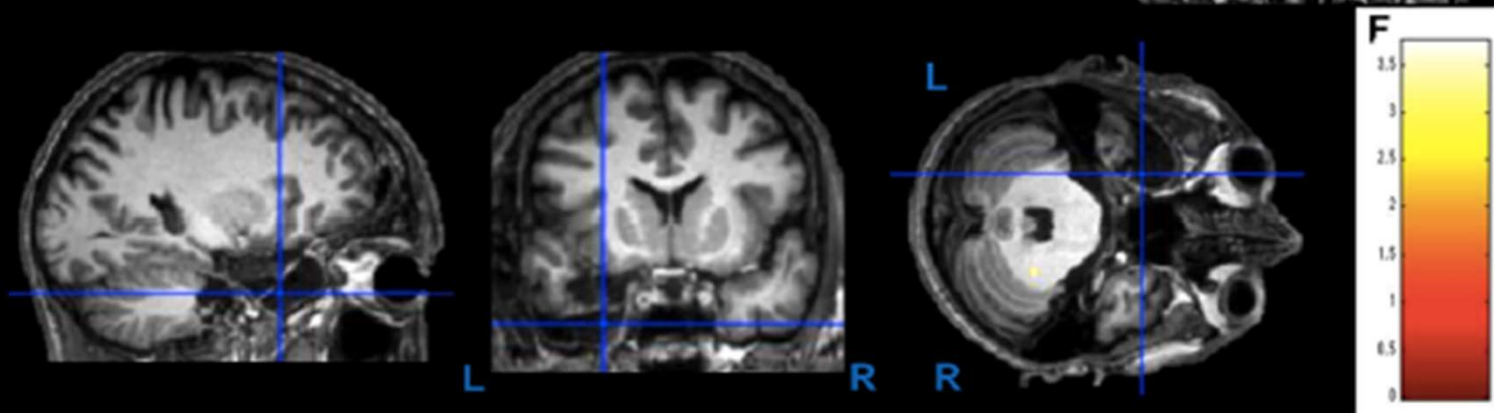
Ana C Coan,¹ Umair J Chaudhary,^{2,3} Frédéric Grouiller,⁴ Brunno M Campos,¹
Suejen Perani,^{2,3} Alessio De Ciantis,^{2,3} Serge Vulliemoz,⁵ Beate Diehl,^{2,3}
Guilherme C Beltramini,⁶ David W Carmichael,^{2,3} Rachel C Thornton,^{2,3}
Roberto J Covolan,⁶ Fernando Cendes,¹ Louis Lemieux^{2,3}

- ❑ 30 Pts undergoing pre-surgical evaluation with EEG-fMRI and proceed to TL resection
- ❑ Result of BOLD change was overlying on Post surgical MRI
 - 16 concordance 13 good outcome (81%)
 - 14 discordance 3 good outcome (21%)

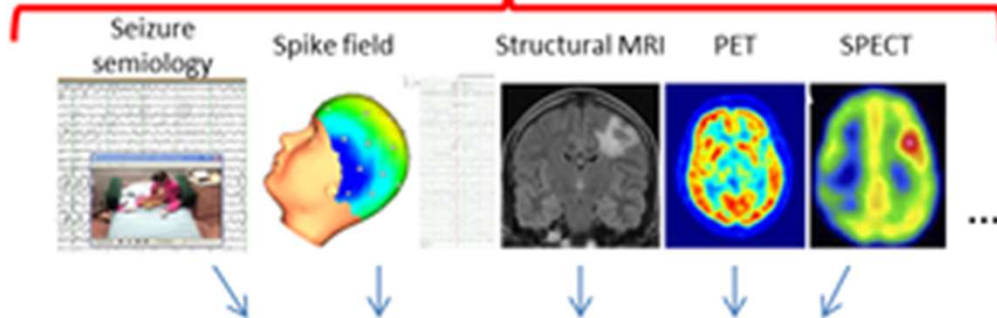
PPV = 81%

NPV = 79%

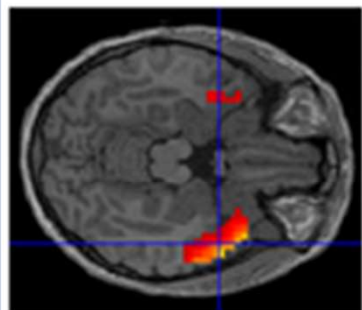
A1**A2****B**

A1**A2****A3**

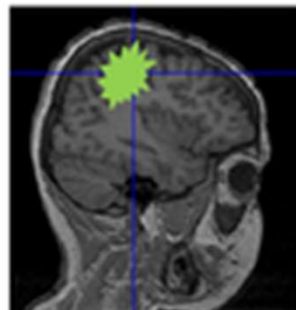
Clinical information



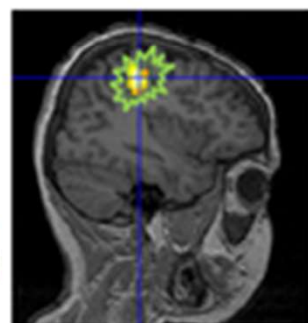
EEG-fMRI map



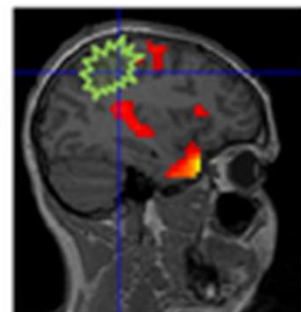
Presumed epileptic focus



Concordant



Discordant



Limitation of EEG-fMRI

- Inside scanner spike require
- Temporal lobe epilepsy the EEG-fMRI result is better than extra temporal lobe epilepsy
- In Frontal lobe epilepsy : Result of BOLD change in unilateral spike is better than bilateral spike
- MRI and Cardiobalistic artifact should be removed well.

THANK

YOU!