Defining epileptic network by seizure semiology and EEG findings

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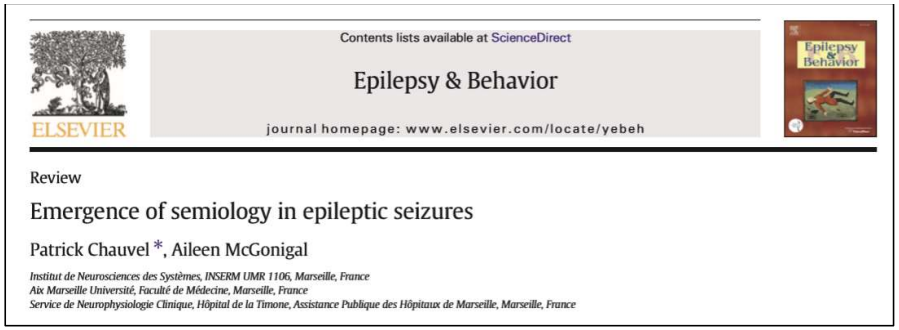
Outline

- How to use semiology and EEG to define Epileptic networks

- Example of epileptic networks
  - Limbic network
  - Fronto-temporal network
  - Fronto-parietal network
  - Frontal network

Semiology is shaped by *cable wiring* of the brain
And *hierarchical* organization of the cortex



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Review

Emergence of semiology in epileptic seizures

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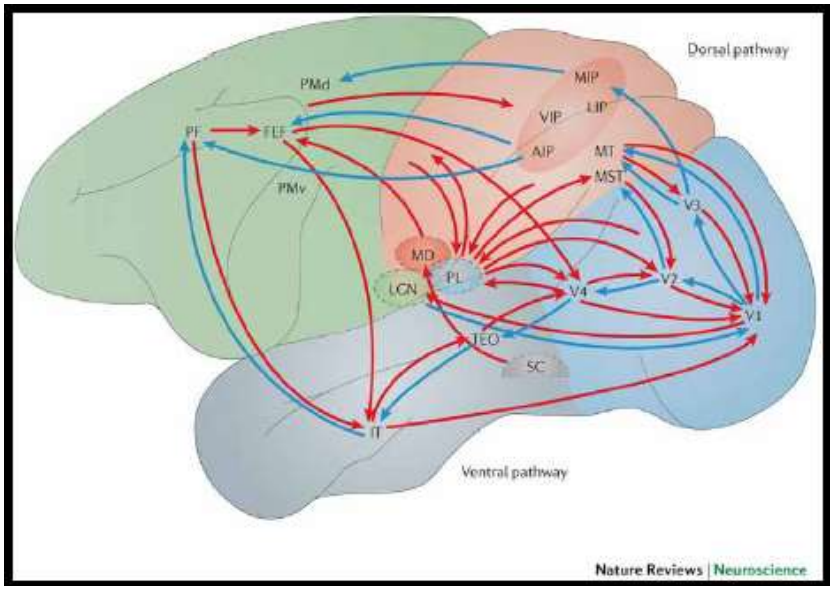
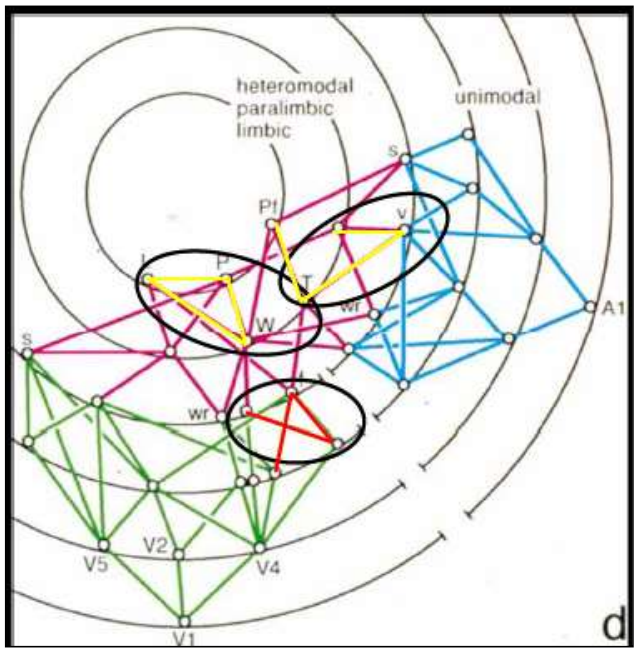
Service de Neurophysiologie Clinique, Hôpital de la Timone, Assistance Publique des Hôpitaux de Marseille, Marseille, France



A hard-wired system
With short and long connections



Functional coupling establishes
dynamic patterns

Chauvel, 2014

Semiology is expressed with dynamic spatiotemporal characteristics

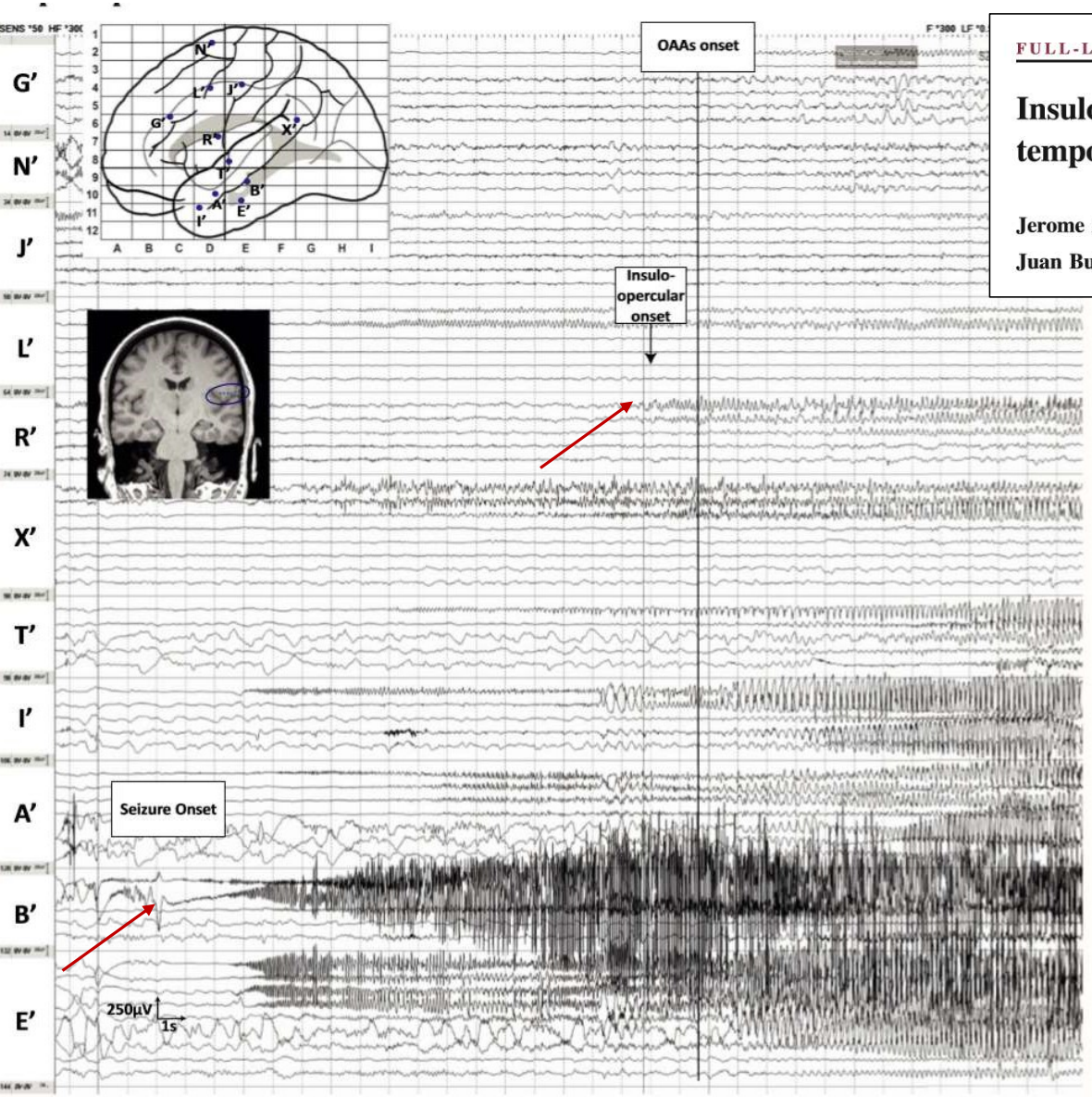
Table 1
Use of a multiscale framework to think about spatial and temporal features in seizures and epilepsy

Data Source	Level	Timescale	Modes of Exploration	Timescale	Spatial Features	Temporal Features
Cerebral electrical activity	Brain: local circuit, area, system, whole brain	• Microseconds to minutes for seizures • Hours to days for interictal data	EEG, SEEG (ictal and interictal) Also, MRI, PET, and other neuroimaging methods (interictal)	• Microseconds to minutes for seizures • Hours to days for interictal data	Anatomic structures involved in seizure discharge: onset and propagation	Discharge features: • Frequency • Time lag between structures • Synchrony changes between signals in different structures
Seizure semiology	Body, mind, environment: cognition, emotions, movement, behavior (including social interaction, use of objects)	• Usually seconds to minutes for seizures • Sometimes hours for preictal and postictal changes • Days to years for interictal data (eg, interictal psychiatric or cognitive disturbance)	Direct clinical observation and patient report of ictal and interictal symptoms and signs; video and audio recording of seizures; sometimes quantitative analysis (eg, accelerometry, automated video analysis); recording of other physical parameters (eg, ECG, EMG)	• Usually seconds to minutes for seizures • Sometimes hours for preictal and postictal changes • Days to years for interictal data (eg, psychiatric disturbance)	Body segments involved (eg, axial, proximal vs distal, left vs right, upper vs lower) Displacement of body in space (eg, direction, amplitude)	• Timing of appearance of different signs within same seizure • Duration of signs • Frequency and regularity of repeated movements (eg, rocking, tapping)

Cerebral localization

Epileptiform discharges features

McGonigal, 2020



FULL-LENGTH ORIGINAL RESEARCH

Epilepsia

Insulo-opercular cortex generates oroalimentary automatisms in temporal seizures

Jerome Aupy[1,2,3] | Ika Noviawaty[1,4] | Balu Krishnan[1] | Piradee Suwankpakdee[1,5] | Juan Bulacio[1] | Jorge Gonzalez-Martinez[1] | Imad Najm[1] | Patrick Chauvel[1]

- In seizures with medial temporal onset, oroalimentary automatism occurrence depends on ictal discharge propagation to ***operculo-insular areas***

Spatial features

- Rhythmically synchronized activity at ***theta frequency*** between amygdala-hippocampus and operculo-insular cortex underlies the emergence of oroalimentary automatisms in temporal seizures

Temporal features

Do we need to know epileptic network?

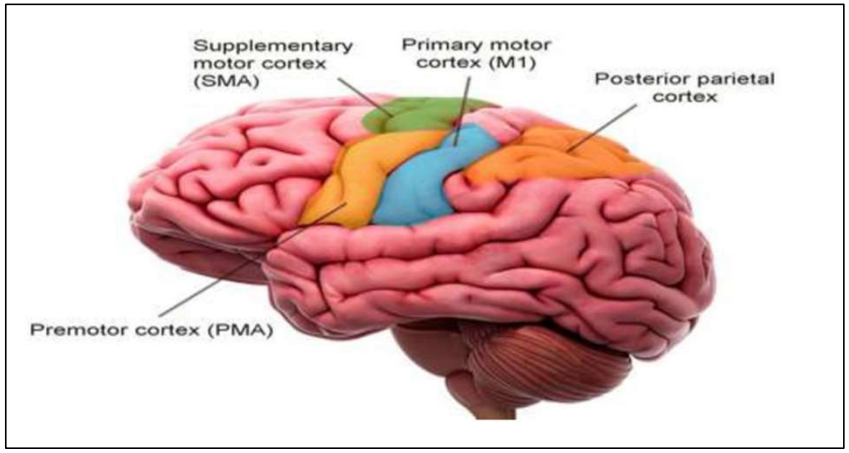
Semiological pattern recognition

Fine without knowing epileptic network

Seen in primary cortex (motor, somatosensory, auditory, visual)

- video

- **Focal clonic seizure**
- **Indicate involvement of contralateral primary motor cortex**



Other semiology may be less well localizing

- Semiology arising from ***associative cortex***
  - More wide-spread networks
  - Complex dynamics
- Complex behaviors
- Emotional change
- Altered consciousness

McGonigal, 2020

Other semiology may be less well localizing

Knowing epileptic network helps

- Case a 15 years old female with intractable epilepsy.
- Seizure semiology described as most of seizure **started with fear** then left arm stiffeness followed shortly by numbness or pain that going down form shoulder toward leg, with postictal left sided weakness. Sometimes oroalimentary automatisms were noted.

- video

Courtesy of General Charcrin Nabangchang, MD

Other semiology may be less well localizing

Knowing epileptic network helps

- Case a 10 years old female with epilepsy.
- During daytime, She **presents with fear** followed by screaming and tachycardia lasted 20 sec.
- During nighttime, she arose from sleep and looked scary followed by screaming and vigorous movements.

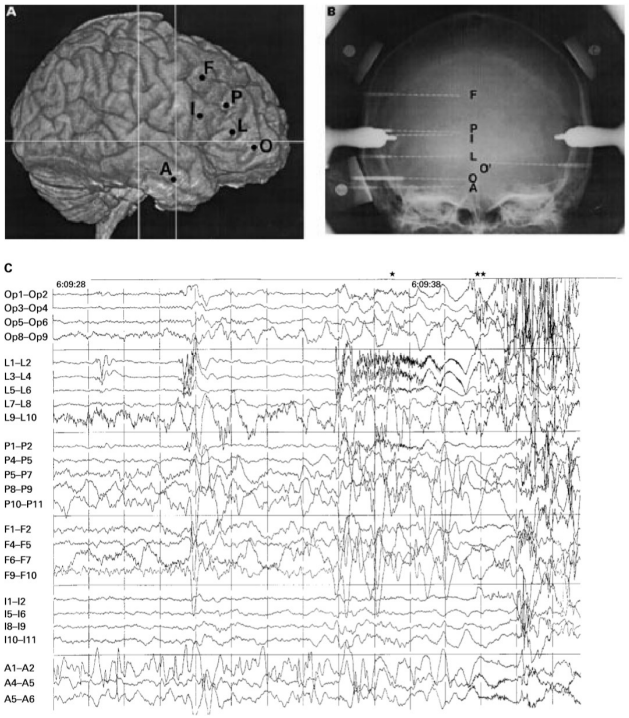
- Video

Analyze semiology in order
Early signs more reliable

J Neurol Neurosurg Psychiatry 2001;**70**:186–191

Fear as the main feature of epileptic seizures

A Biraben, D Taussig, P Thomas, C Even, J P Vignal, J M Scarabin, P Chauvel

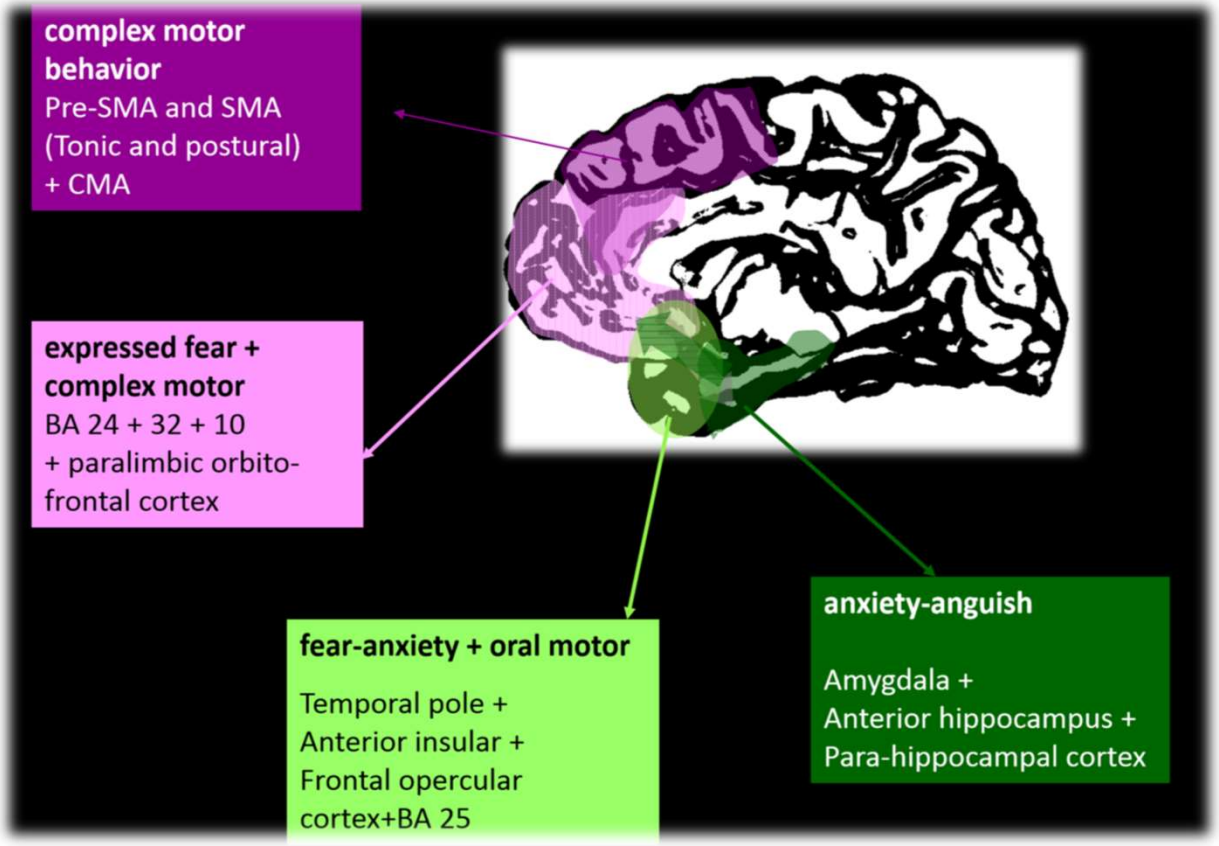


This limbic network involve- Orbitoprefrontal
- Anterior cingulate
- Temporal limbic cortices

Biraben et al, 2001

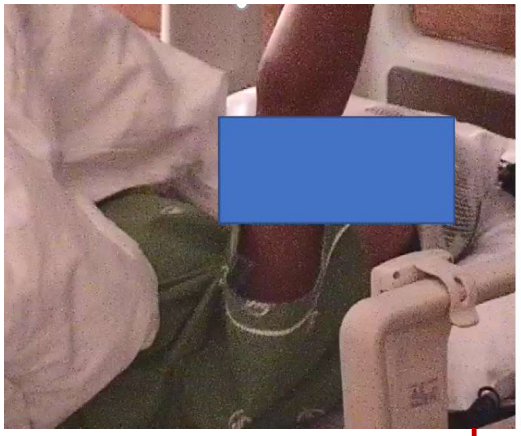
Look for the clue of exactly localization

- The ictal *motor* behavior appears as an *integrated* feature within an emotional context



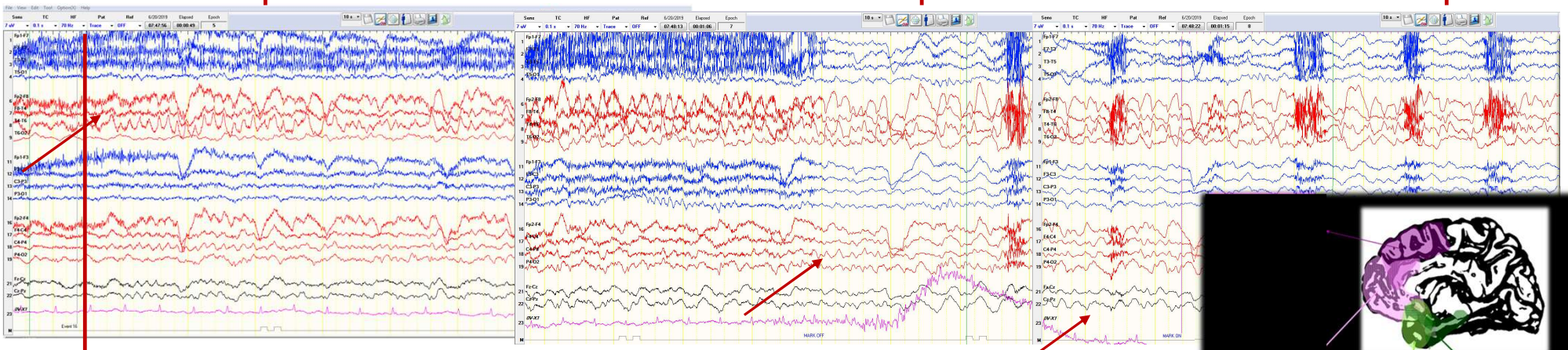
Chauvel P, SEEG workshop, Cleveland clinic

Fear

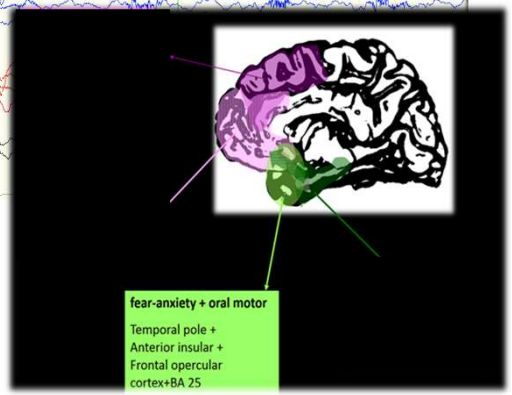


Left arm stiffed/ felt numb

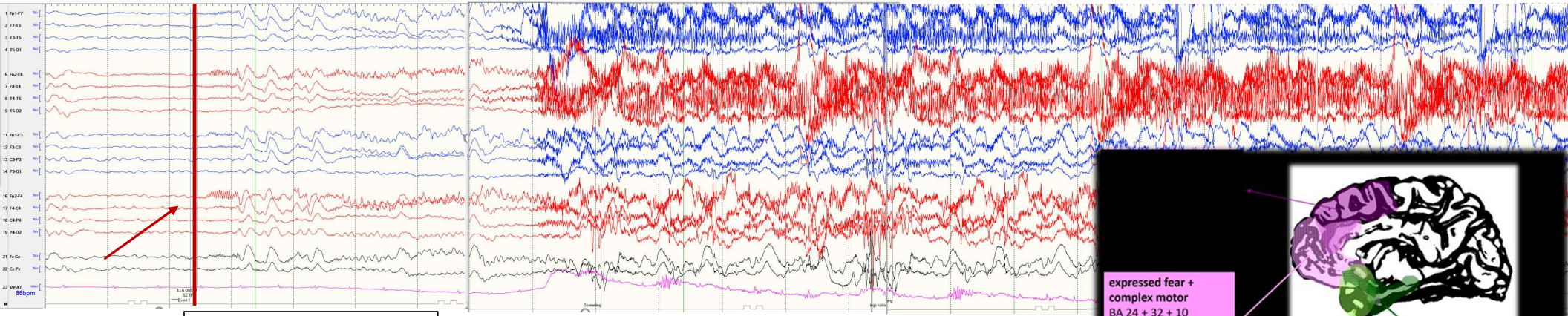
Mouth automatisms



EEG onset
R temporal



Expressed Fear | Scream | Hypermotor



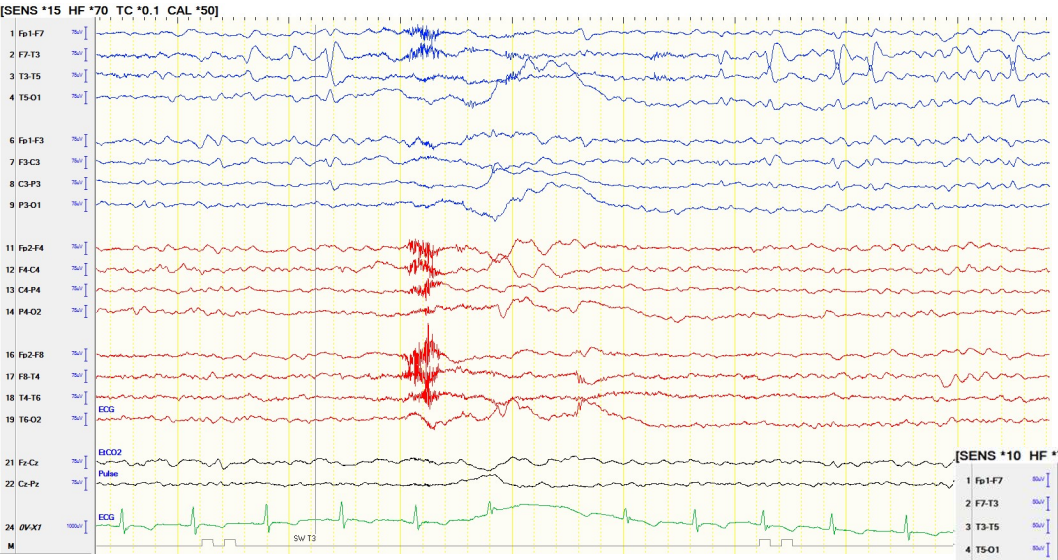
EEG onset
Fp2 (R frontopolar)

Knowing epileptic network prevent fall in the trap

Case a 9-year-old boy with intractable epilepsy

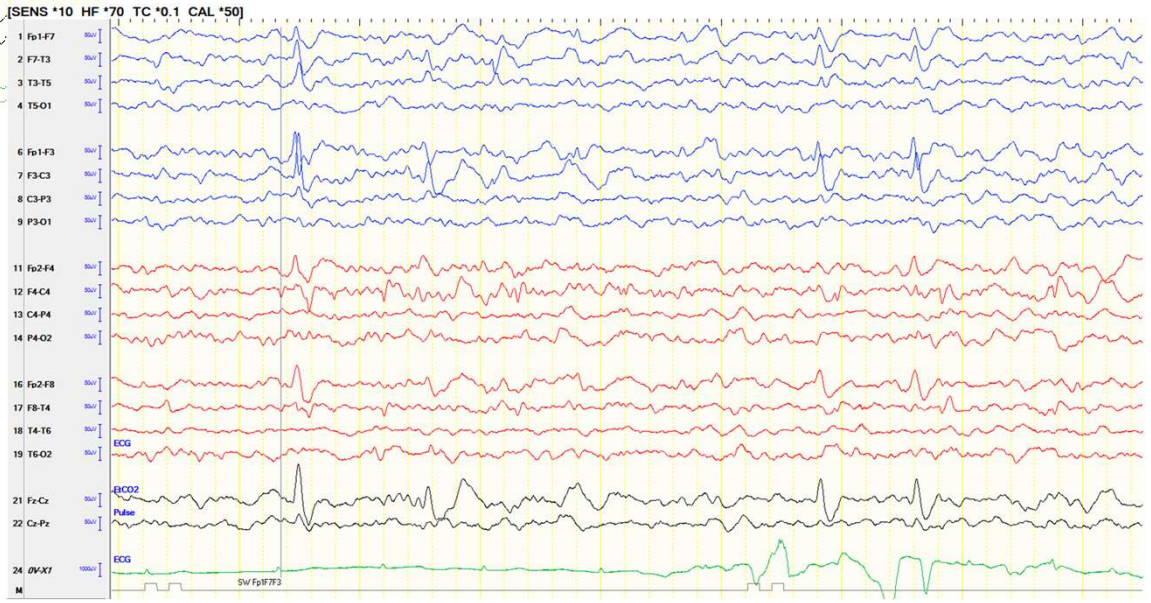
- ชักครั้งแรก อายุ 3 ปี
- ลักษณะชัก : ผู้ป่วยจะดูสับสน ขยับตัว มือขยับไปมา เรียกไม่รู้สึกตัว เป็นนาน 10-15 นาที
- MRI brain: unremarkable
- EEG:
  - Interictal: T3, F7, Fp1, Fz
  - Ictal: 1. F7, T3
    2. Fp1, F3
- Video

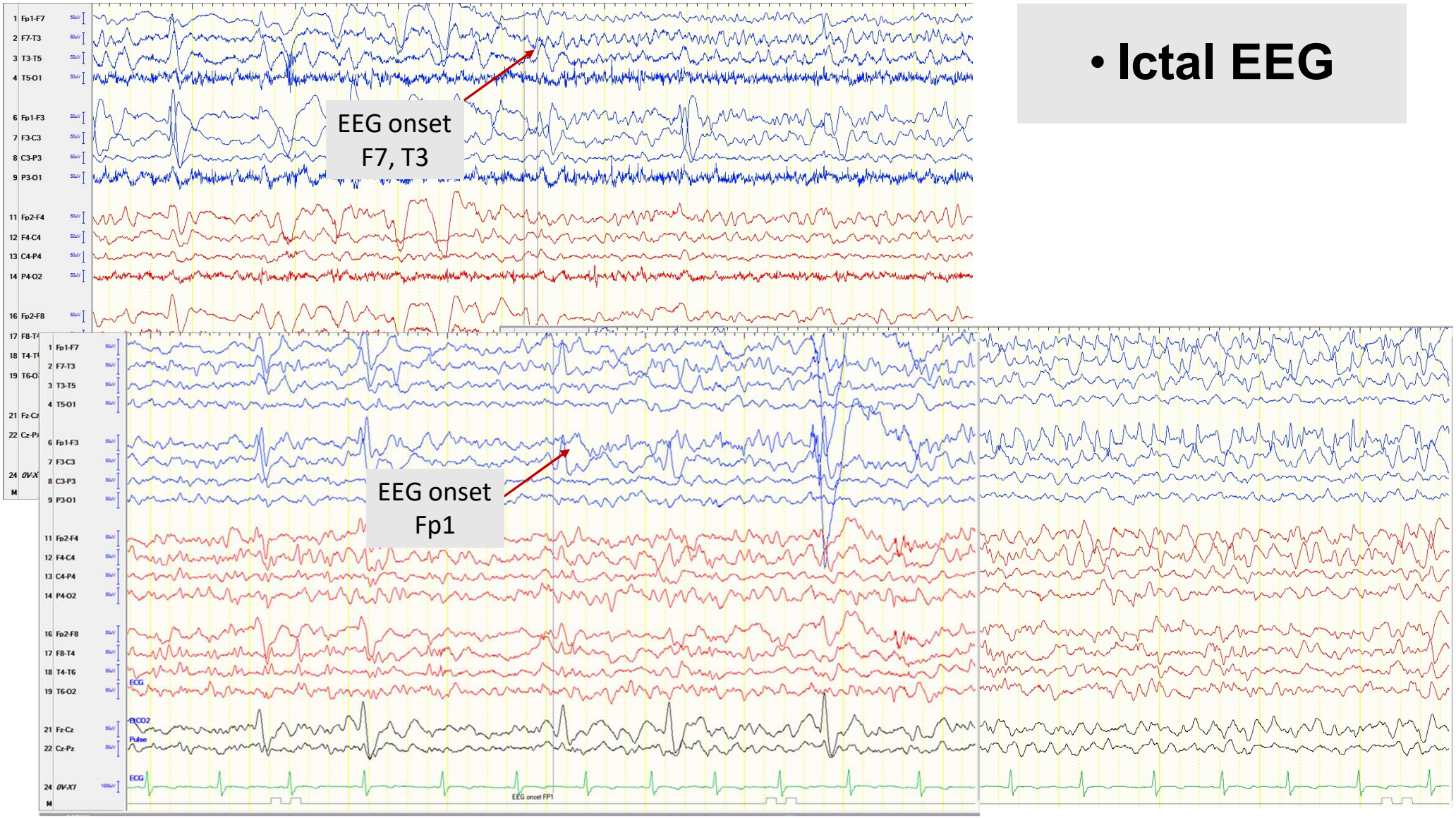
SW T3



- Interictal EEG

SW Fp1/ Fz

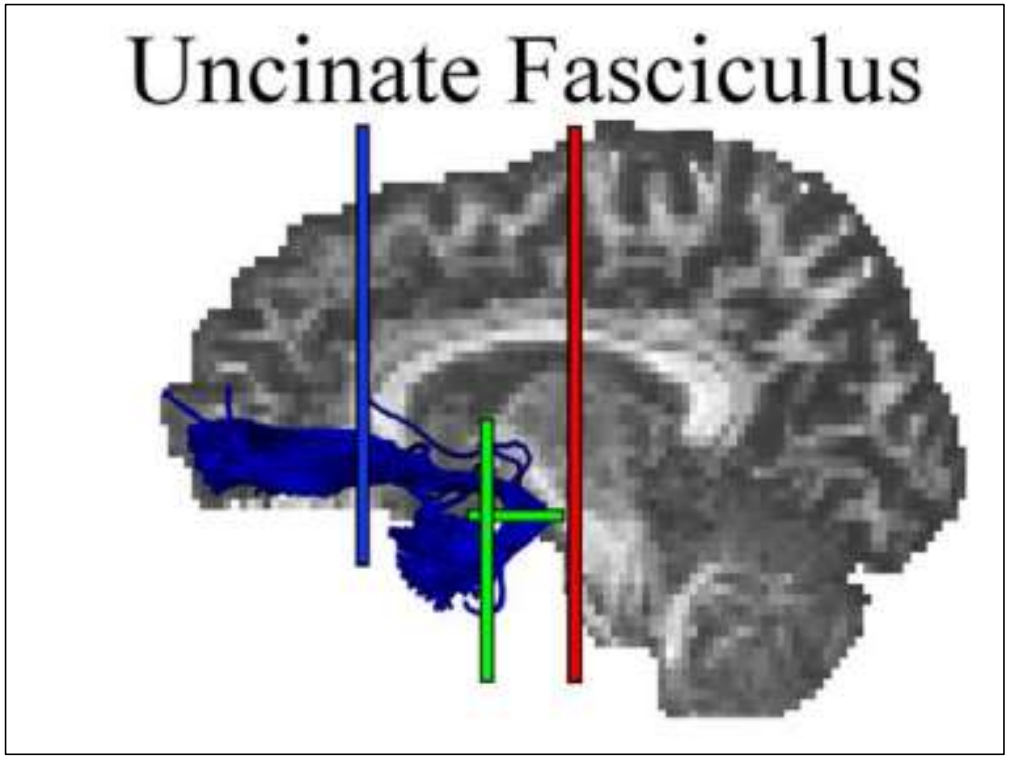




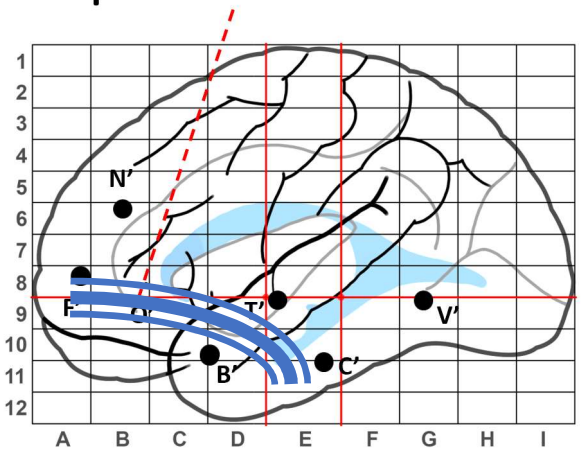
- **Ictal EEG**

Frontotemporal network

Knowing epileptic network helps



SEEG map



F'- Frontopolar
N'- MFG – Ant. Cingulate
O' - Orbitofrontal
B' – Head of hippo/temporal pole
T' – STG-Ant. Insula
C' - Inferior temporal gyrus- PHG

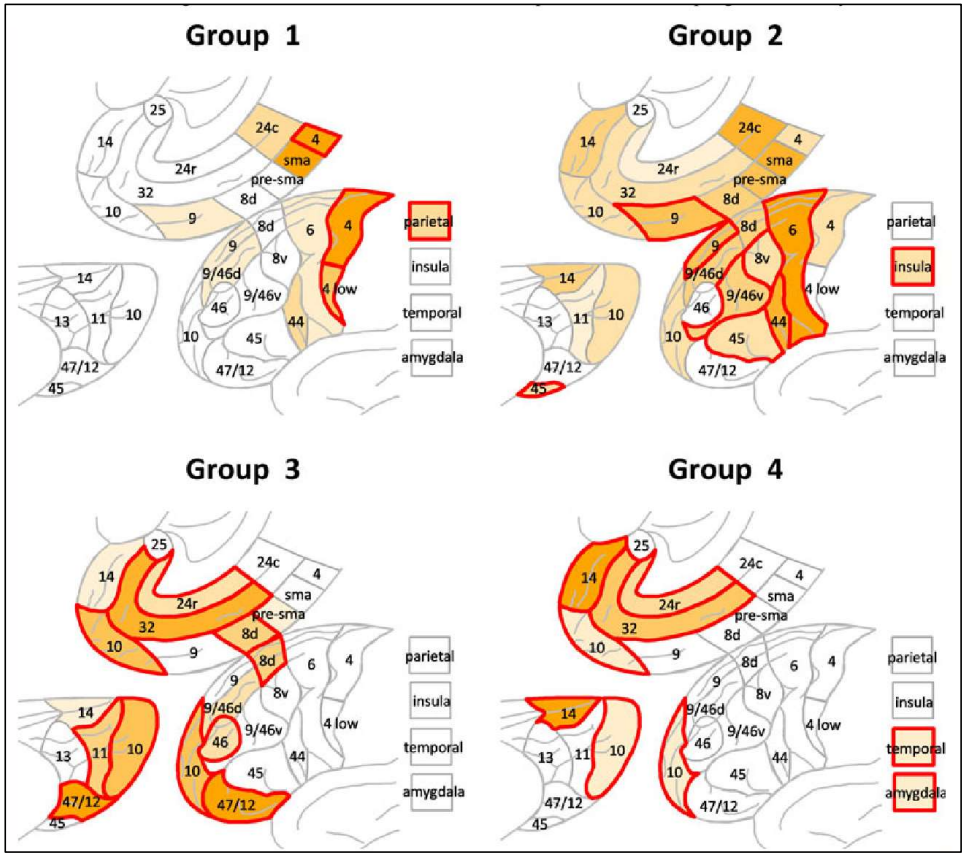
V' – Posterior temporal

Hypothesis: frontotemporal network

Frontal lobe seizures: From clinical semiology to localization

*†[1]Francesca Bonini, *†‡[1]Aileen McGonigal, *†‡Agnès Trébuchon, *†‡Martine Gavaret, *†‡Fabrice Bartolomei, *†§Bernard Giusiano, and *†‡Patrick Chauvel

Epilepsia, 55(2):264–277, 2014
doi: 10.1111/epi.12490



Group 1
Elementary motor signs
With no gestural behaviour

Group 2
Association of elementary motor signs and Proximal gestural motor Beh; non-integrated appearance

Group 3
Distal stereotypies, Integrated appearance, No elementary signs

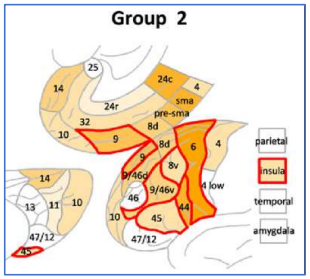
Group 4
Fear-related behaviour, no elementary motor signs

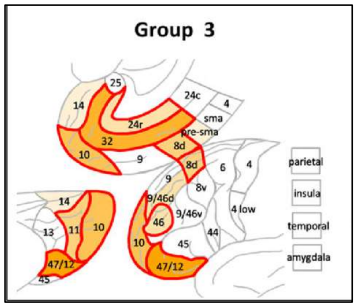
Proximal stereotypies

No facial expression

distal stereotypies

R leg stereotypies



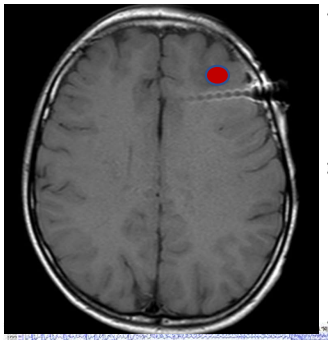


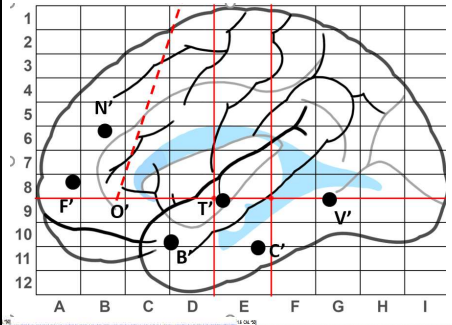
Group 2

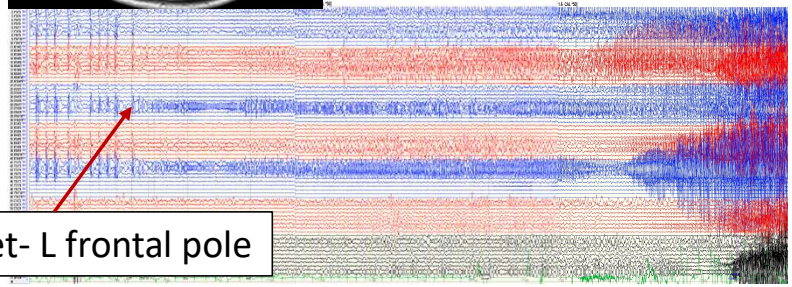
Association of elementary motor signs and Proximal gestural motor Beh; non-integrated appearance

Group 3

Distal stereotypies, Integrated appearance, No elementary signs

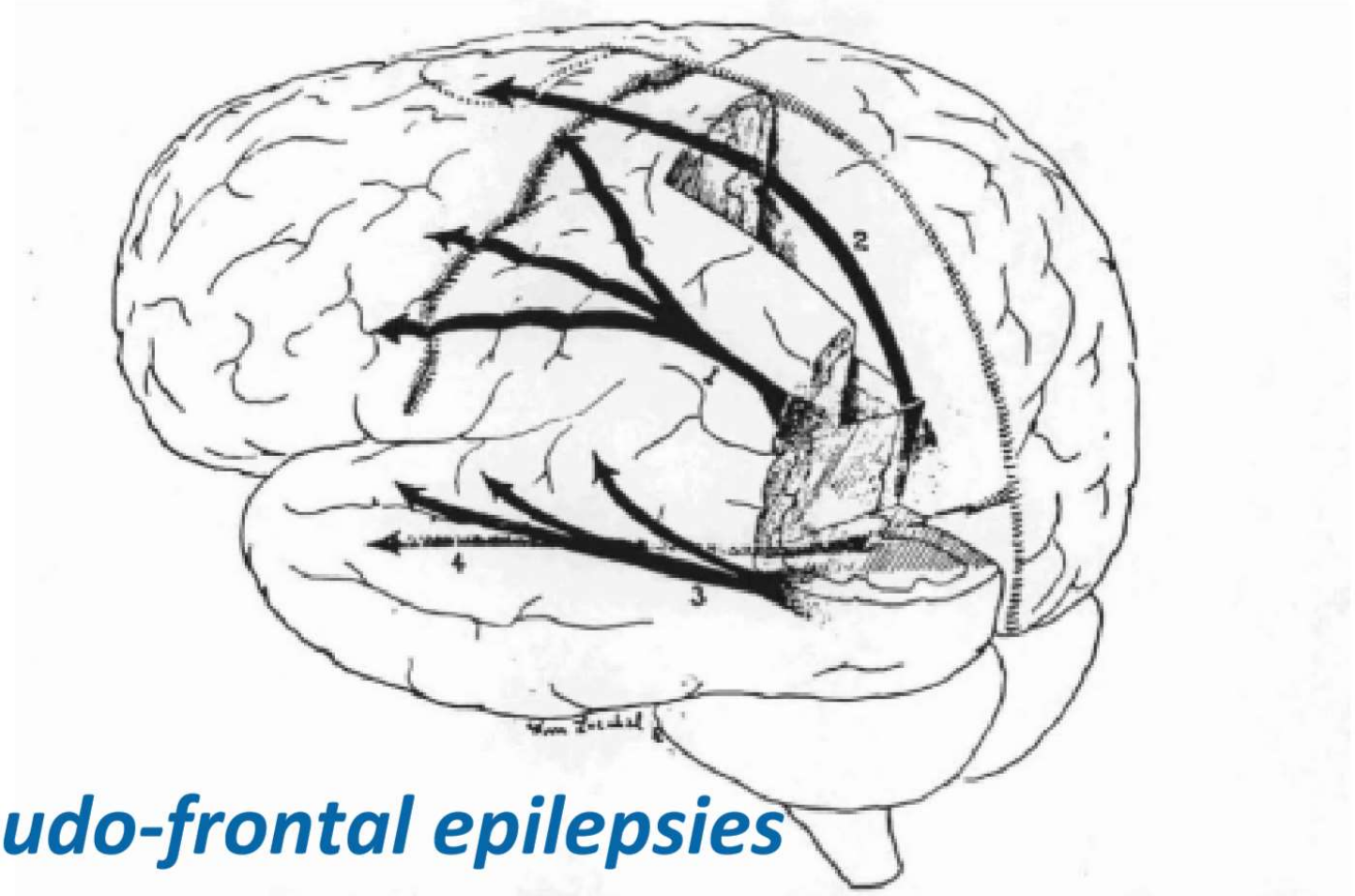






Ictal onset- L frontal pole

Parietal lobe epilepsy: *"frontal pattern"*



Patterns of spread from occipital lobe seizure origin. (From Ajmone-Marsan and Ralston, 1957, with permission.)

pseudo-frontal epilepsies

Fronto-parietal network

- เด็กผู้หญิงอายุ 6 ปี
- เริ่มชักเมื่ออายุ 4 เดือน

ลักษณะชักเป็นGTC

- อายุ 2 ปี ลักษณะชักเปลี่ยนเป็น

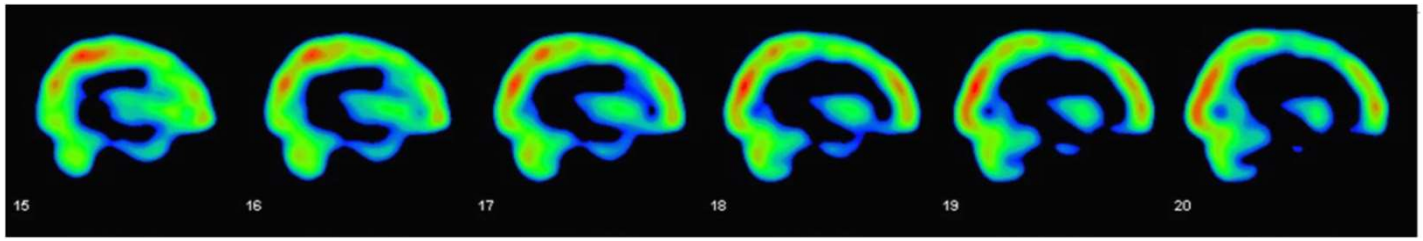
ตาลอย กระพริบตา ไม่รู้สึกตัว นานครั้งละ 5-10 วินาที 10-20ครั้งต่อวัน

Interictal SPK R frontal

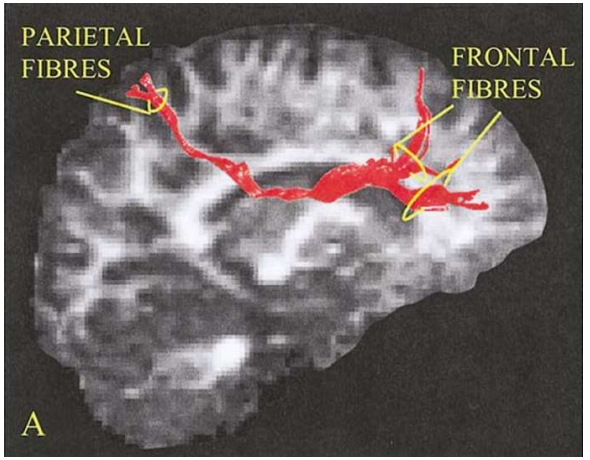
Ictal: EEG onset- Generalized max R frontal

- Case a 6-year-old girl with intractable epilepsy
- Semiology: brief eye twitching
- Negative MRIs
- Interictal scalp EEG max F4
- Ictal scalp EEG- gen max F4

Ictal SPECT



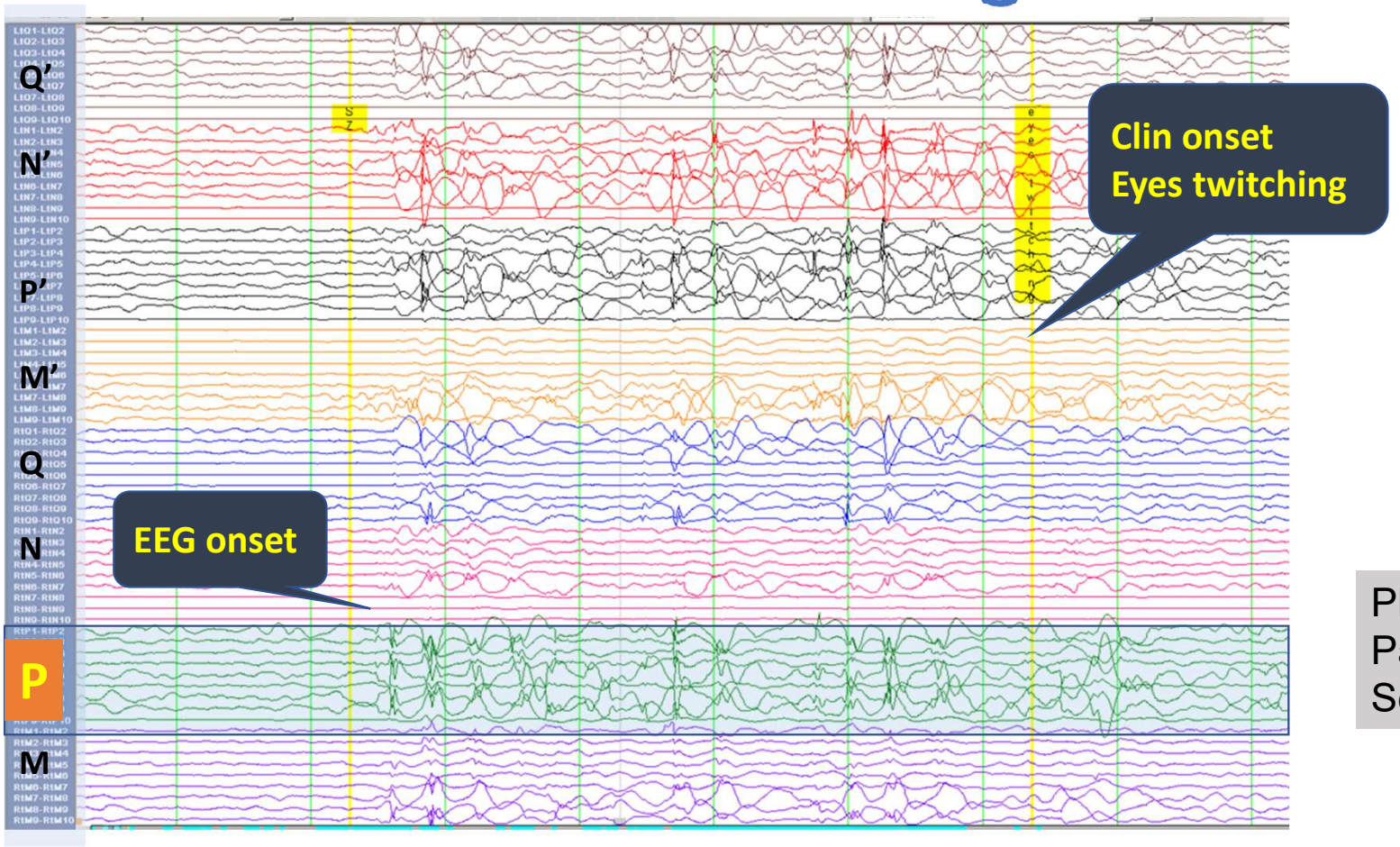
Increase perfusion at L frontoparietal, R parietal region (injection time 7 sec)



Catani 2002

Fronto-parietal network

Ictal SEEG finding

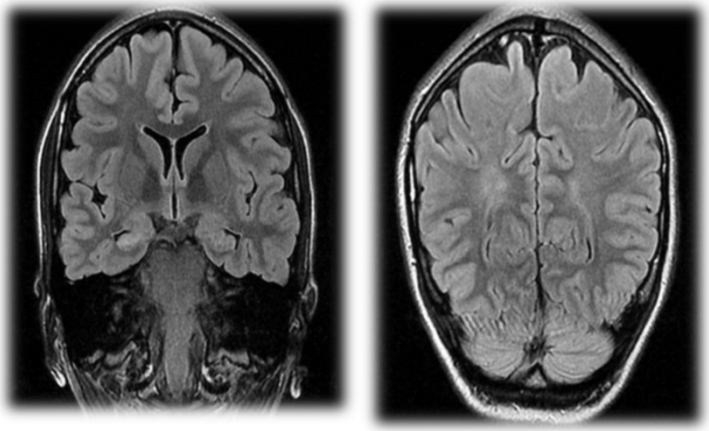


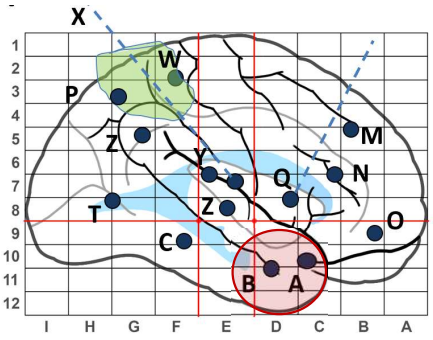
R parietal cortex

Plan: R parietal resection
Patho: FCD type IIa
Seizure outcome: Engel II

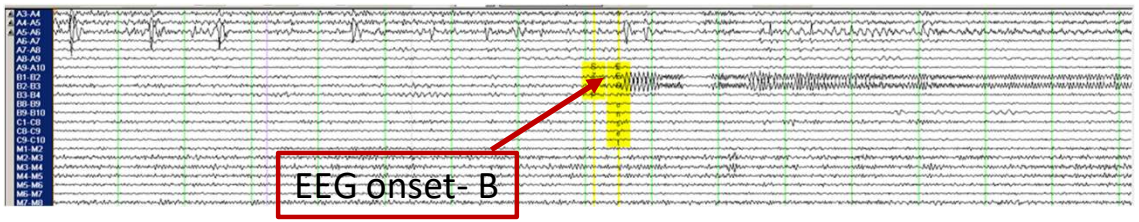
Knowing epileptic network helps

- A 15 years old female with intractable epilepsy
- EEG: 2 Ictal onset: F8T4, T4P4
- MRI brain: 2 lesions
  (R hippocampal sclerosis,
  ulegyria of R precuneus)
- Ictal SPECT:Increased perfusion at right frontal cortex (Injection time 10 s)





Plan: SEEG exploration



Seizure outcome: Engel I

Semiology sequence of insular epilepsy

Epilepsia, **45**(9):1079–1090, 2004
Blackwell Publishing, Inc.

Clinical Manifestations of Insular Lobe Seizures: A Stereo-electroencephalographic Study

*Jean Isnard, †Marc Guénot, †Marc Sindou, and *François Mauguière

*Functional Neurology and Epileptology Department and †Functional Neurosurgery Department, Neurological Hospital, Lyon, France

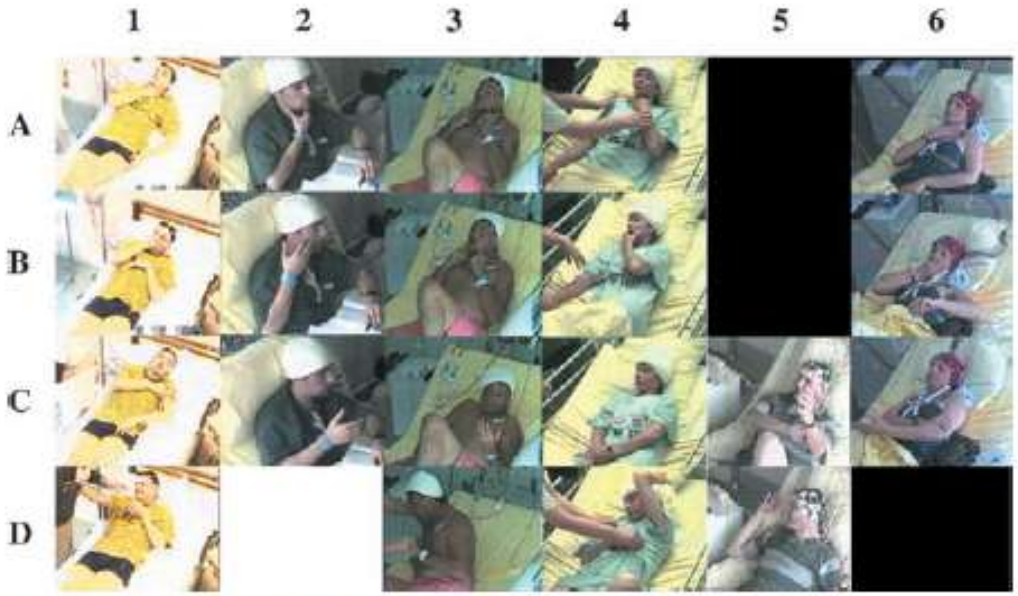


FIG. 2. Video sequence of ictal symptoms in the six patients with insular seizures. Black areas (5A, 5B, and 6D) correspond to missing symptoms in the sequence. All illustrated seizures are simple partial seizures with complete preservation of contact during phases A, B, and C of the sequence. A brief loss of contact occurred in phase D for patients 4 and 5, in association with intense somatomotor convulsive symptoms. **A:** Laryngeal constriction (five patients). **B:** Paresthesiae in the perioral region (five patients). **C:** Lateralized somatosensory symptoms in upper limb (six patients). **D:** Focal somatomotor symptoms (five patients; for patient 2, the white area 2D means that somatomotor symptoms did not occur during the three video-stereo-electroencephalographic recorded seizures, whereas most of spontaneous seizures in patient's history ended with this type of symptom).

A. Laryngeal constriction

B. Paresthesia in the perioral region

C.Lateralized somatosensory symptoms in upper limb

D.Focal somatomotor symptoms

Semiology and Epileptic Networks

Aileen McGonigal, MD, PhD[a,b]

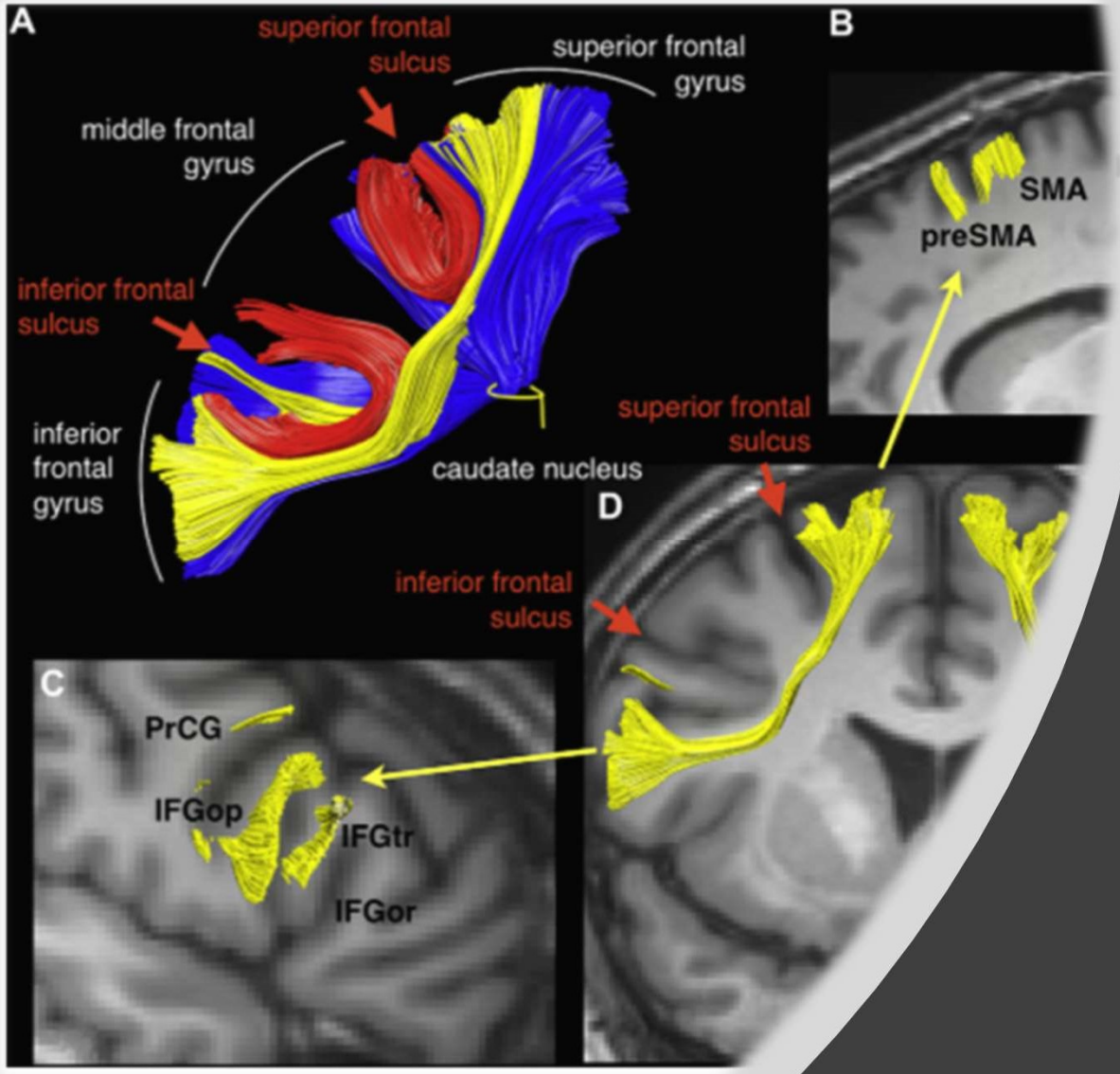
Table 2
Examples of studies examining semiology in conjunction with signal analysis of stereoelectroencephalography

Investigators, Year	Semiological Pattern	Epilepsy Localization	Main Anatomic Structures	Signal Analysis	Change in Network Synchrony
Bartolomei et al,[51] 2002	Humming	Temporal lobe	STG, prefrontal cortex	Rhythmic discharge over STG (6 or 15 Hz). Increased coherence between STG and prefrontal cortex	Increased
Bartolomei et al,[52] 2005	Fear behavior	Prefrontal cortex	Ventromesial orbitofrontal cortex, anterior cingulate, amygdala (limbic system)	Sudden loss of synchrony between orbitofrontal cortex and amygdala at seizure onset/clinical onset	Decreased
Arthuis et al,[53] 2009	Impaired consciousness	Temporal lobe	Temporal structures, parietal lobe, thalamus	Excessive synchrony; ie, functional coupling, between temporal and extratemporal structures, notably parietal cortex and thalamus	Increased
Bartolomei et al,[54] 2012	Déjà vu	Mesial temporal lobe	Rhinal cortices, hippocampus	Increased high-frequency EEG signal correlation between mesial temporal structures in seizures producing déjà vu	Increased
Lambert et al,[55] 2012	Impaired consciousness	Parietal lobe	Superior and inferior parietal lobules, precuneus, parietal operculum, supplementary motor area	Increased synchrony was associated with progressively greater degrees of altered responsiveness. A statistically significant nonlinear relationship was found between h2 values and degree of alteration of consciousness, suggesting a threshold effect	Increased
Aupy et al,[56] 2018	Oroalimentary automatisms	Temporal lobe	Medial basal temporal lobe, opercular cortex	Increased coherence occurred between mediobasal temporal structures and insulo-opercular cortex before onset of rhythmic chewing movements	Increased

Neurosurg Clin N Am 31 (2020) 373–385

Take home points regarding semiology

- Analyze semiology in order is important- *early signs more reliable*
- Record sufficient number of seizures
- Look for consistency between seizures
- Identifying features in common is the key to categorization
- Think of *epileptic networks* could be involved according to electroclinical correlation!



Thank you for your attention