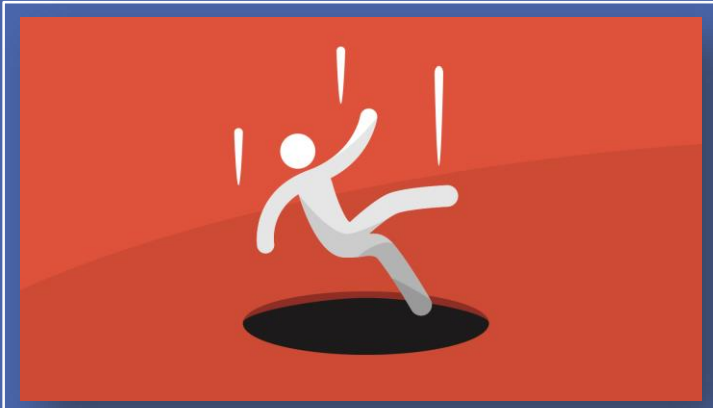


UNUSUAL EEG PATTERNS AND COMMON PITFALLS IN EEG INTERPRETATION

Chusak Limotai, MD.

Chulalongkorn Comprehensive Epilepsy Center of Excellence

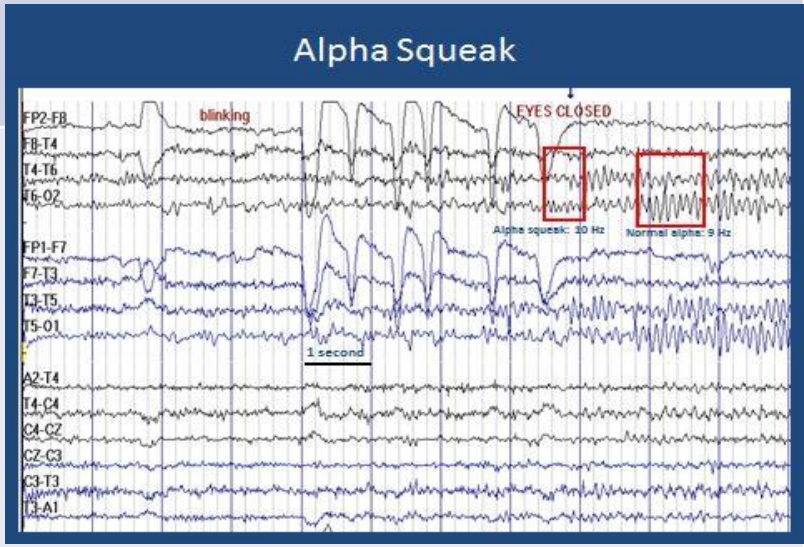
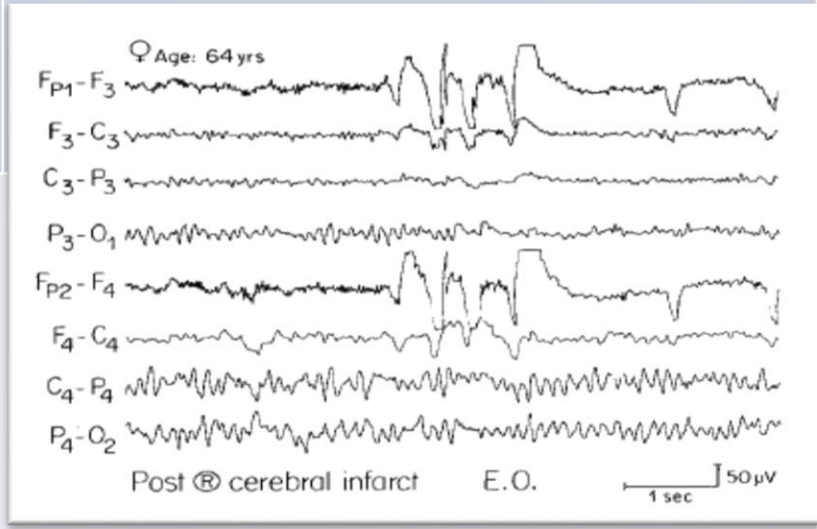
Talk overview

1. Unusual EEG patterns

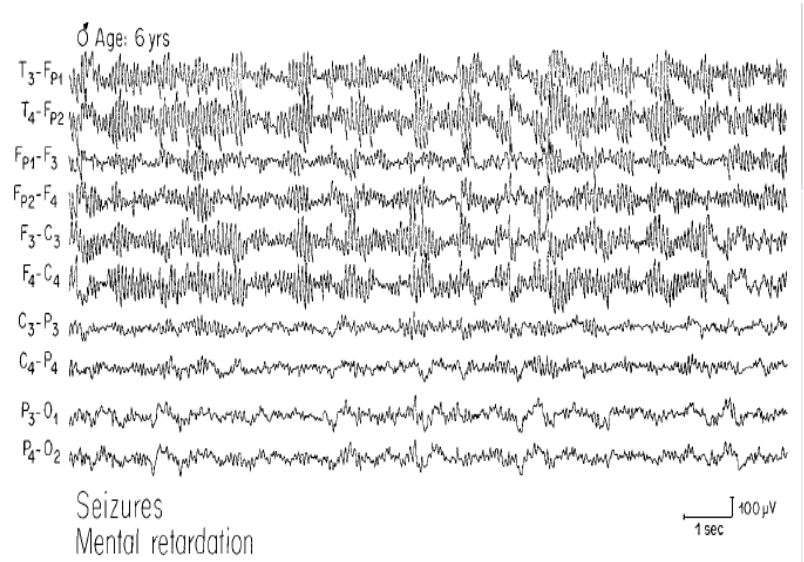
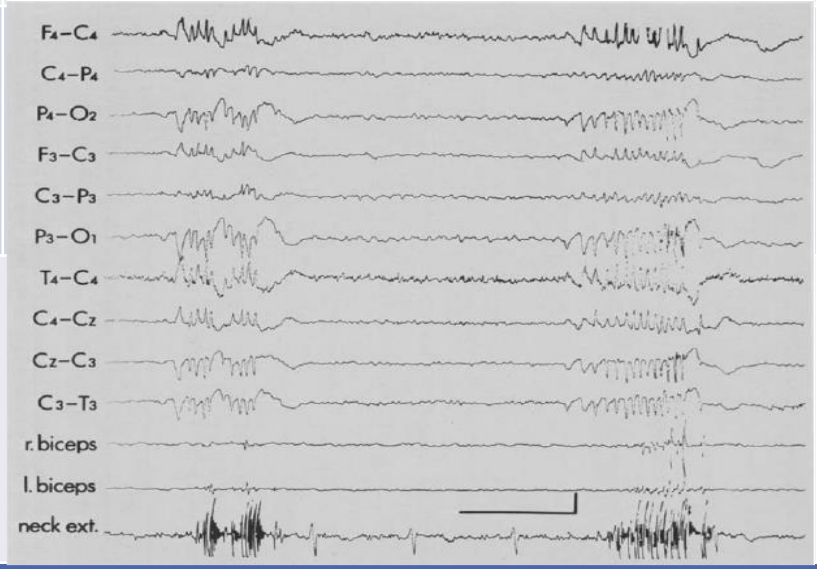
2. Common pitfalls in EEG interpretation

1. UNUSUAL EEG PATTERNS

Alpha frequency

EEG patterns	Frequency (Hz)	Amplitude (μV)	Distribution	Pictures
Alpha squeak	Alpha-beta	low	Posterior head	
Significance: - occurs in normal subjects - No known clinical significance				
Bancaud phenomenon	Alpha	N/A	Posterior head	
Significance: lesions that involve the parietal, temporal, and occipital regions				

Beta/spindle frequency

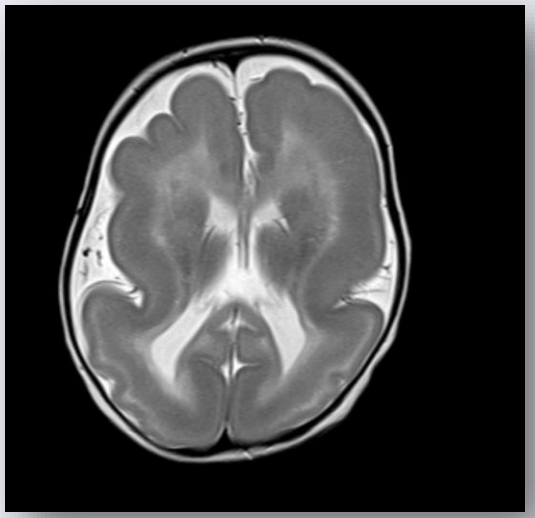
EEG patterns	Frequency (Hz)	Amplitude (μV)	Distribution	Pictures
Extreme spindles	Spindle-beta (6-18 Hz)	Low to high, waxing and waning	Generalized, maximum frontocentral	
Significance: - Drug effect (barbiturates, benzodiazepines) - children with mental retardation (common in children < 5 yrs, may be seen in adults)				
Pathologic central fast activity	Beta (20-40 Hz) Some reports 10-20 Hz	20-50 μV	Rolandic and central vertex regions	
Significance: seen in cherry-red-spot myoclonus syndrome (Sialidosis type I)				

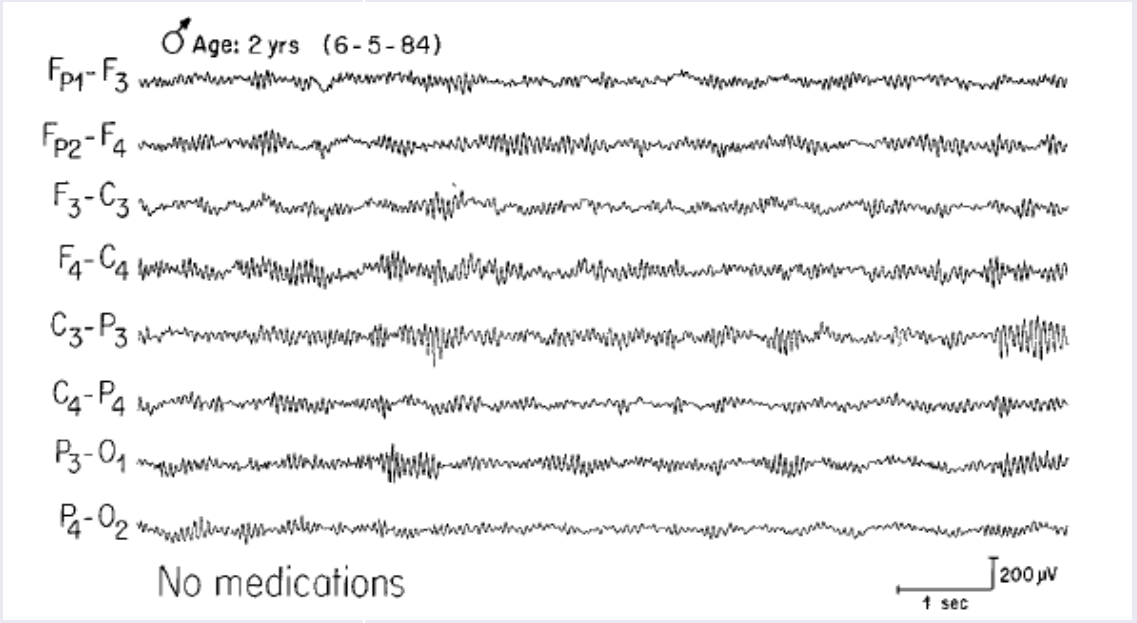
** increased by movements of contralateral limbs

Beta/spindle frequency

EEG patterns	Frequency (Hz)	Amplitude (μV)	Distribution	Pictures
Pathologic diffuse fast activity	Beta	can attain amplitude up to 350-400 μV	Generalized	

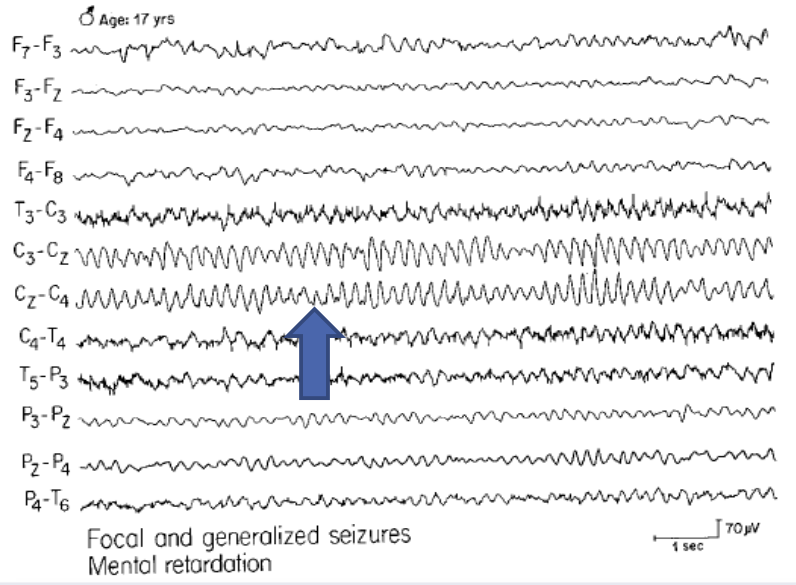
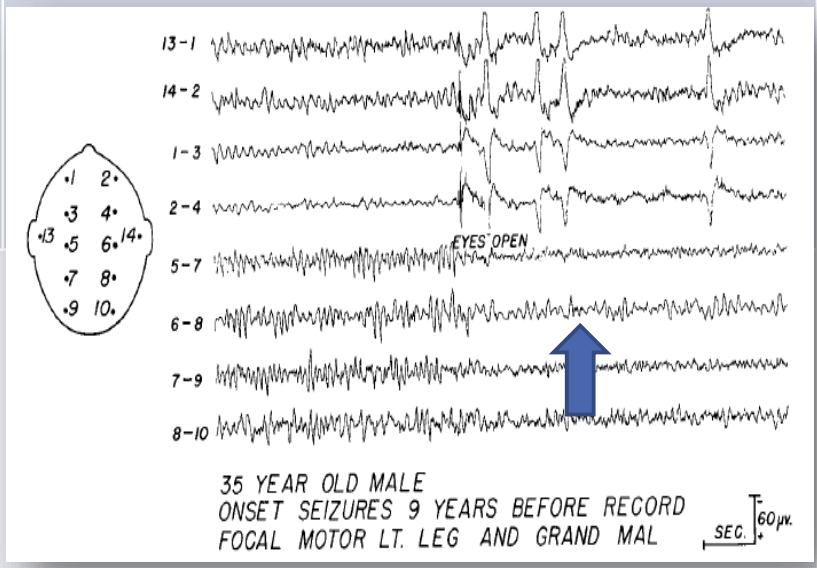
Significance: seen in some infants with lissencephaly



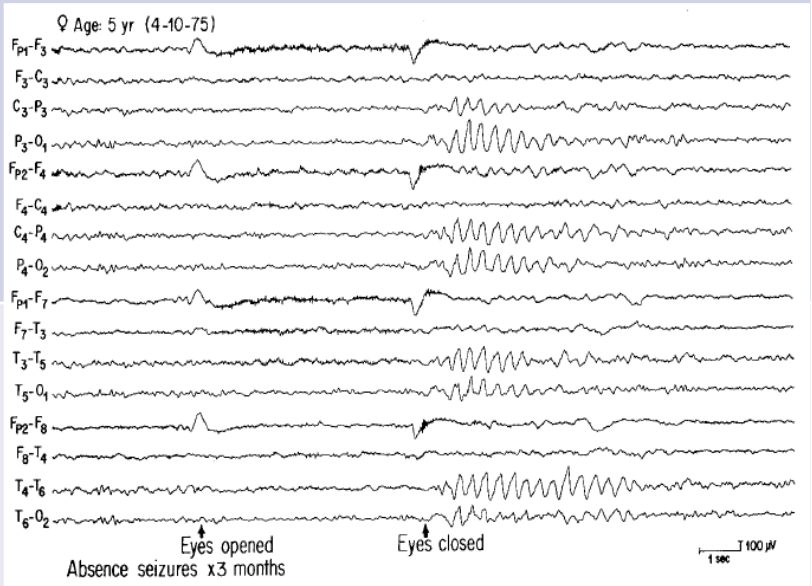


** - paroxysmal appearance, abrupt increase or decrease in amplitude
- little reactivity to various activating procedures
- little change during sleep, sleep features are not apparent

Theta frequency

EEG patterns	Frequency (Hz)	Amplitude (μV)	Distribution	Pictures
Midline theta activity (Frontal-central midline theta rhythm of Ciganek)	Theta (5-7 Hz)	medium, waxing and waning	Central vertex or midline frontal	
Significance: - nonspecific phenomenon that can occurs in a mixed group of patients ** sinusoidal, arciform, spiky, or mu-like appearance				
Focal parietal theta rhythm	Theta (mostly 7 Hz)	medium	Parietal	
Significance: abnormalities in the parietal lobe ** does not react to eye opening and alerting procedures				

Delta frequency

EEG patterns	Frequency (Hz)	Amplitude (μV)	Distribution	Pictures
Posterior rhythmic slow-wave activity with eye closure (Phi rhythm)	Delta (2-4 Hz)	medium, lasting 1-3 s	Posterior head, within 2 seconds after eye closure, at least 2 occasions	

Significance: - nonspecific disturbance of function (reported in pts with absence seizures, Sydenham's chorea, posterior fossa tumors, migraine head tumor, Tourette's syndrome)

** usually occurs in children and young adults

Posterior rhythmic delta activity (spontaneous) (OIRDA)	Delta (3 Hz)	Medium-high	Parietal	

Significance: occur in 11-60% of various patient groups with absence seizures

2. COMMON PITFALLS IN EEG INTERPRETATION

Diagnostic yield of routine EEG

Approximately 50% of first routine EEG in adults and children suspected of having a seizure disorder do not show epileptiform activities

Salinsky M et al; Epilepsia 1987
Shinnar S et al; Epilepsia 1994

Diagnostic yield of multiple routine EEGs

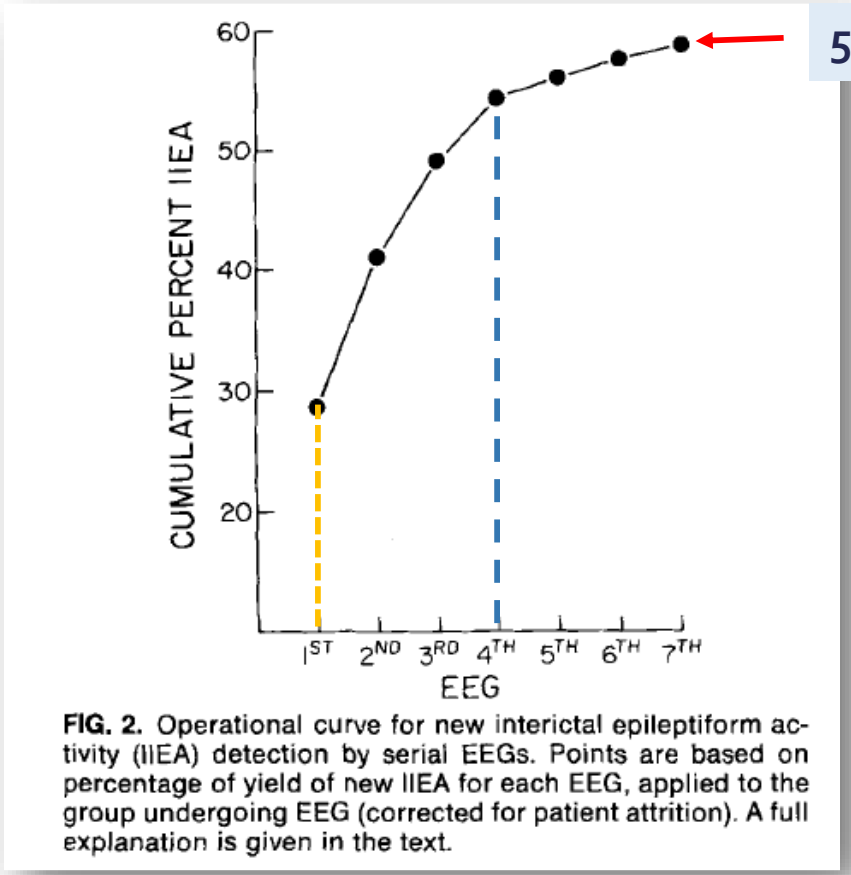


FIG. 2. Operational curve for new interictal epileptiform activity (IIEA) detection by serial EEGs. Points are based on percentage of yield of new IIEA for each EEG, applied to the group undergoing EEG (corrected for patient attrition). A full explanation is given in the text.

- 59% of the epileptic patients demonstrated IEDs by the seventh serial EEG
- 50% of these patients showed IEDs on the first record
  84% showed it by the third EEG
  92% showed it by the fourth EEG

Little yield can be expected beyond this point

Salinsky M et al; Epilepsia 1987

Diagnostic yield of multiple routine EEGs

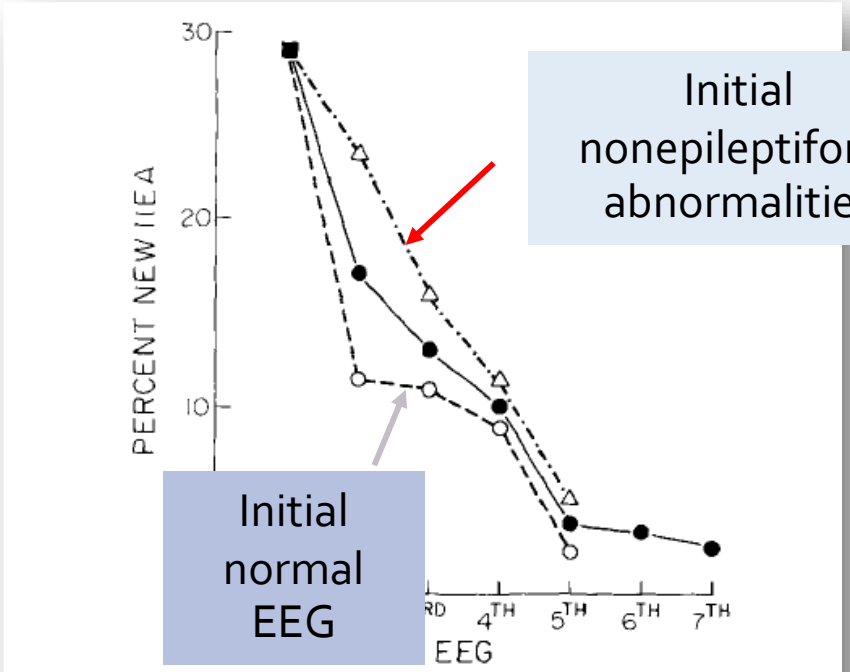


FIG. 1. Percentage of yield of new interictal epileptiform activity (IIEA) with serial EEG recordings. Data points represent number of patients with IIEA divided by number of patients undergoing EEG who had not previously shown IIEA. Percentage of IIEA on the first EEG (■); first EEG nonepileptiform (NS) (△); first EEG normal (NL) (○); and first EEG NL or NS (●).

Initial nonepileptiform abnormalities

Initial normal EEG

The presence of nonepileptiform abnormalities on the initial EEG predicts a relatively high percentage yield of new interictal epileptiform discharges on subsequent tracings, as compared with the initial EEG normal group

Salinsky M et al; Epilepsia 1987

Diagnostic yield of sleep EEG recording

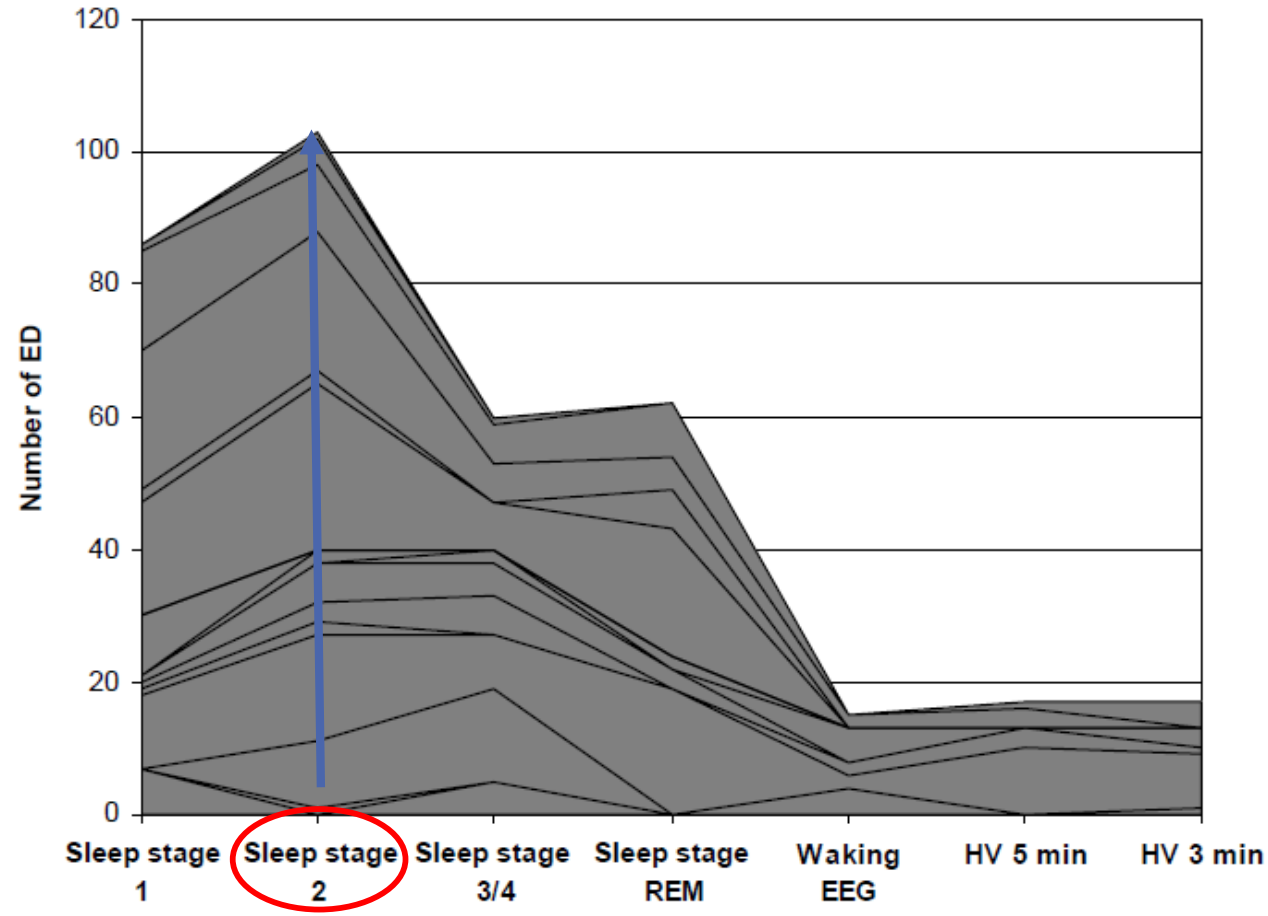


Fig. 1. Stapled visualization of the number of ED of all 20 patients during the different activation procedures.

In TLE patients

- All NREM sleep stages activate EDs
- Sleep stage 2 was associated with the strongest activation
- Sleep stage 2 shows a significantly higher sensitivity for ED than 5 min of hyperventilation

Klein KM et al; Epilepsy Res 2003

Diagnostic yield of sleep-deprived EEG

Table 1: Activation rate.

Method	CDE (patients with epilepsy)	ODS (patients with other disorders)
Sleep deprivation (general group 2)	45/199 (22.6%)	37/308 (12%)
Sleep deprivation with drowsiness (group 2A)	40/178 (22.5%)	36/285 (12.6%)
Sleep deprivation without drowsiness (group 2B)	5/21 (24%)	1/23 (4.3%)
Drug-induced sleep (group 3)	5/18 (27.7%)	2/18 (11%)
Repeated routine (group 1)	5/52 (9.6%)	2/91 (2.2%)

Activation rate of sleep deprivation (22.6%) was statistically different from the **9.6%** increased rate of abnormal patterns elicited by the simple repeating **second routine EEG**

No definite conclusion can be drawn about the relative contribution of lack of sleep (stressful effect) and sleep itself to the efficacy of sleep deprivation as an activating method of EEG

Roupakiotis SC et al; Seizure 2000

Gregory RP et al; Electroceph and Clin Neurophysiol 1993

Specificity of epileptiform discharges in healthy population

13,658 candidates for aircrew training aged 17-25 yrs

69 subjects (0.5%) showed unequivocal epileptiform discharges

- **21 had generalized or focal EDs at rest**
- **44 had EDs (PPR) only during intermittent photic stimulation (IPS)**
  - **(39 self-limited, 5 prolonged)**
- **4 had EDs both at rest and during IPS**
  - **1 with generalized polyspike and slow waves at rest and prolonged PPR subsequently developed epilepsy**
- **1 developed a generalized convulsion on IPS**
  - **(remained well on follow-up)**

If a healthy individual has a black-out, it is very likely to be epileptic if there are epileptiform discharge, even more significant if occurring at rest

38 subjects were traced successfully for 5-29 yrs

INCIDENCE AND PROGNOSTIC SIGNIFICANCE OF "EPILEPTIFORM" ACTIVITY IN THE EEG OF NON-EPILEPTIC SUBJECTS

BY

L. ZIVIN AND C. AJMONE MARSAN

(From the Branch of Electroencephalography and Clinical Neurophysiology, National Institute of Neurological Diseases and Blindness, National Institutes of Health, Bethesda, Maryland 20014)

- 6,497 nonepileptic patients referred for EEG exam for reasons other than investigation of a seizure disorder were included
- 142 **(2.2%)** pts had no clinical evidence of epilepsy before the date of EEG exam
- Aged 1 to 74 yrs (82 pts < 20 yo, 60 pts > 20 yo)
- 20 **(14.1%) pts developed seizures** (follow-up period: few months to 10 yrs)
- **Seizure propensity among pts < 20 yrs**, especially in pts with EDs associated with traumatic, vascular and post-operative states, the use of anti-neoplastic agents and/or steroids

Zivin L and Marsan A et al; Brain 1968

Pediatric neurobehavioral disorders

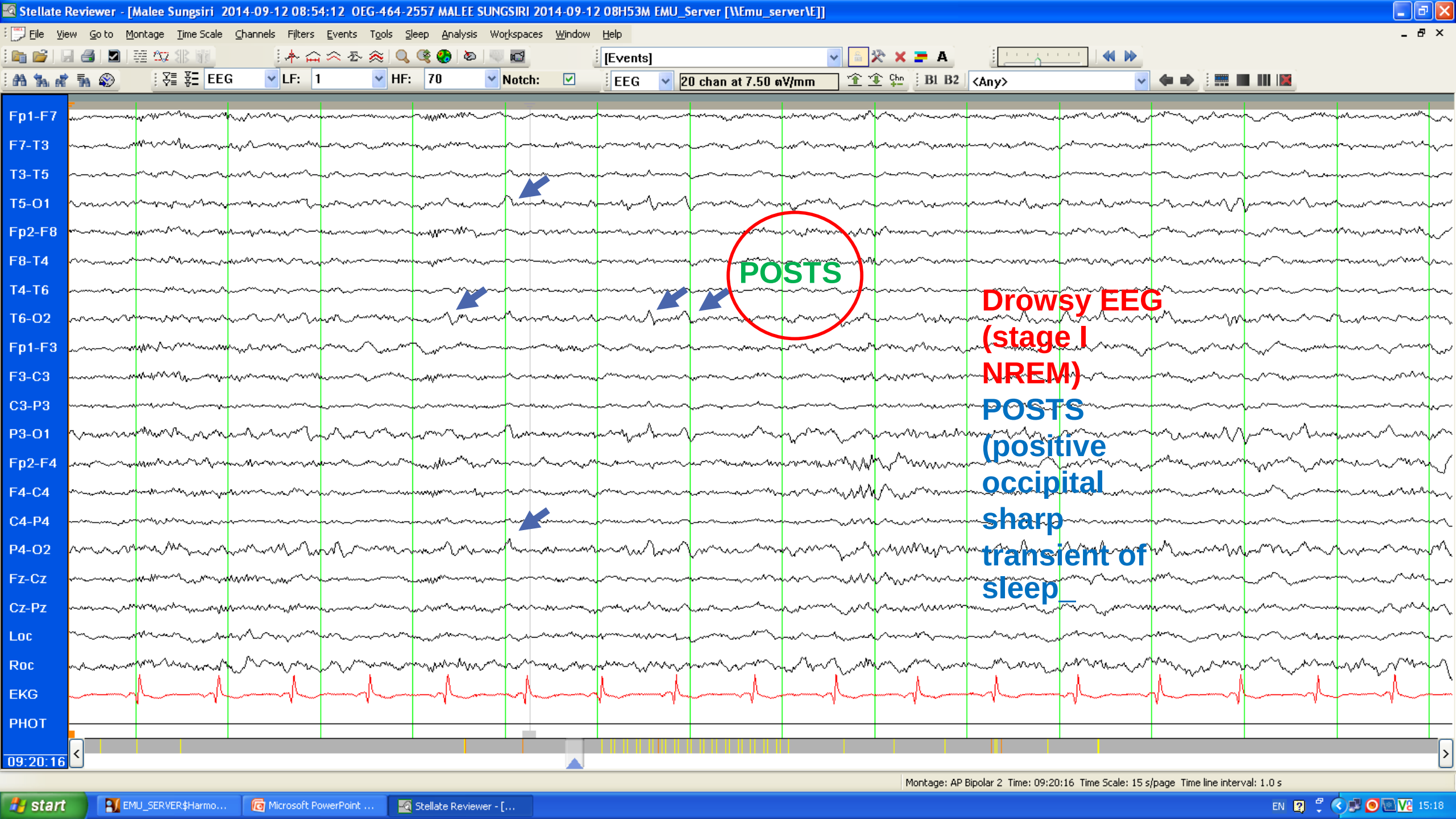
- **Increased prevalence (5.7-60.7%)** of **“subclinical epileptiform discharges (no overt clinical seizures)”** in autistic spectrum disorders and attention deficits disorders with or without hyperactivity (ADHD)

- represent ***age-dependent epiphenomenon of impaired brain maturation***, with cumulative effects of these EEG discharges contributing to ***cognitive abnormalities***

The lack of properly functioning corticocortical fibers which restricts the spread of epileptiform activity from one brain area to another and prevents its evolution to a clinical seizure

Shelley BP et al; J Neuropsychiatry Clin Neurosci 2008

Physiologic waves misinterpreted as epileptiform discharges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EEG 20 chan at 7.50 uV/mm
B1 B2 <Any>
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F7-T3
T3-T5
T5-O1
Fp2-F8
F8-T4
T4-T6
T6-O2
Fp1-F3
F3-C3
C3-P3
P3-O1
Fp2-F4
F4-C4
C4-P4
P4-O2
Fz-Cz
Cz-Pz
Loc
Roc
EKG
PHOT
09:20:16
POSTS
Drowsy EEG (stage I NREM)
POSTS (positive occipital sharp transient of sleep_
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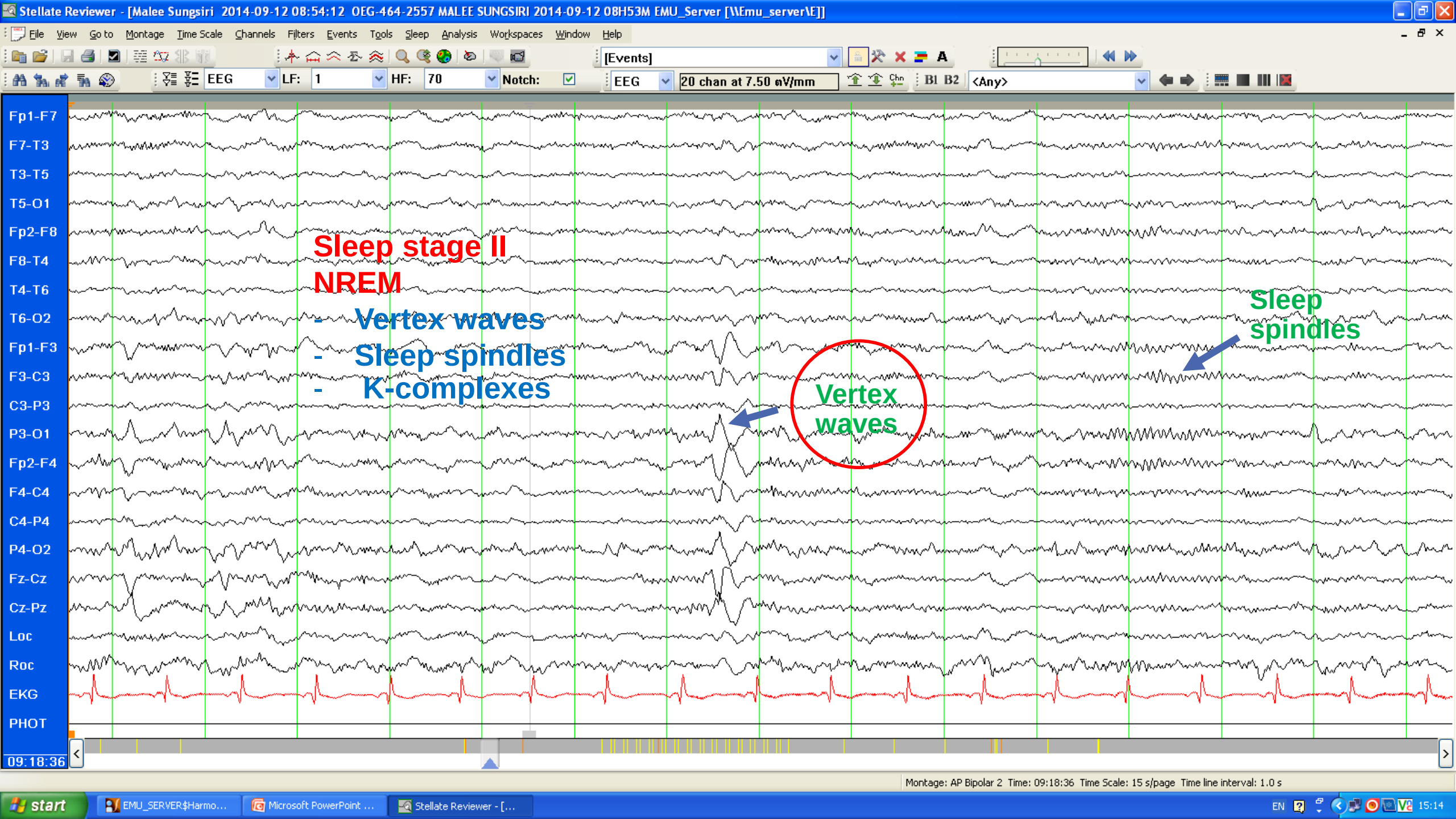
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Fp2-F8
F8-T4
T4-T6
T6-O2
Fp1-F3
F3-C3
C3-P3
P3-O1
Fp2-F4
F4-C4
C4-P4
P4-O2
Fz-Cz
Cz-Pz
Loc
Roc
EKG
PHOT
Sleep stage II
NREM
- Vertex waves
- Sleep spindles
- K-complexes
Vertex waves
Sleep spindles
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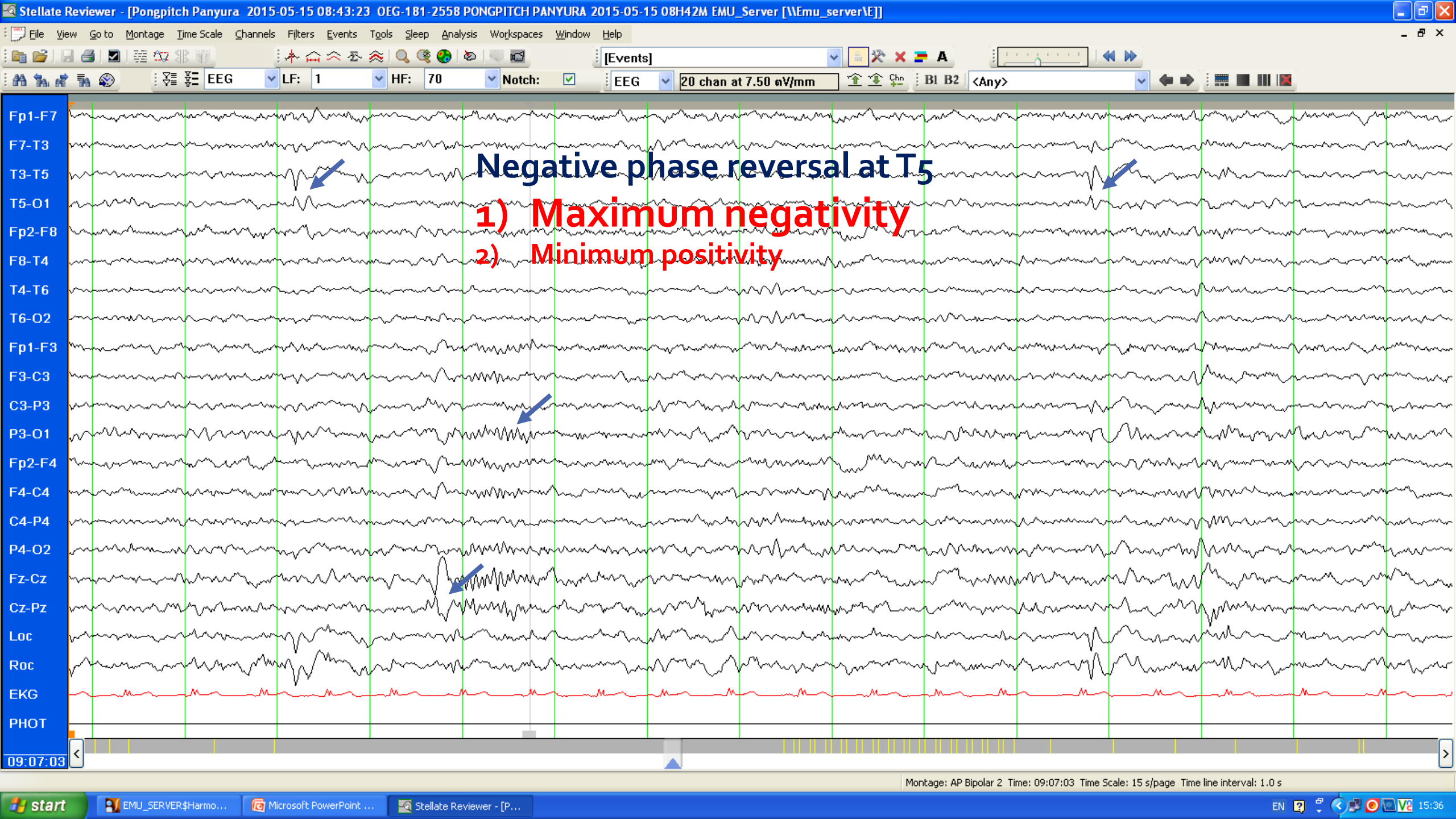
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[Events]
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EEG 20 chan at 7.50 uV/mm
B1 B2 <Any>
Fp1-F7
F7-T3
T3-T5
T5-O1
Fp2-F8
F8-T4
T4-T6
T6-O2
Fp1-F3
F3-C3
C3-P3
P3-O1
Fp2-F4
F4-C4
C4-P4
P4-O2
Fz-Cz
Cz-Pz
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Roc
EKG
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09:07:03
Negative phase reversal at T5
1) Maximum negativity
2) Minimum positivity
Montage: AP Bipolar 2 Time: 09:07:03 Time Scale: 15 s/page Time line interval: 1.0 s
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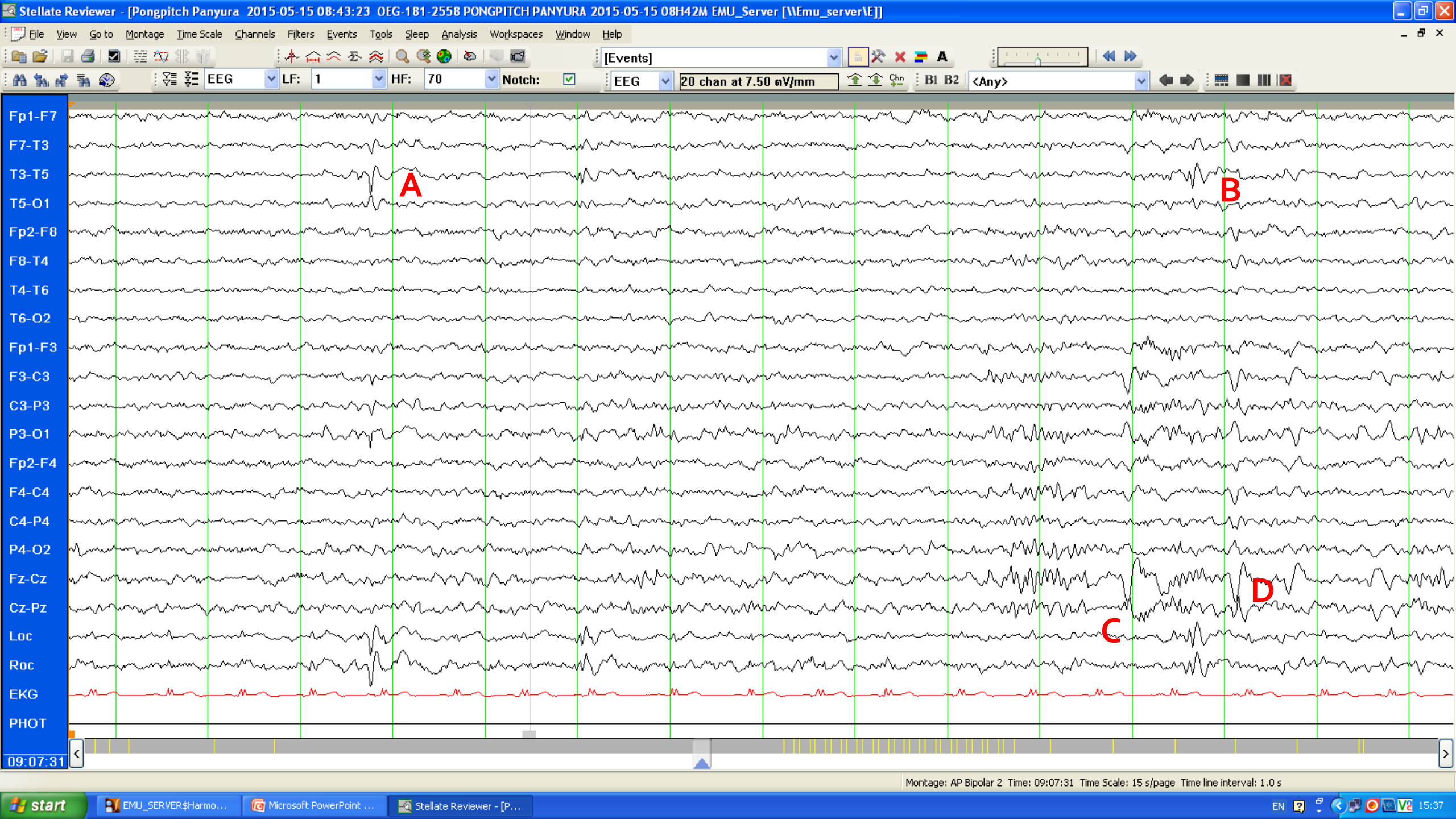
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EEG 20 chan at 7.50 uV/mm
B1 B2 <Any>
Fp1-F7
F7-T3
T3-T5
T5-O1
Fp2-F8
F8-T4
T4-T6
T6-O2
Fp1-F3
F3-C3
C3-P3
P3-O1
Fp2-F4
F4-C4
C4-P4
P4-O2
Fz-Cz
Cz-Pz
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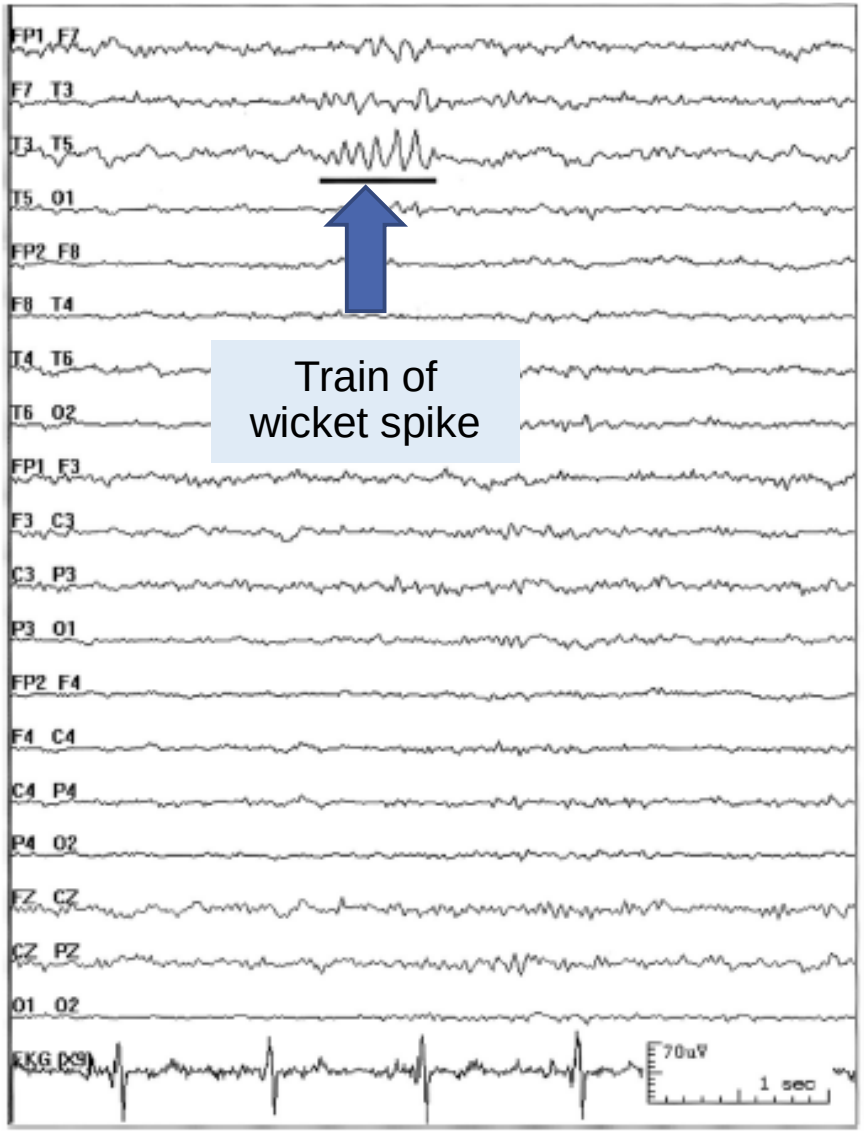
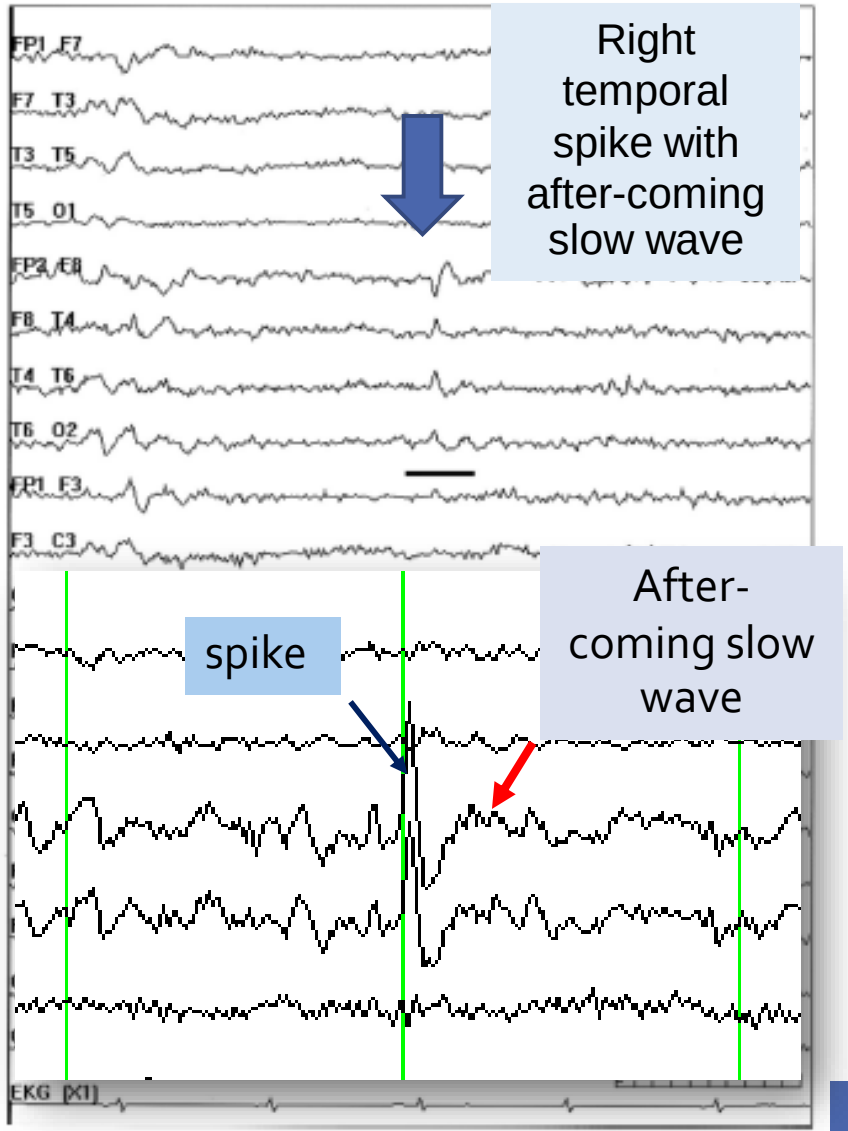
Benign variants misinterpreted as epileptiform discharges

Wicket spikes and right temporal IED





Wicket spikes

Train: 6-11 Hz

- Crescendo-decrescendo envelope
- Found bilaterally over both temporal regions, though not necessary on both sides at the same time

Single: no after-coming slow wave

****No epileptogenic potential****

Krauss GL et al; Neurology 2005

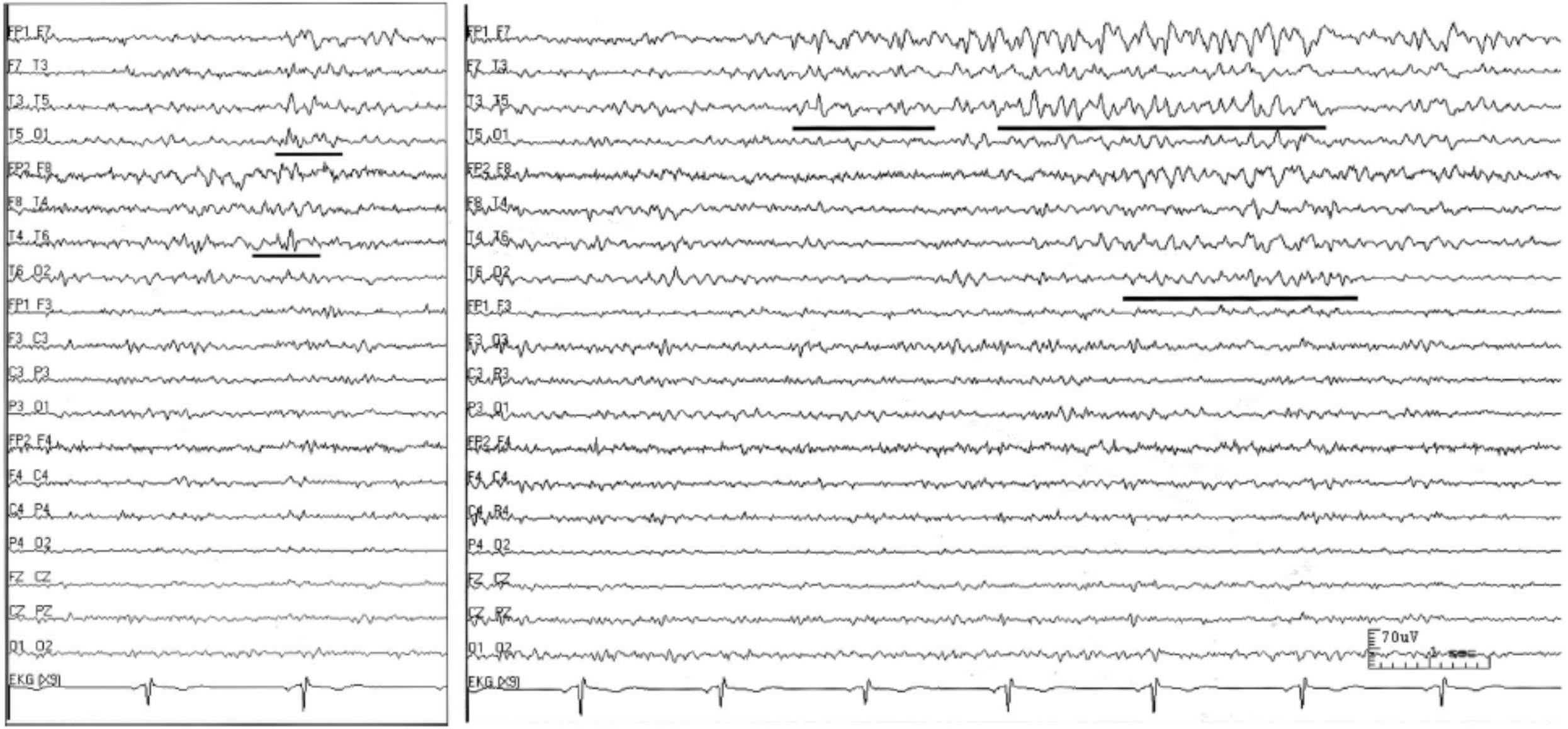
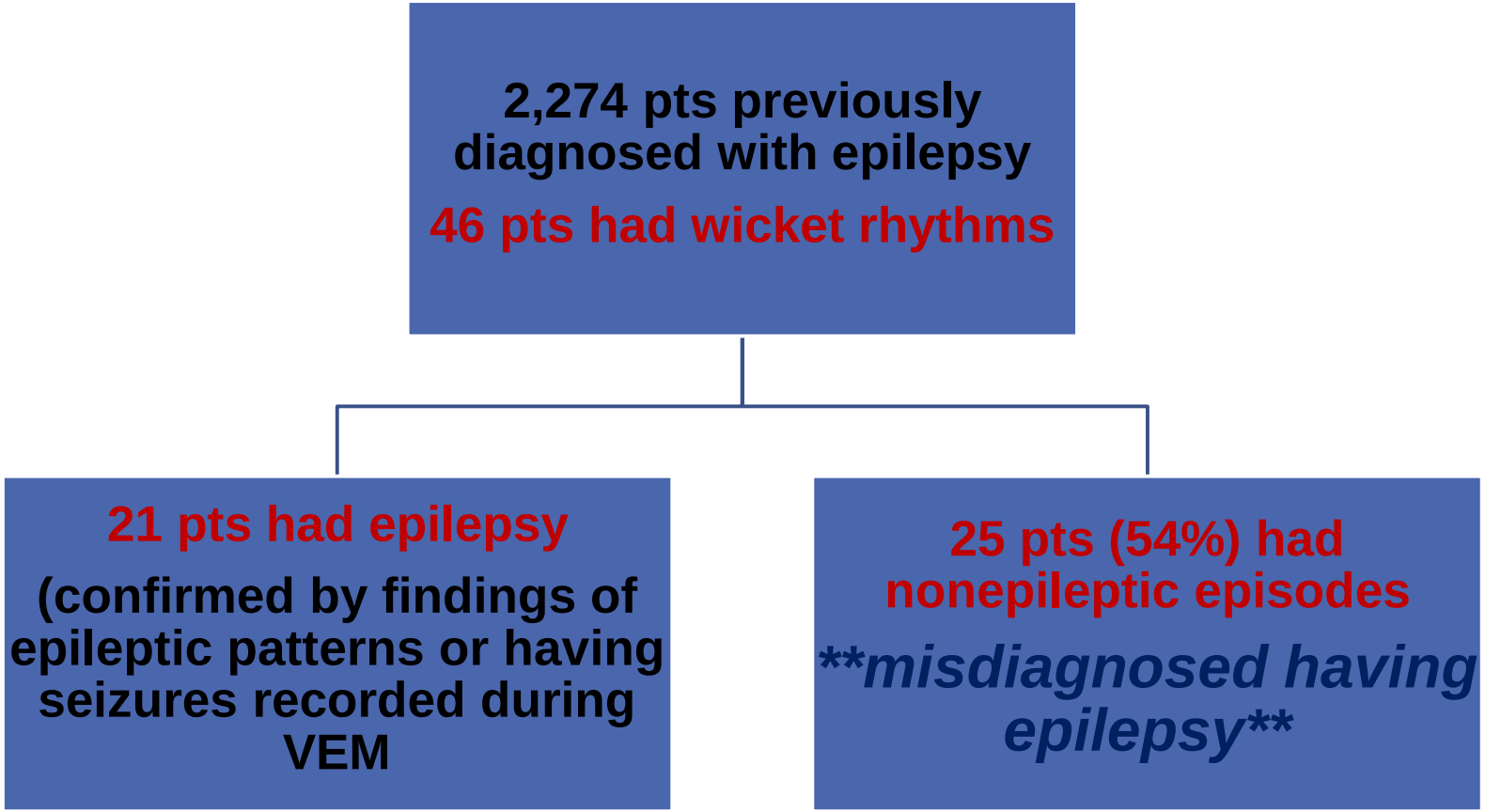


Figure 3. There is a brief burst of wicket activity in the left and right temporal leads (A). Six seconds later, there is more prolonged wicket activity (B), which is recorded maximally over the left temporal lobe. The more prolonged wicket activity helps distinguish the brief bursts of wicket activity from interictal spikes and sharp waves.

Krauss GL et al; Neurology 2005

Clinical and EEG features of patients with EEG wicket rhythms misdiagnosed with epilepsy

G.L. Krauss, MD; A. Abdallah, BA; R. Lesser, MD; R.E. Thompson, PhD; and E. Niedermeyer, MD

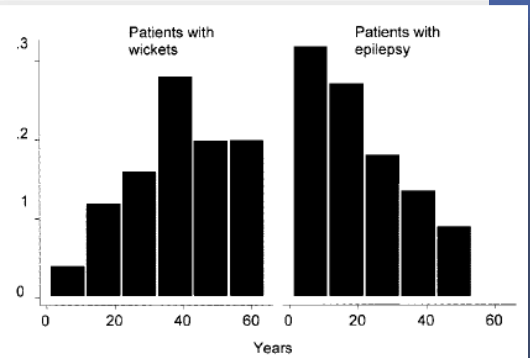


Krauss GL et al; Neurology 2005

Differentiation between wicket rhythms and epileptiform discharges

25 pts with wicket rhythms and nonepileptic episodes compared with age-and sex-matched 25 pts with partial-onset epilepsy

Characteristics	Wicket rhythms	Epileptiform discharges
Onset of clinical episodes	**Mid-life** (mean 38.4 yrs)	Late-teen and early adult years (mean 19.8 yrs)
Duration of clinical episodes	**Much longer** (mean 155.8 min, $p < 0.0001$)	Shorter (mean 2.4 min)
Burst duration	**Longer** (mean 0.66 s)	Shorter (mean 0.11 s)
Signs and symptoms during clinical episodes	**- Confusion** **- Oral automatisms**	- Sensory symptoms (paresthesia) - Fainting



gure 1. Distribution of age at onset of clinical episodes = 25 for each group).

- All patients with wicket activity also had long focal run of semirhythmic 6- to 11-Hz activity that contained wickets
- EEG waveform durations greater than 0.26 s indicated a wicket pattern with a corresponding 100% sensitivity and specificity

Krauss GL et al; Neurology 2005

Table Adapted from Maulsby's guidelines[5] for assessing spikes and sharp waves

1. Every spiky-looking wave is an artifact unless there are one or more good reasons for suspecting otherwise.
2. Spikes and sharp waves of cerebral origin always occupy a definable electrical field on the scalp and should always be seen in 2 or more nearby electrode sites.
3. Clinically significant spikes and sharp waves are almost always surface negative in polarity initially, or at least the sharpest or highest voltage component of the wave is usually surface negative.
4. Most spike or sharp wave discharges of clinical import are followed by a slow wave or series of slow deflections. If it does not have a slow after-wave, be more suspicious of artifact or of a sudden alteration in voltage of physiologic background rhythms.
5. Ignore sharp or spiky events that can be logically explained by simple alterations in voltage of the existing background rhythms or by superimposition of several components in the background activity of the record.
6. There are several types of physiologic spikes or sharp waves, particularly during sleep; these should be thoroughly familiar to the interpreter and can be discriminated from abnormalities by knowledge of the patient's age, state of consciousness, location on the scalp, and form or pattern of the wave in question.

Tatum WO; Neurology 2013
Maulsby RL; Am J EEG Technol 1971

THANK YOU FOR YOUR ATTENTION