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EEG Primer

Sándor Beniczky

Sensitivity & specificity: avoiding false positives & negatives

sbz@filadelfia.dk

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WARNING:

The false-positive EEG report (over-reading) is potentially more harmful to the patient than the false negative one (under-reading)!

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CAVEAT:

Not all that is ”sharp” or “slow” is abnormal!

- **ARTIFACTS**
  - Biological: muscle, heart, respiration, perspiration, tongue
  - Non-biological: electrode, movement, induction from nearby equipment

- **NORMAL VARIANTS**
  - Fourteen- and 6-Hz positive burst
  - Hypnagogic paroxysmal slow activity in children
  - Needle –like occipital spikes of the blind
  - Positive occipital sharp transient of sleep
  - Rhythmic temporal theta burst of drowsiness (RTTD)
  - Slow fused transient
  - Subclinical rhythmic EEG discharge of adults (SREDA)
  - Wicket spikes
  - Benign epileptiform transients of sleep (BETS)
  - Six Hz spike and slow wave

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Induction artifact

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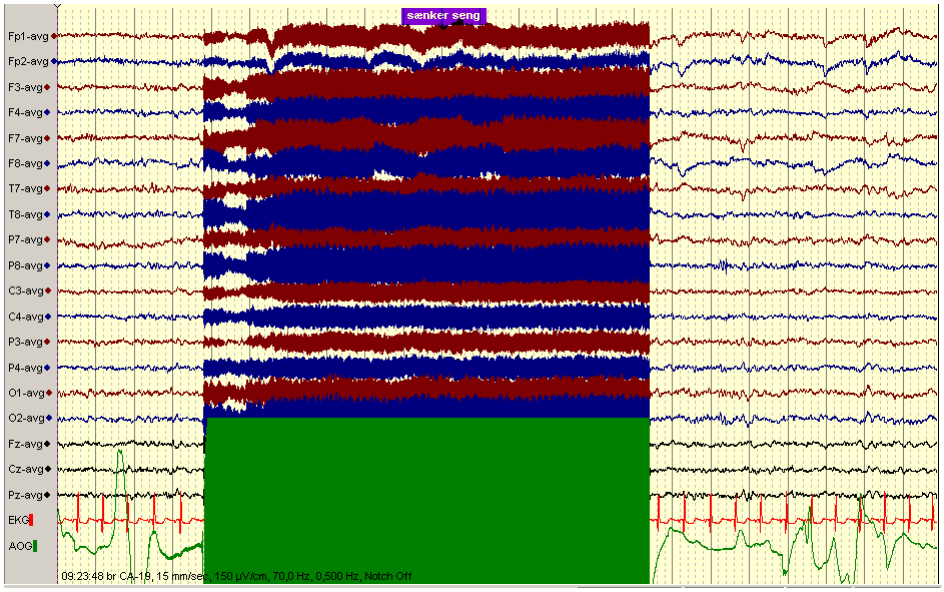

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Muscle artifact / IPS

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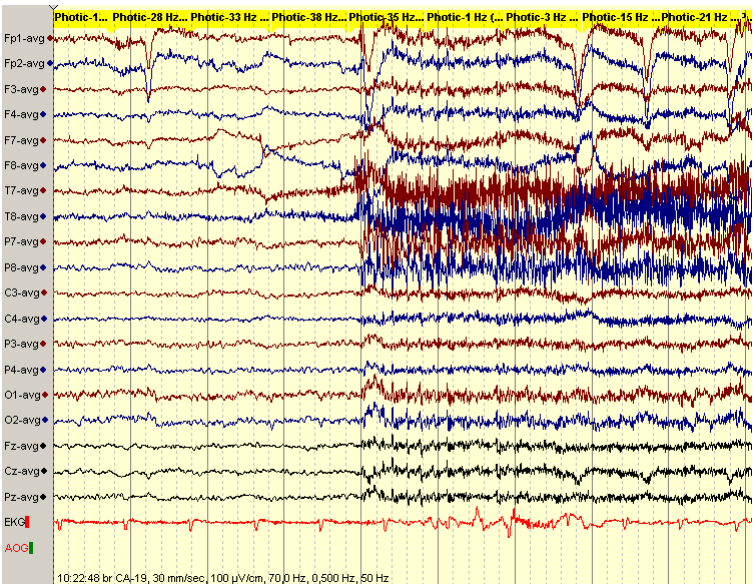

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BETS
ECG artifact

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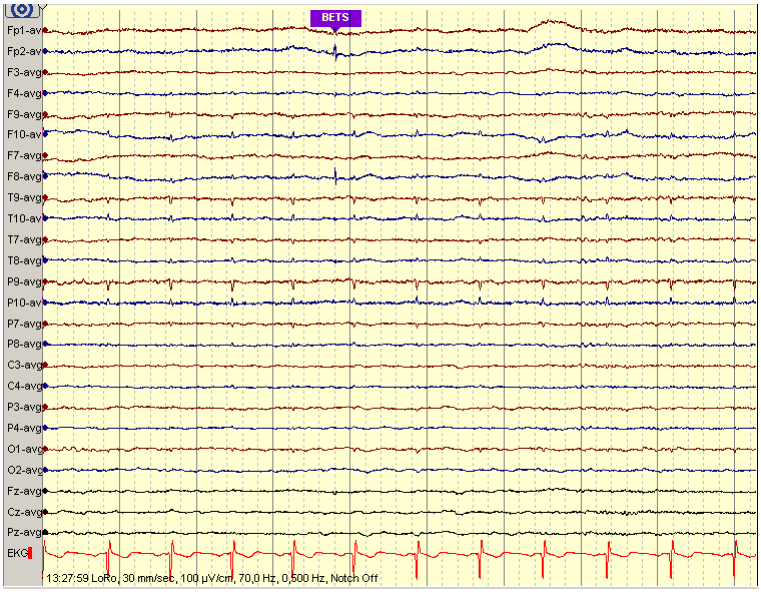

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14 Hz positive spikes

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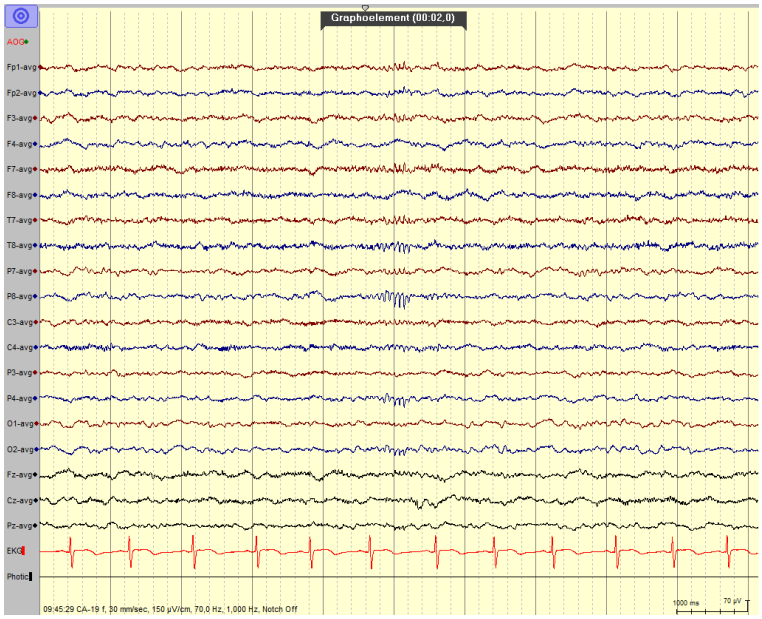

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14 Hz positive spikes

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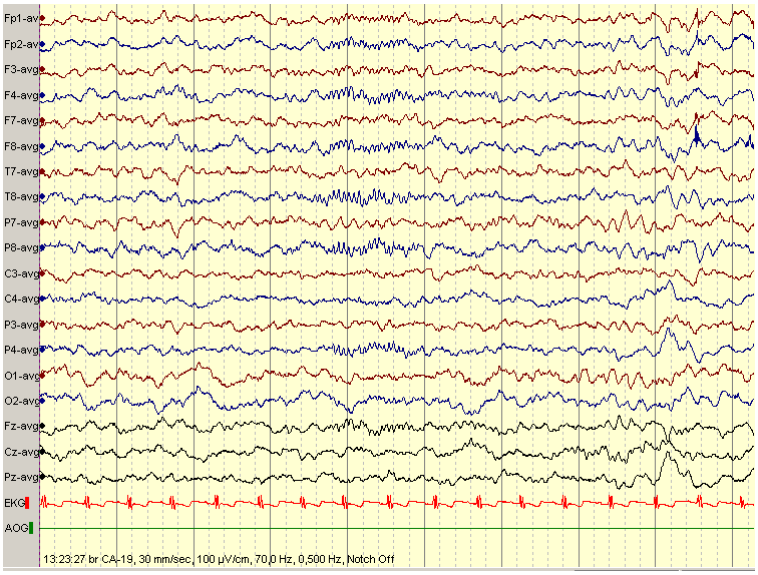

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Slow-fused transients

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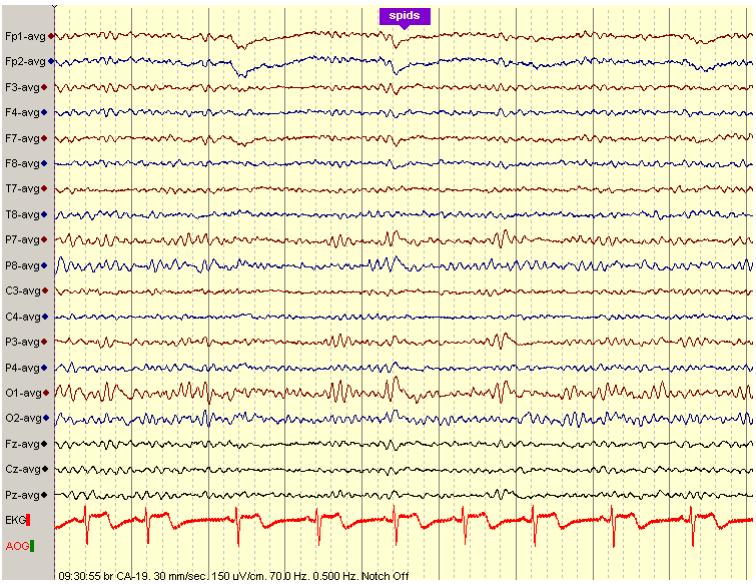

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Slow-fused transients

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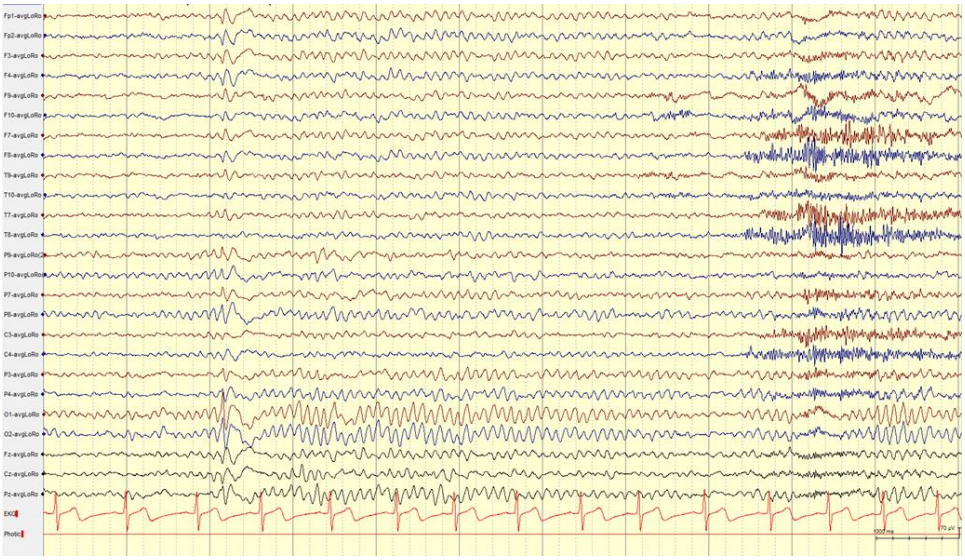

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Wicket spikes / rhythm

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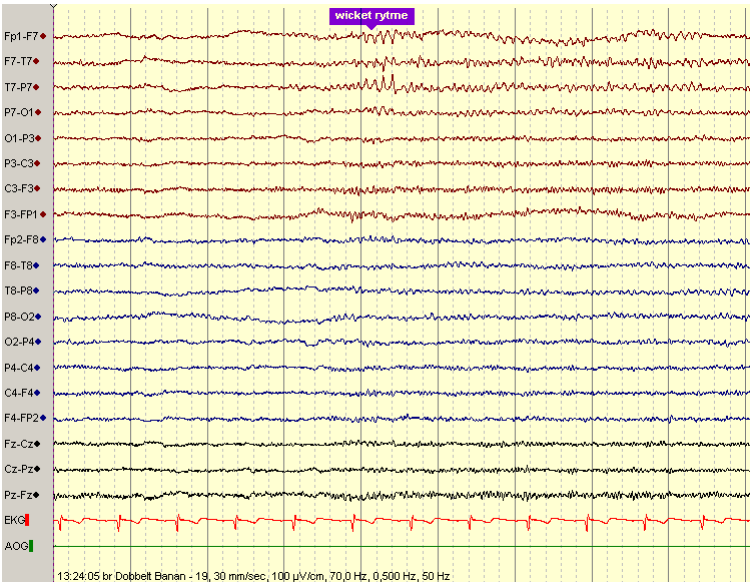

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Fluctuation of the bgr.

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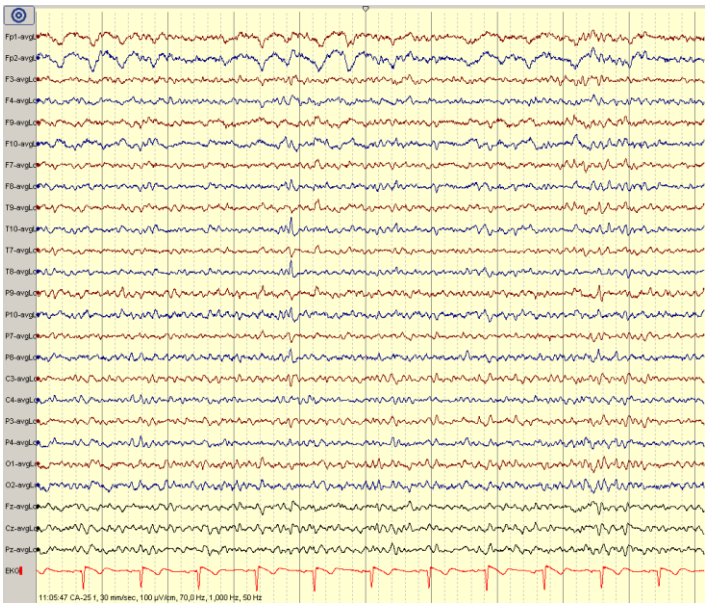

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RTTD

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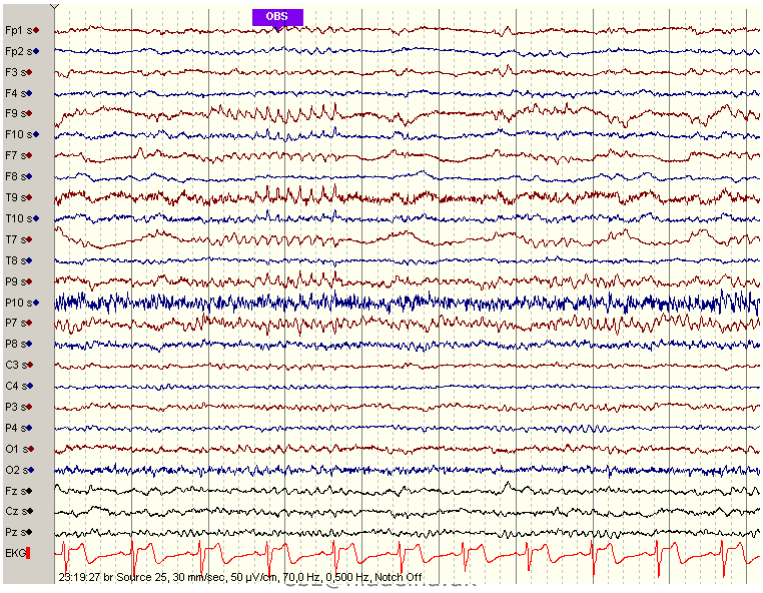

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Breach rhythm (C3,P3)

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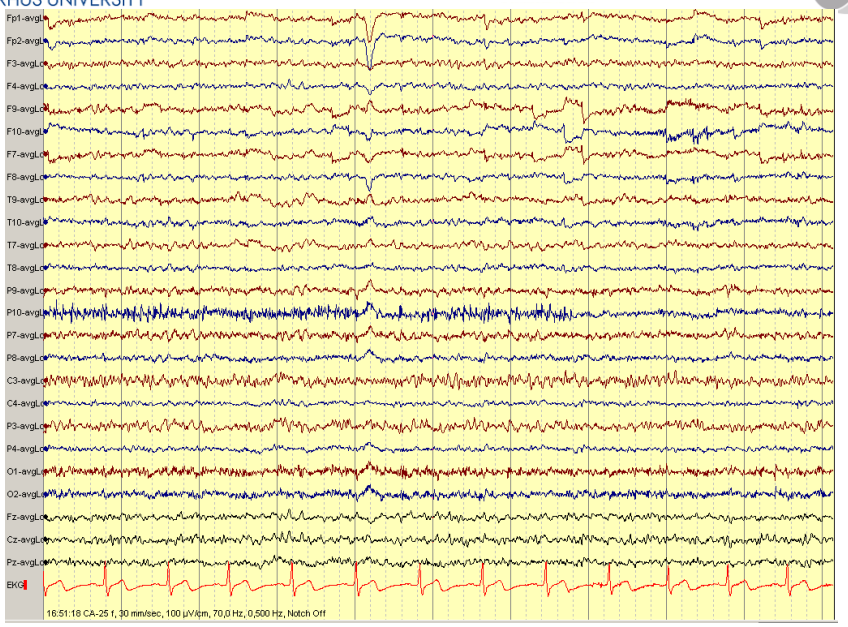

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Swallowing artifacts

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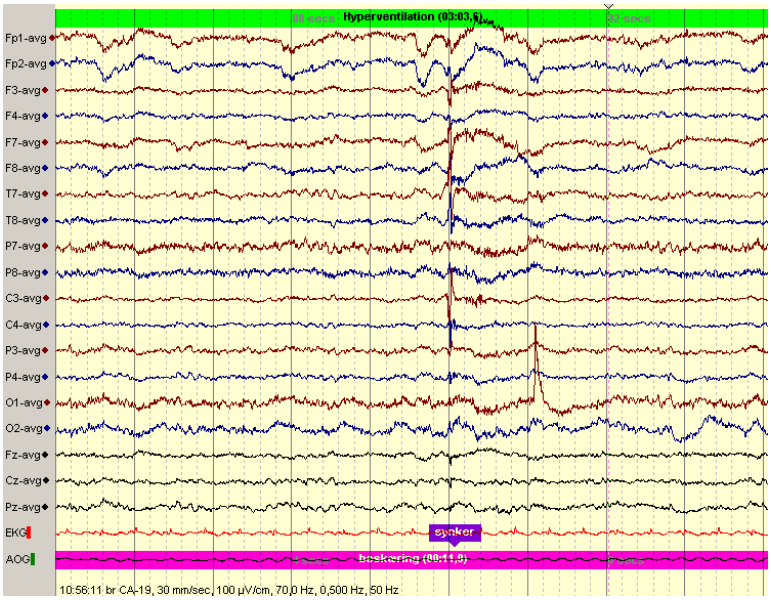

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6 Hz spike-and-slow-waves

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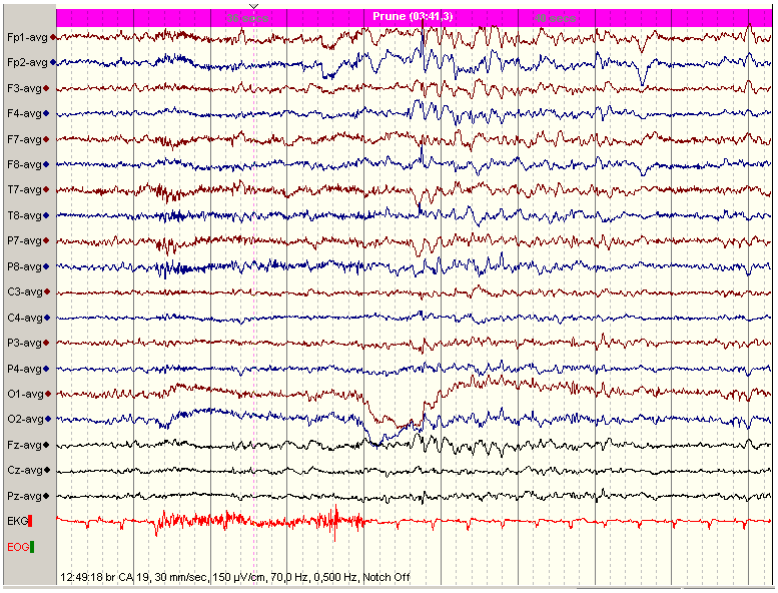

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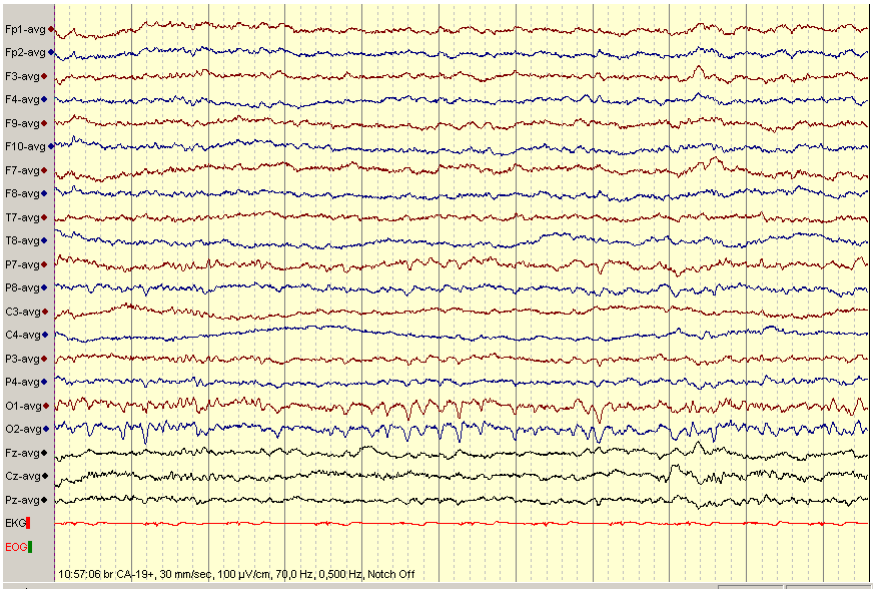
POSTS



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CAVEAT: not all that is "slow" is abnormal!

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Eye movement artifacts

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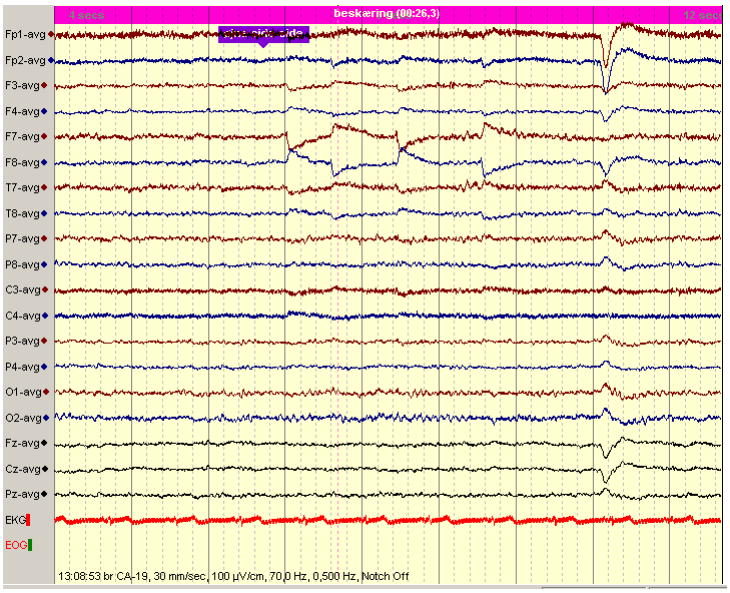

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Pulse artifact

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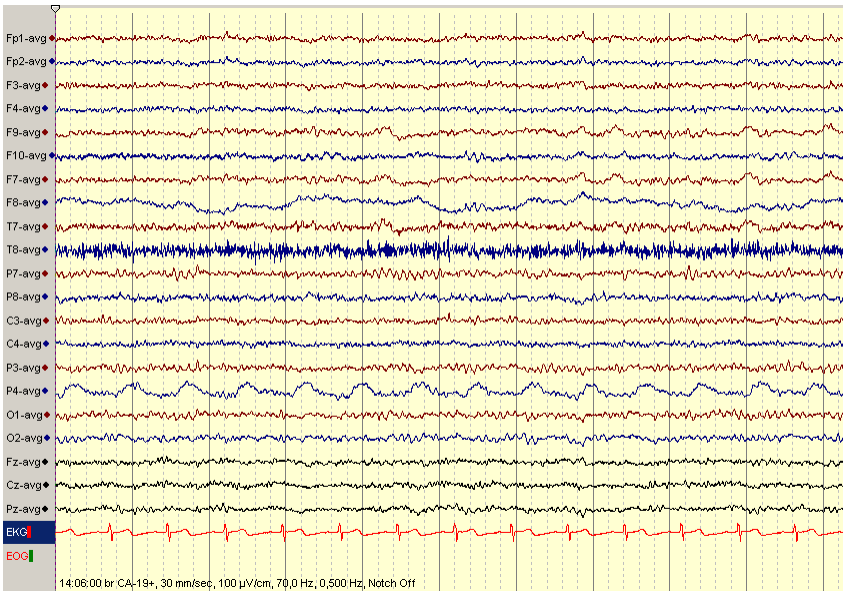

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Subharmonic alpha ("halpha")

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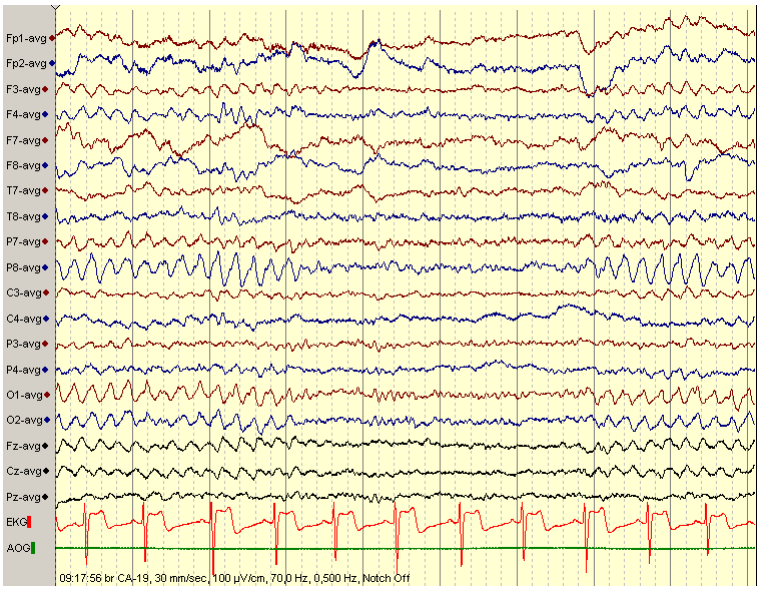

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Normal hyperventilation response

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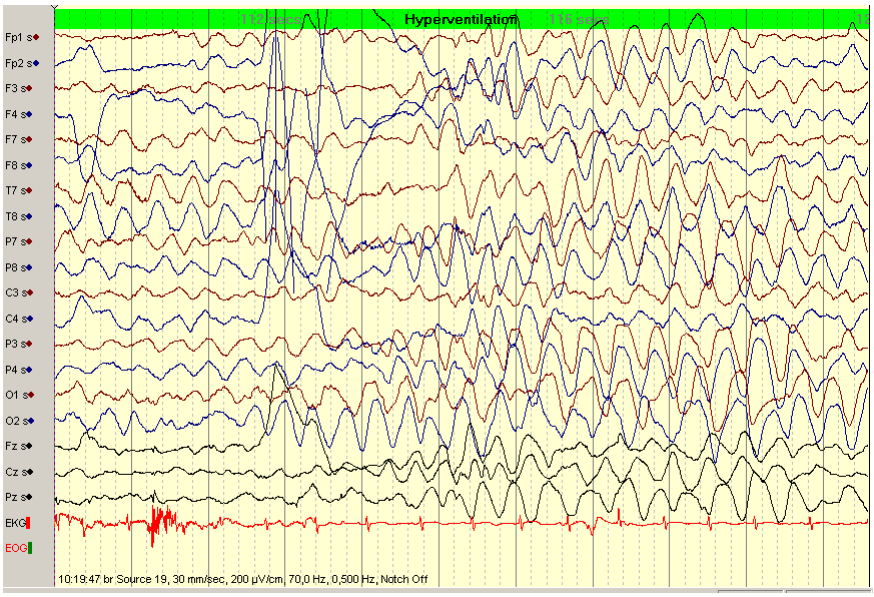

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Hypnagogic paroxysmal slow activity in children

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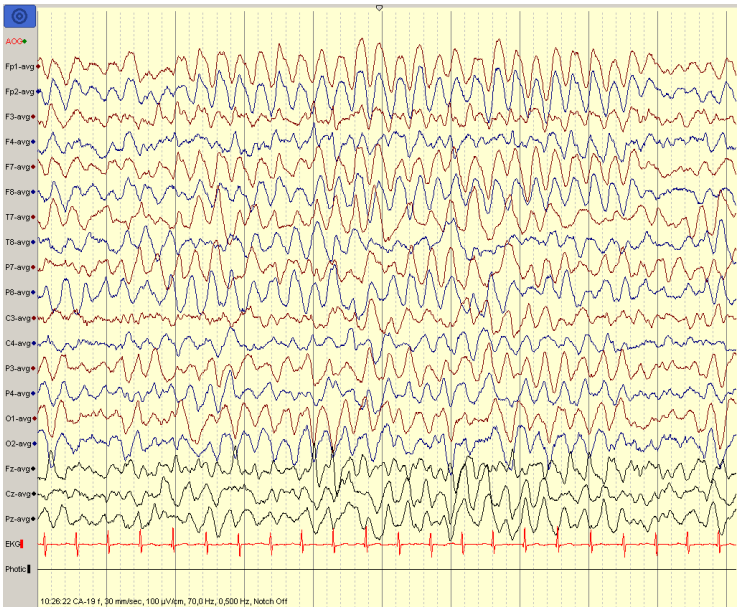

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Electrode / movement artifact

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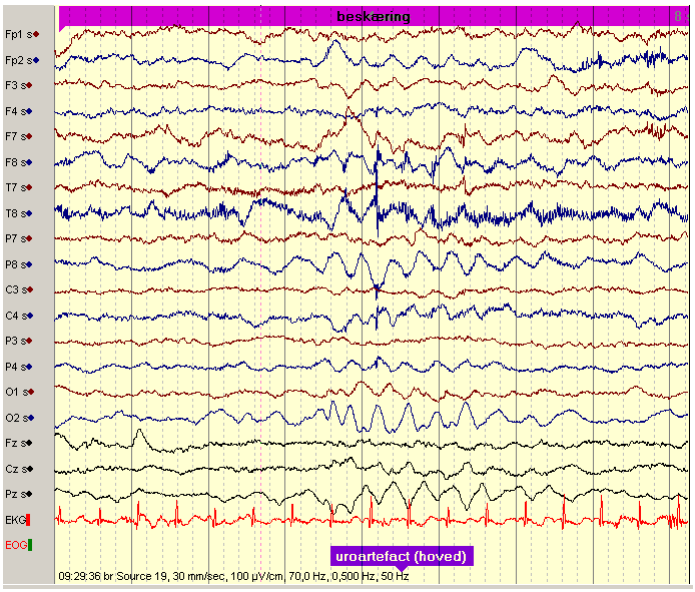

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Electrode / movement artifact during PNES

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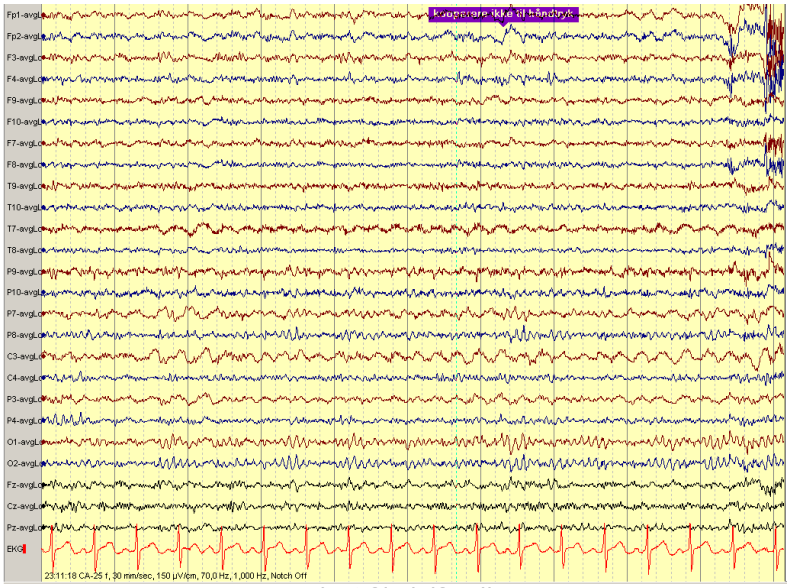

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SREDA

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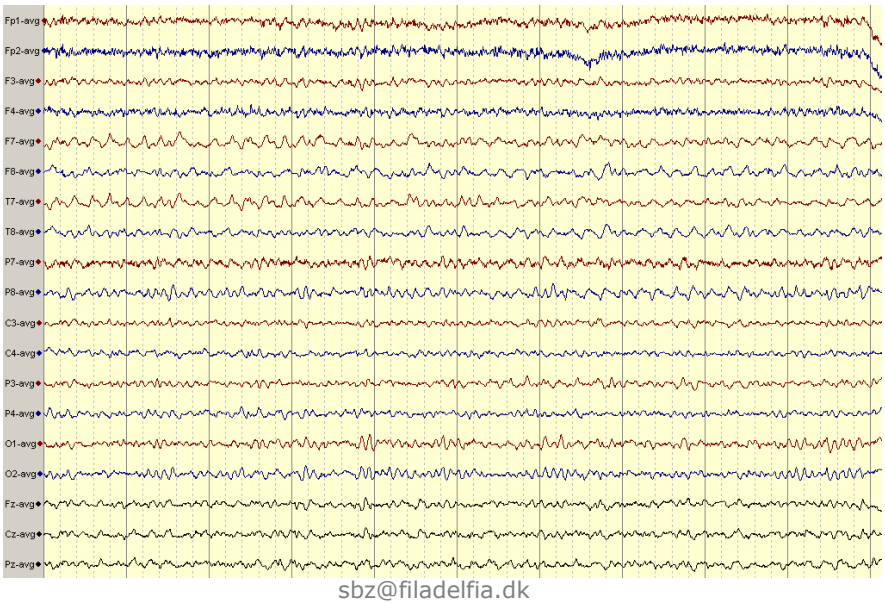

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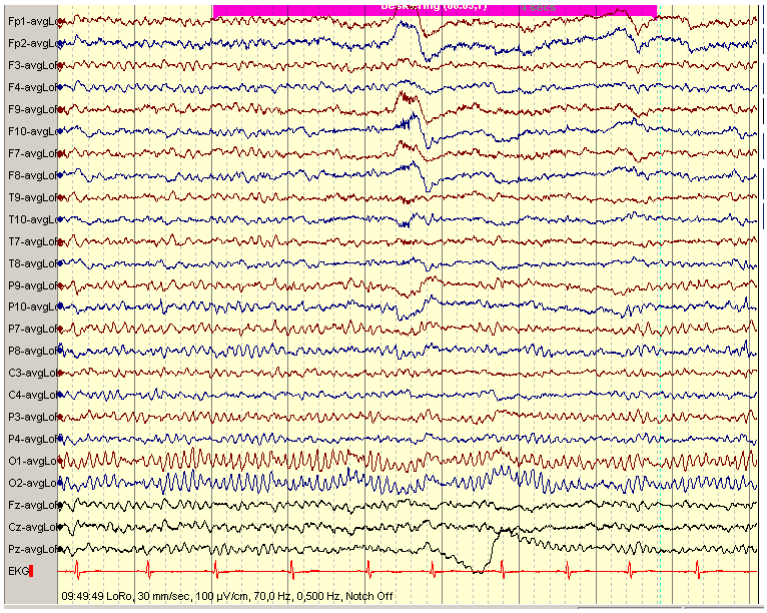
Glossokinetik artifact



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WARNING:

- **Over-reading is potentially more harmful to the patient than under-reading!**

- Flowchart of "unbiased" reading:
  1. Visual analysis of the recording = feature extraction
     Only information at this point: age, state of consciousness
  2. Describing the clinically relevant EEG-features
  3. Reading the referral
  4. Interpretation of the EEG findings in the clinical context

sbz@filadelfia.dk

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Interpretation of EEG-findings (”use and abuse”)

sbz@filadelfia.dk

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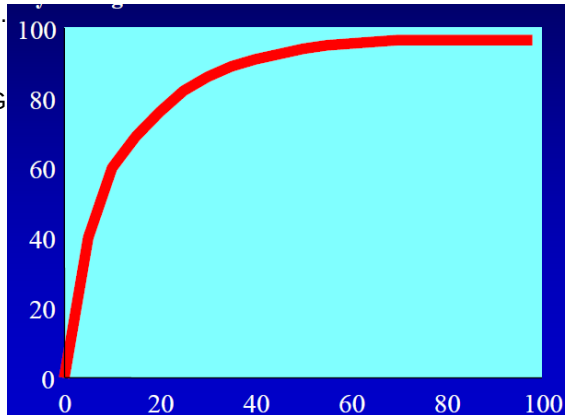
Contribution of epileptiform EEG activity to the probability of a diagnosis of epilepsy

Probability of dg. based on clinical data + abnormal EEG



Probability of diagnosis based on clinical data only

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(after Goodin & Aminoff)

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ILAE OFFICIAL REPORT

A practical clinical definition of epilepsy

*Robert S. Fisher, †Carlos Acevedo, ‡Alexis Arzimanoglou, §Alicia Bogacz, ¶J. Helen Cross, #Christian E. Elger, **Jerome Engel Jr, ††Lars Forsgren, ‡‡Jacqueline A. French, §§Mike Glynn, ¶¶Dale C. Hesdorffer, ##B.I. Lee, ***Gary W. Mathern, †††Solomon L. Moshé, ‡‡‡Emilio Perucca, §§§Ingrid E. Scheffer, ¶¶¶Torbjörn Tomson, ###Masako Watanabe, and ****Samuel Wiebe

Epilepsia, 55(4):475–482, 2014
doi: 10.1111/epi.12550

sbz@filadelfia.dk

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Summary

Epilepsy was defined conceptually in 2005 as a disorder of the brain characterized by an enduring predisposition to generate epileptic seizures. This definition is usually practically applied as having two unprovoked seizures >24 h apart. The International League Against Epilepsy (ILAE) accepted recommendations of a task force altering the practical definition for special circumstances that do not meet the two unprovoked seizures criteria. The task force proposed that epilepsy be considered to be a disease of the brain defined by any of the following conditions: (1) At least two unprovoked (or reflex) seizures occurring >24 h apart; (2) one unprovoked (or reflex) seizure and a probability of further seizures similar to the general recurrence risk (at least 60%) after two unprovoked seizures, occurring over the next 10 years; (3) diagnosis of an epilepsy syndrome. Epilepsy is considered to be resolved for individuals who either had an age-dependent epilepsy syndrome but are now past the applicable age or who have remained seizure-free for the last 10 years and off antiseizure medicines for at least the last 5 years. "Resolved" is not necessarily identical to the conventional view of "remission or "cure." Different practical definitions may be formed and used for various specific purposes. This revised definition of epilepsy brings the term in concordance with common use.

sbz@filadelfia.dk

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Probability of further seizures after the first unprovoked seizure:

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Probability of further seizures after the first unprovoked seizure:

Children
- Normal EEG: .. %

Adults
- Normal EEG: .. %

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Probability of further seizures after the first unprovoked seizure:

Children
- Normal EEG: 38 %

Adults
- Normal EEG: 12 %

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Probability of further seizures after the first unprovoked seizure:

Children
- Normal EEG: 38 %
- EEG=ED: … %

Adults
- Normal EEG: 12 %
- EEG=ED: … %

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Probability of further seizures after the first unprovoked seizure:

Children
- Normal EEG: 38 %
- EEG=ED: 65 %

Adults
- Normal EEG: 12 %
- EEG=ED: 83 %

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EEG: sensitivity

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- Only one, standard recording: 50%
- 4 repeated EEG (including sleep): 92%

- No significant gain beyond the 4th EEG

Salinsky et al., Epilepsia 1987

"Normal" EEG(s) do NOT exclude epilepsy

sbz@filadelfia.dk

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EEG: specificity

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- **Healthy subjects:**
  false-positive=1%; specificity=99%

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EEG: specificity

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- **Healthy subjects:**
  false-positive=1%; specificity=99%

- **Neurology patients:**
  false-positive=2.2%; specificity=97.8%
  (false-positive: without epileptic seizures in the history)
  - *Mental retardation:* *30% false positive*
  - *Perinatal brain injury:* *24%*
  - *Cranial surgery:* *12%*
  - *Brain tumor:* *10%*

  HOWEVER: 14% of them later developed epilepsy

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EEG: specificity

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  - *Brain tumor: 10%*

  HOWEVER: 14% of them later developed epilepsy

- **Psychiatry patients:**
  false-positive=2.7%; specificity=97.3%

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EEG: specificity

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- **Healthy subjects:**
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  - *Brain tumor: 10%*

  HOWEVER: 14% of them later developed epilepsy

- **Psychiatry patients:**
  false-positive=2.7%; specificity=97.3%

- **Relatives of patients with epilepsy:**
  false-positive=20%; specificity=80%

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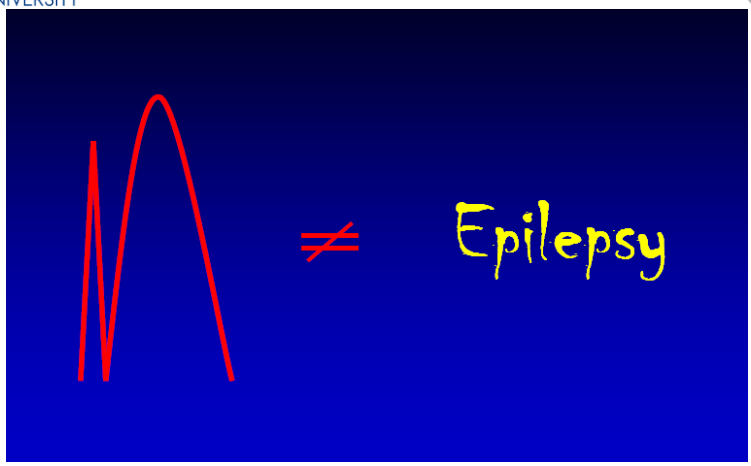

You have to know the context/clinical background!

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Reading EEG is easy:

- **Proper recordings – including inferior temporal electrodes**
- **Proper montages – both bipolars and common average**
- **Inteirctal findings: What? Where? When? Why?**
- **Use voltage maps for localization**
- **Ictal: look for the spatio-temporal dynamics**
- **Be aware of false positives and negatives**
- **Integrate EEG findings with clinical data**

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