PITFALLs of
EEG INTERPRETATION

Normal Variants

- Mimic single epileptiform waves
- Mimic repetitive epileptiform waves
- Other normal variants

Resources:
1)John Ebersole. Current Practice of Clinical Electroencephalography
2)Mark Libenson. Practical Approach to Electroencephalography

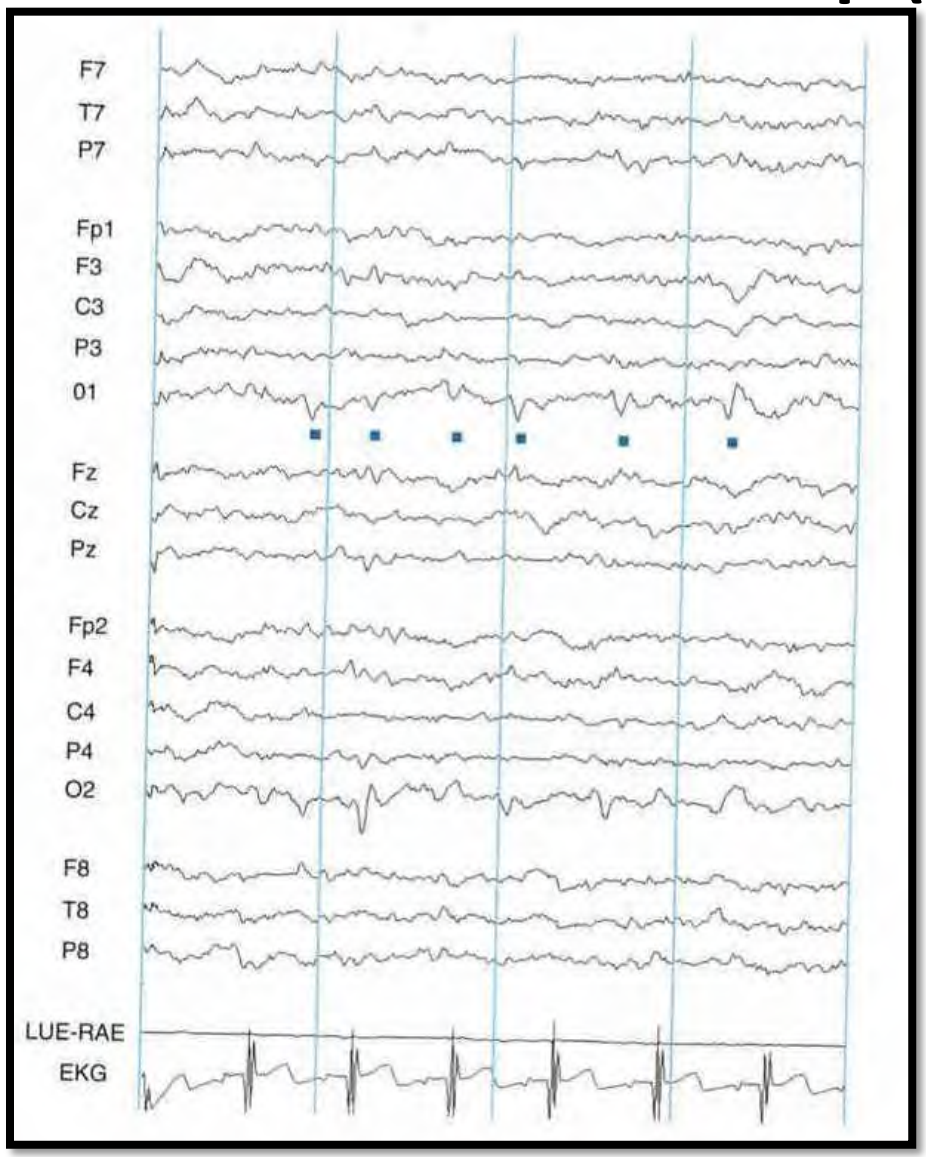
NORMAL VARIANTS MIMICKING SINGLE EPILEPTIFORM WAVES

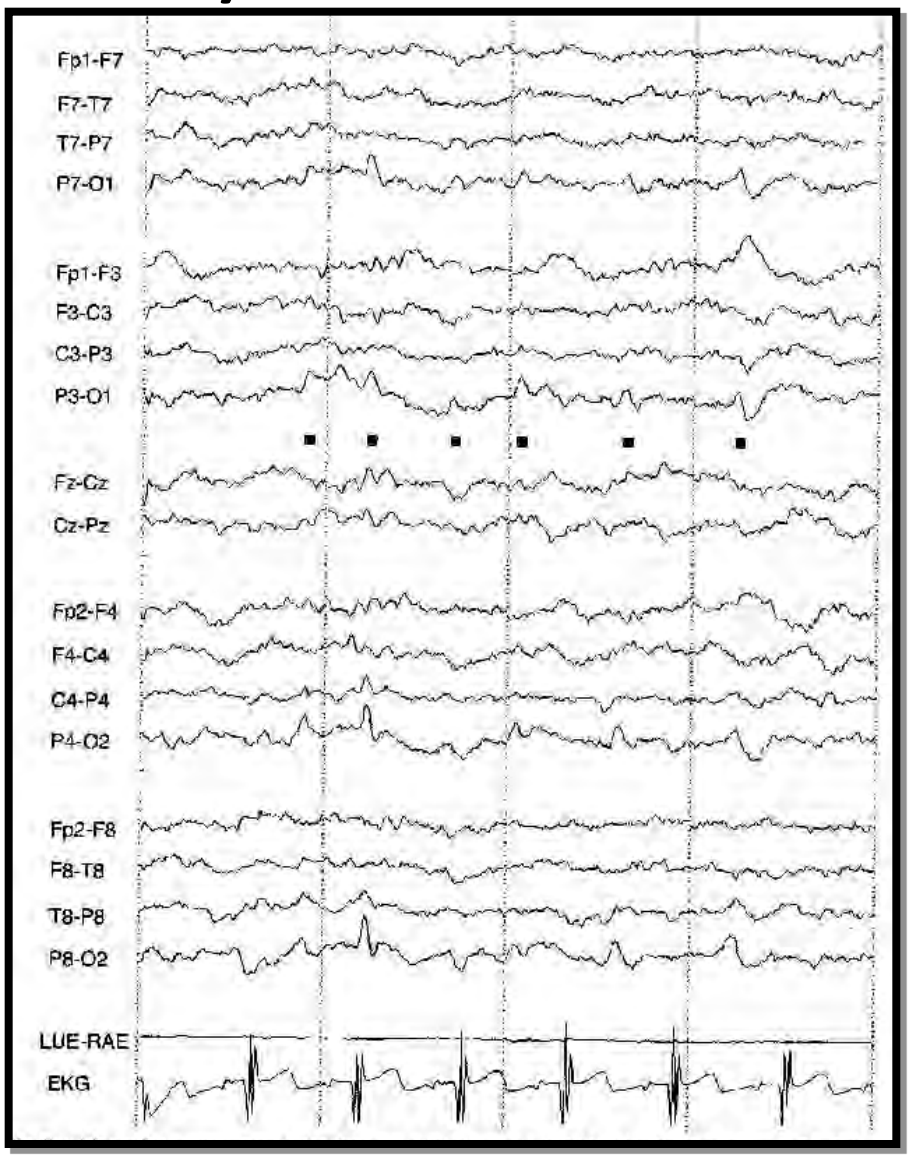
Posterior/Positive Occipital Sharp Transients of Sleep (POSTS)

- Prominent in light sleep, sleep stage 1, 2
- Most common variant; normal sleep feature
- Positive polarity, triangular/V-shaped

  Monophasic checkmark-like wave form
  - Sometimes more spiky
- Low to medium voltage
- Usually, bilateral and synchronous; asymmetric amplitudes
- Trains with repetition rate of 4-5Hz

Posterior/Positive Occipital Sharp Transients of Sleep (POSTS)





Lambda Waves λ

- Awake
  - "awake version of POSTS" but less common
- Occur with lateral searching eye movements
  - Eyes open
  - Can identify by looking for lateral eye movement artifact, fast saccadic eye movements
- Positive or Negative polarity, sharply contoured
- Voltage asymmetry is not abnormal

Lambda Waves λ

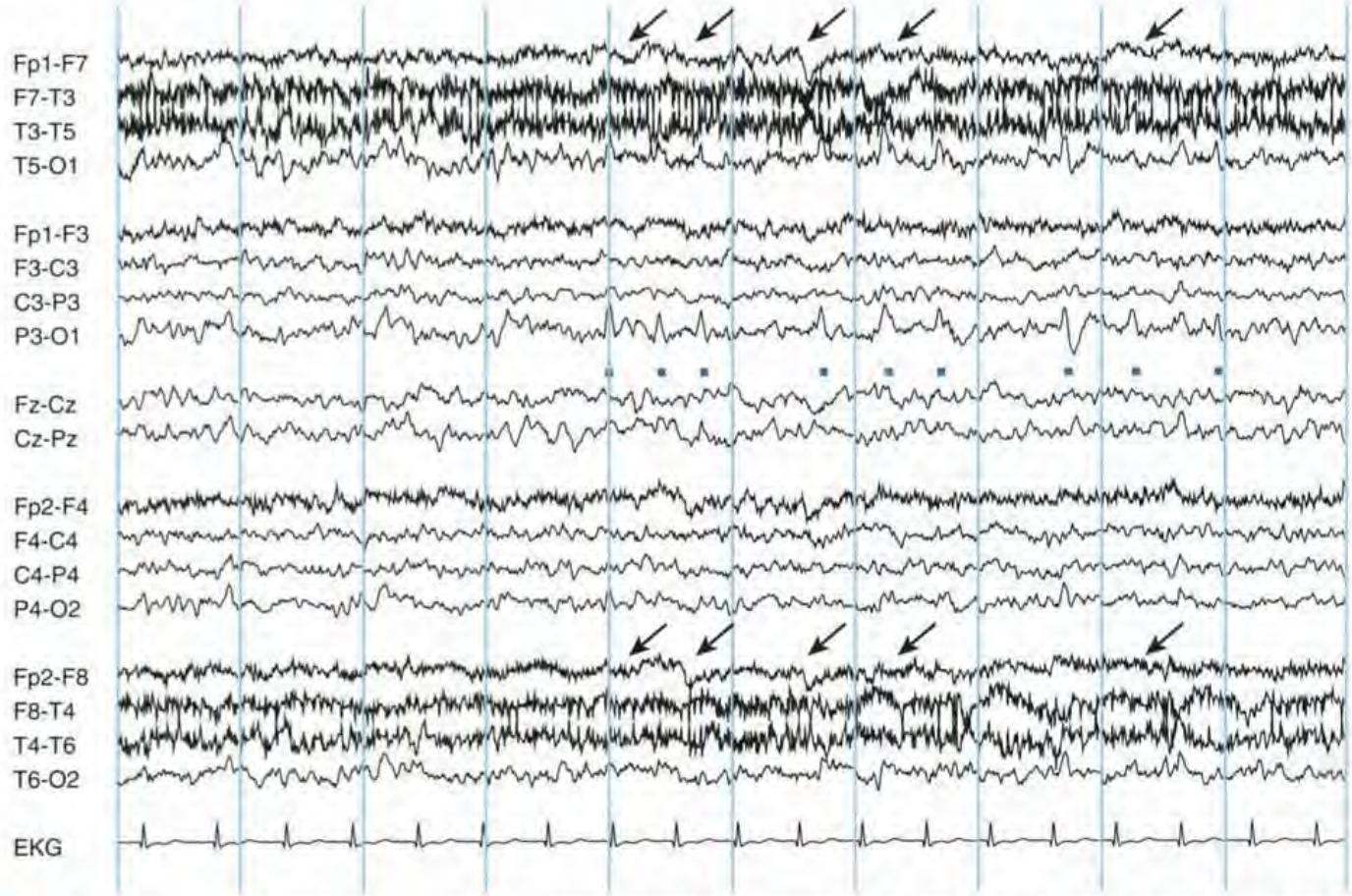
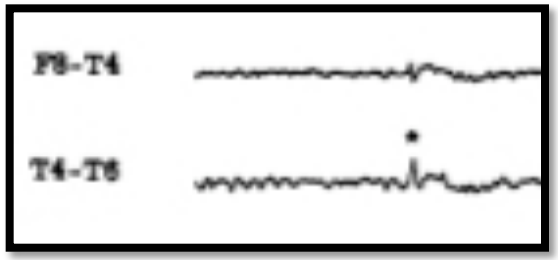


Figure 11-4 The triangular-shaped waves seen in the occipital channels are examples of lambda waves (dots). Lambda waves are associated with horizontal searching eye movements. Subtle lateral eye movement artifact (arrows) is seen in the frontal/anterior temporal channels with opposite polarity on each side (see Chapter 6, "Artifacts") for further description of eye movement artifact).

Small Sharp Spikes (SSS)
Benign Epileptiform Transients of Sleep (BETS)

- Adults
- Drowsiness or Light Sleep; disappear with slow wave sleep
- Monophasic or diphasic
- Low amplitude (<50 uV); Brief (<50 msec, quick)
- With low amplitude after-slowing
- Temporal area

  with broad gradient accross temporal change
- Shifting Laterality
  - May have bilateral opposite polarity
- Not associated with focal slowing



Small Sharp Spikes (SSS)
Benign Epileptiform Transients of Sleep (BETS)

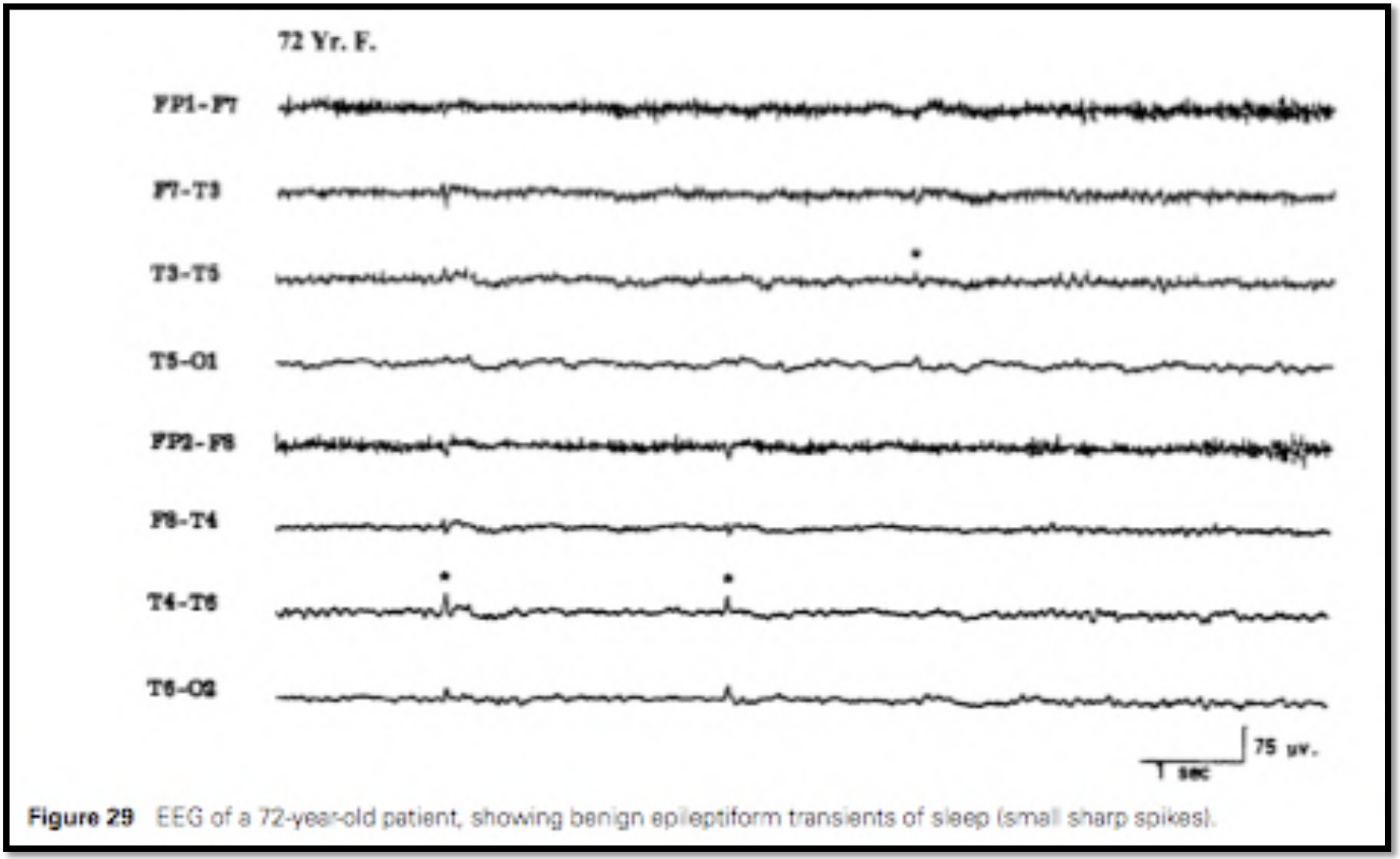
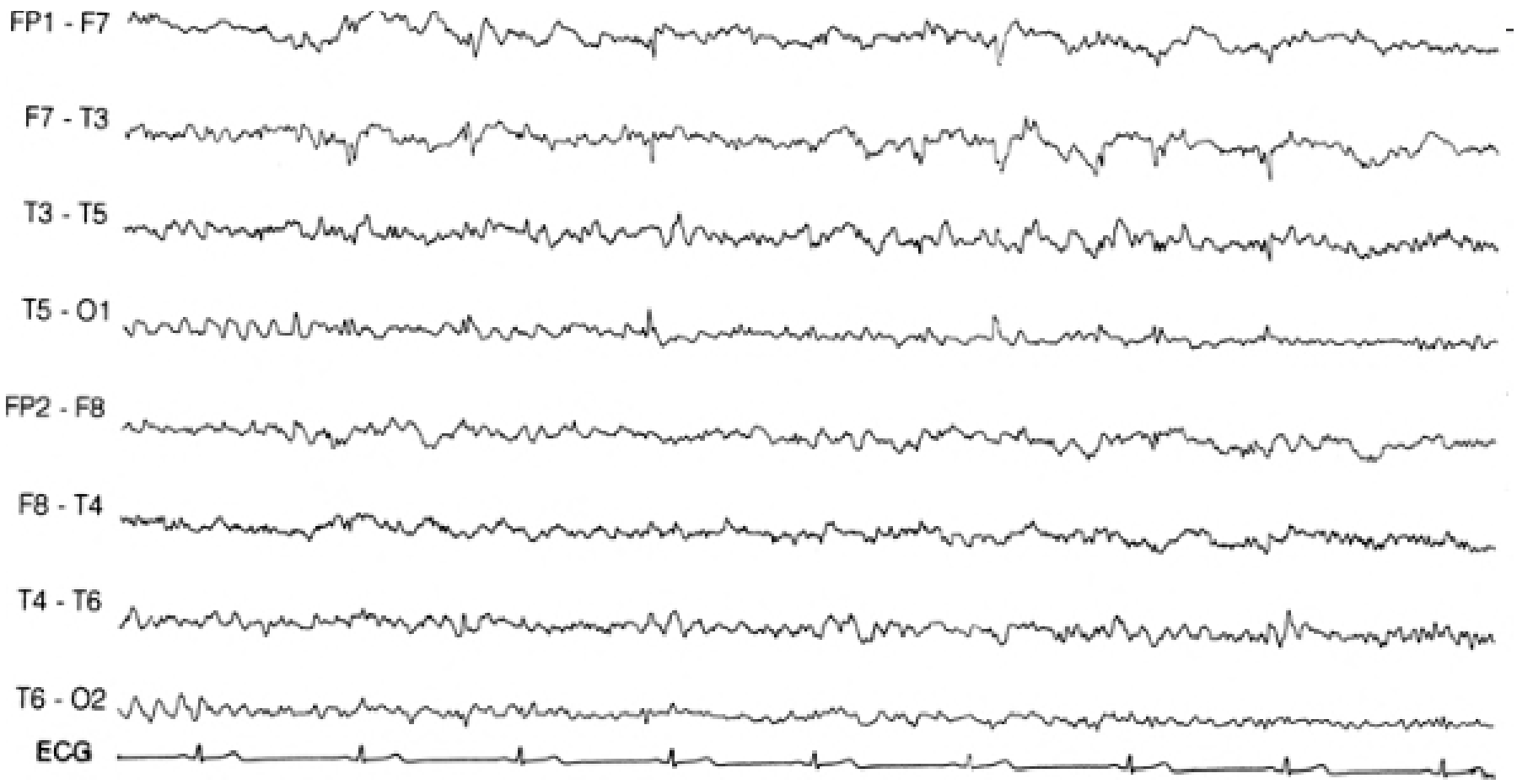


Figure 29 EEG of a 72-year-old patient, showing benign epileptiform transients of sleep (small sharp spikes).

Small Sharp Spikes (SSS)
Benign Epileptiform Transients of Sleep (BETS)



NORMAL VARIANTS MIMICKING REPETITIVE EPILEPTIFORM WAVES

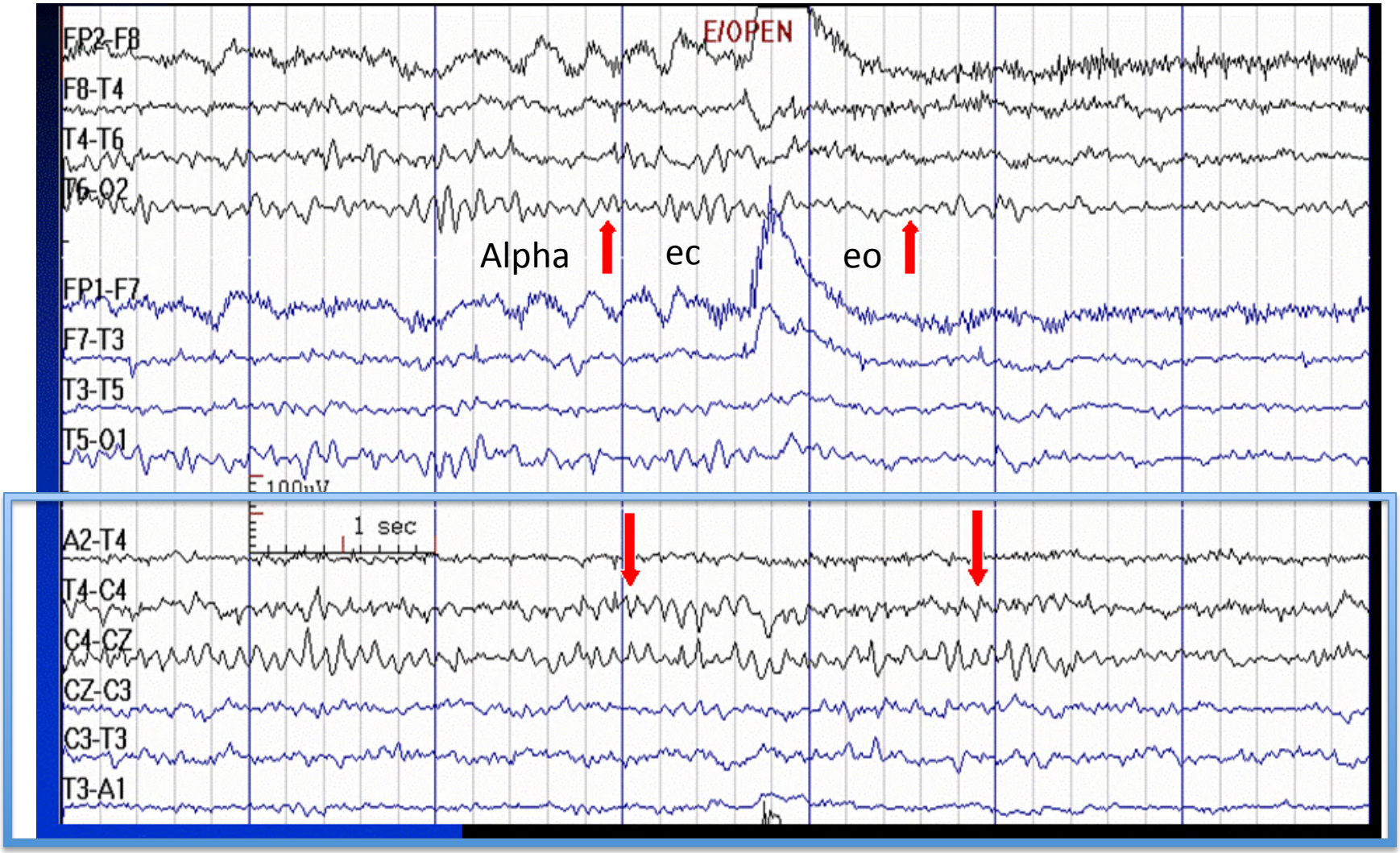
M μ Rhythms

"somatosensory alpha rhythm"

- From older childhood and onwards
- Awake
- Comb-like or arciform, sometimes in trains
- Central areas: C3, C4; may be asymmetric/asynchronous
- Suppressed by voluntary contralateral hand movement "reactivity"
  - Also, suppress sometimes with thought of movement or ipsilateral hand.
- Not suppressed by eye-opening (vs PDR)
- Confusion: fragments of mu - low voltage spike

  low voltage spike fragments in trains – mu

M μ Rhythms


E/OPEN
FP2-F8
F8-T4
T4-T6
T6-O2
Alpha
ec
eo
FP1-F7
F7-T3
T3-T5
T5-O1
1 sec
A2-T4
T4-C4
C4-CZ
CZ-C3
C3-T3
T3-A1

M μ Rhythms

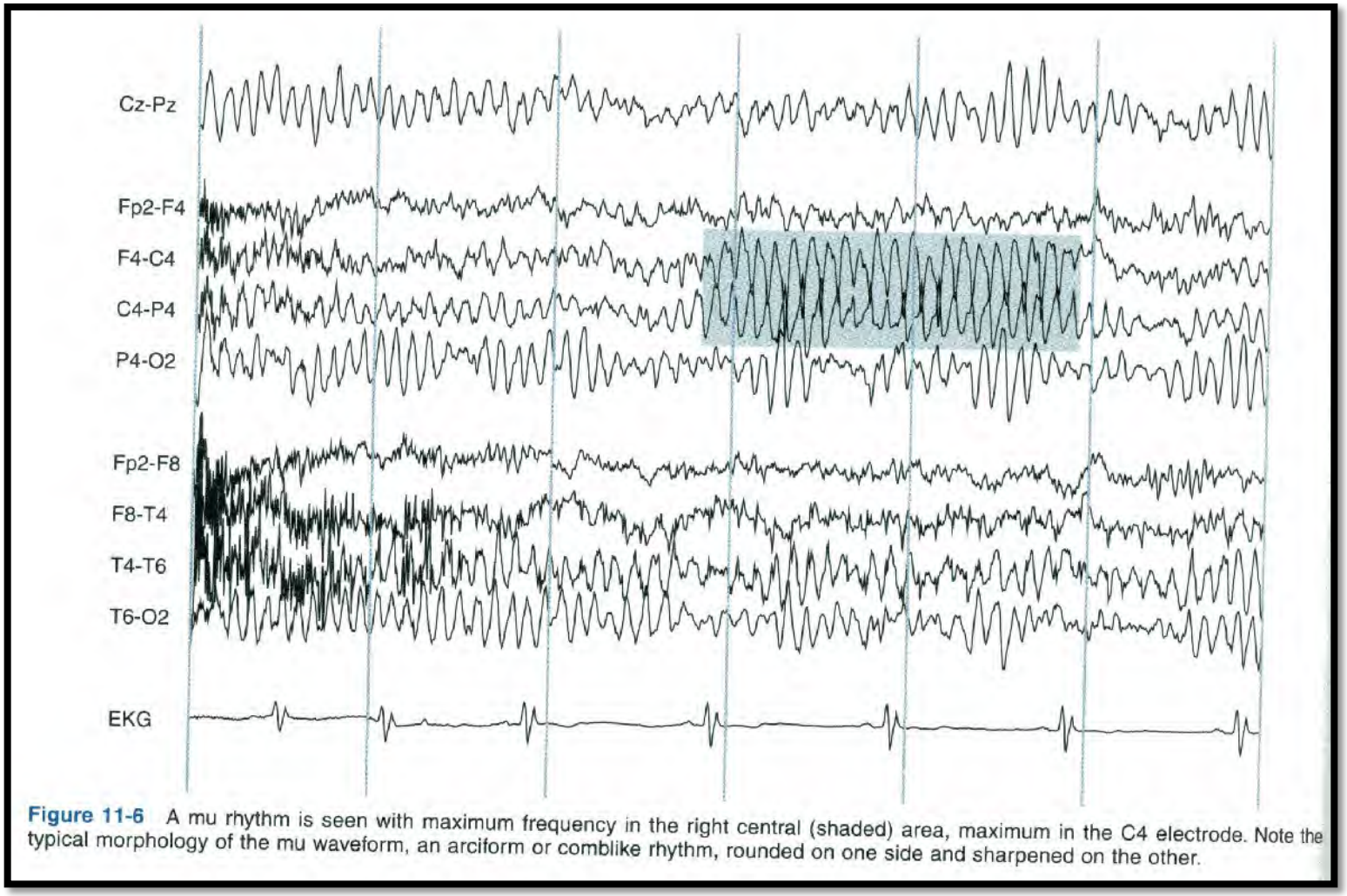


Figure 11-6 A mu rhythm is seen with maximum frequency in the right central (shaded) area, maximum in the C4 electrode. Note the typical morphology of the mu waveform, an arciform or comblike rhythm, rounded on one side and sharpened on the other.

M μ Rhythms

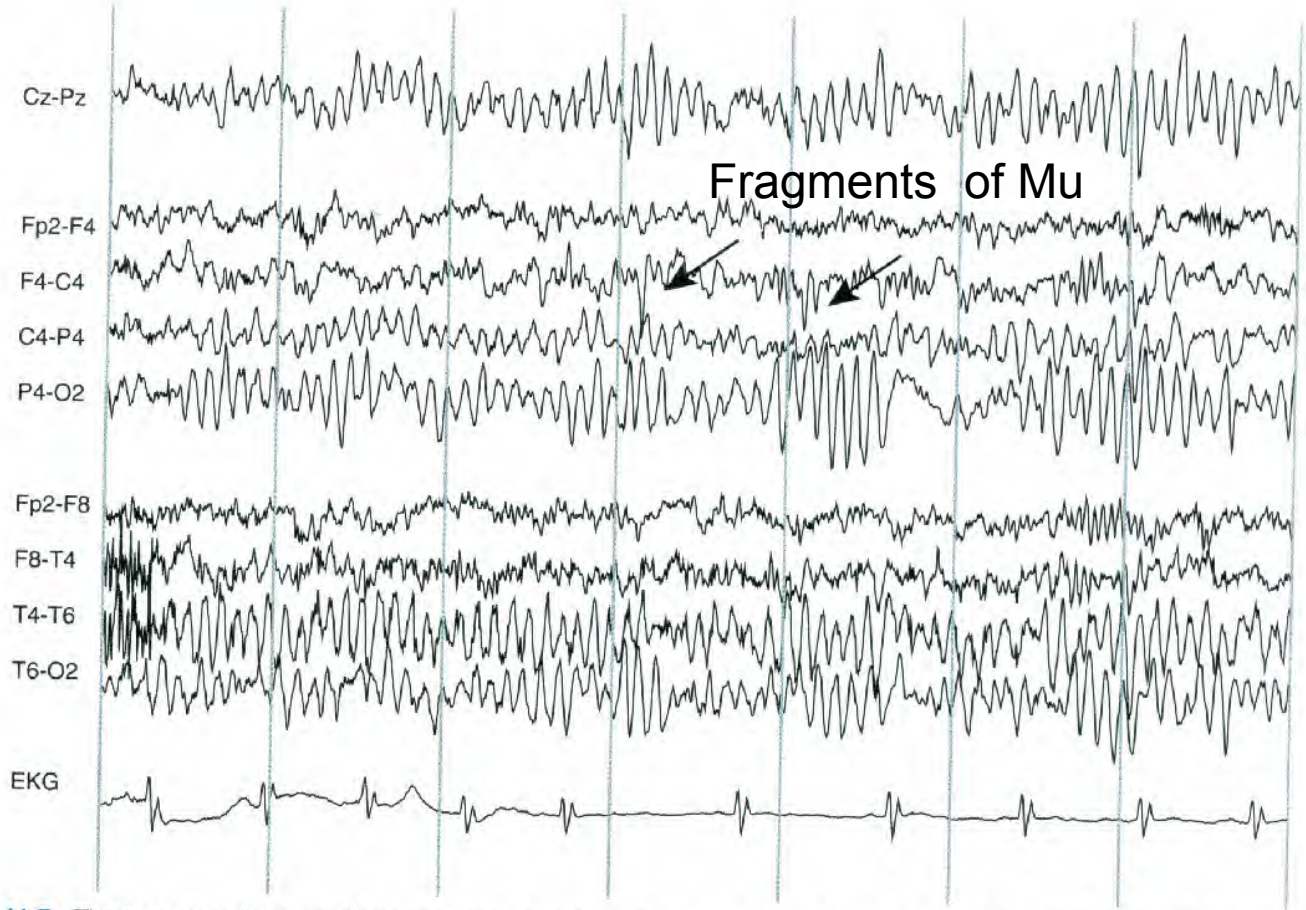


Figure 11-7 The two low-voltage transients (arrows) taken from the same tracing shown in the previous figure could be mistaken for low-voltage spikes. Comparing these transients to the mu rhythm shown in the previous figure, it becomes evident that these waveforms represent fragments of the patient's mu rhythm.

Wicket Spikes & Rhythms

Normal fragment of *"Temporal alpha activity"*

- Adult（>30), uncommon in epilepsy pts
- Similar morphology to Mu rhythm (arciform)
  - but seen in drowsiness and light sleep
- Temporal: T3/T4, also F7/F8; independent
- 6-11 Hz, 60- 200μV
- Short fragments mistaken for epileptiform
  - = *"Wicket spike"*
  - No after slow-wave or disruption of background
  - Compare with trains, as with Mu rhythm

Wicket Spikes & Rhythms

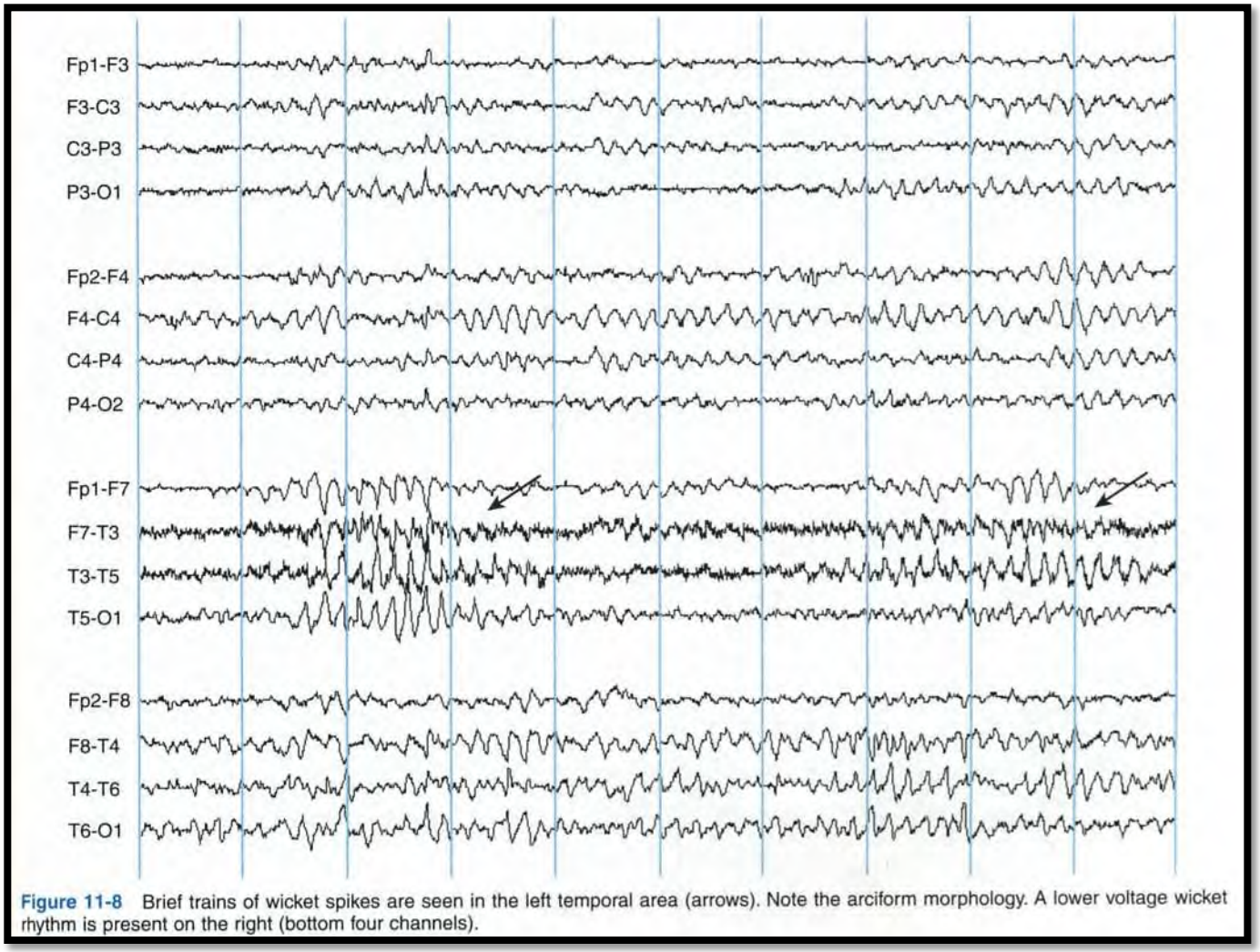


Figure 11-8 Brief trains of wicket spikes are seen in the left temporal area (arrows). Note the arciform morphology. A lower voltage wicket rhythm is present on the right (bottom four channels).

Breach Rhythm

- Faster activity is transmitted preferentially through a region of skull defect (as much as 3X)
- Focal enhanced beta activity
- Sharply contoured arciform

  Mu/Wicket-like rhythm (central/temporal)

  - Could be an over-expression of these natural rhythm
- Important to know about craniotomy scars, burr hole & clinical history(skull fracture)
- Careful not to identify fragments as spikes

  - absence of after slow-wave, lack of spread

Breach Rhythm

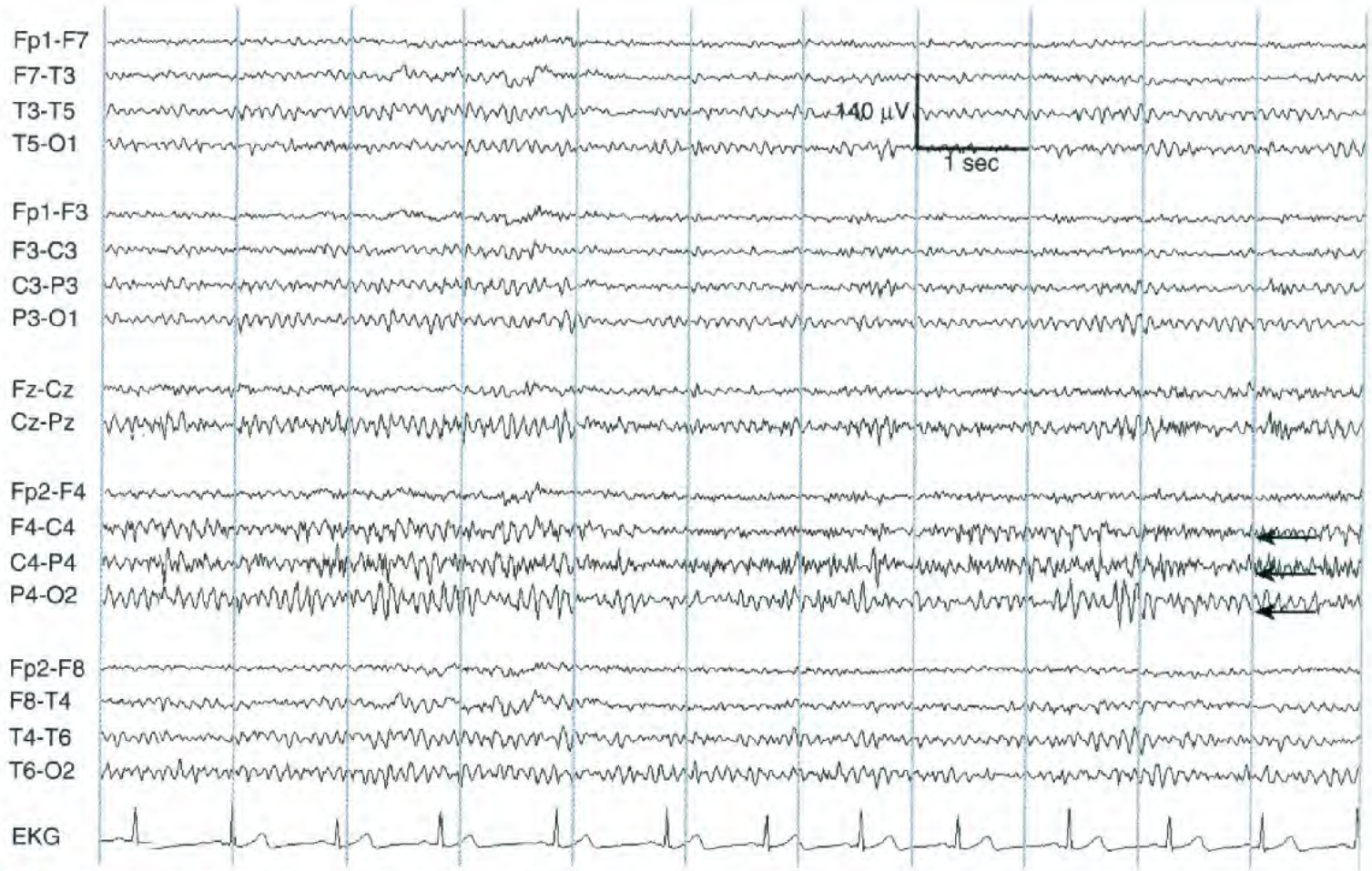


Figure 11-12 A breach rhythm is seen in the right parasagittal area (arrows) after a right-sided craniotomy. Note the higher voltage, sharpened rhythm in the F4-C4, C4-P4, and P4-O2 channels. *(Image courtesy of Dr. Edward Bromfield and Dr. Barbara Dwortesky.)*

Breach Rhythm

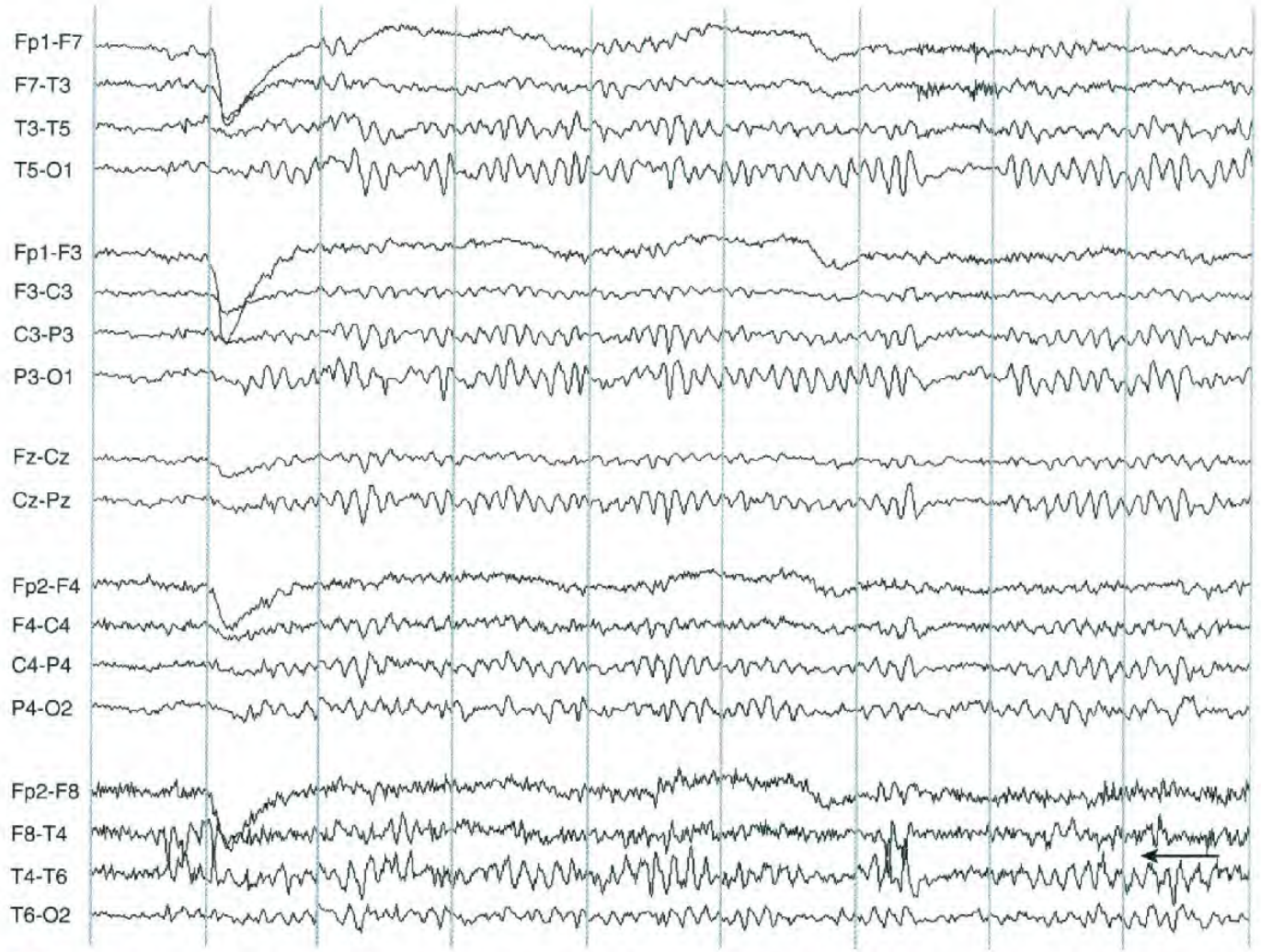
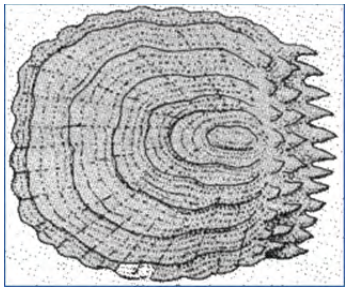
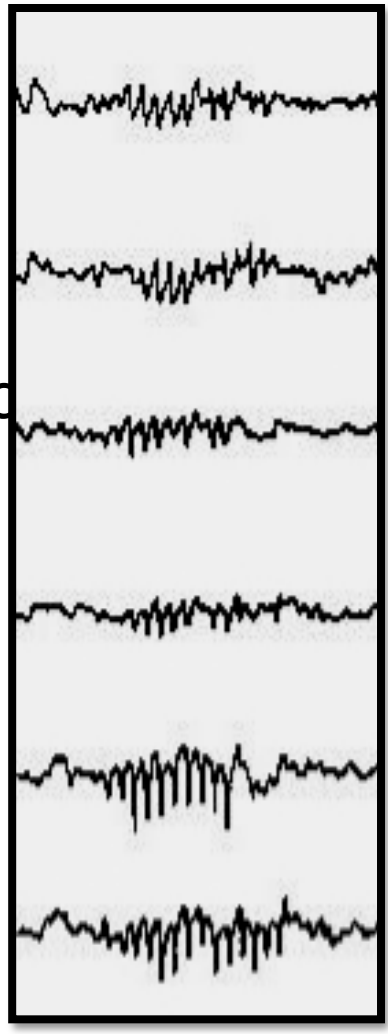


Figure 11-13 A breach rhythm is seen in the right midtemporal area (arrow) after a right temporal craniotomy. Note the arciform nature of the rhythm and compare with the homologous left-sided (T3) electrode. *(Image courtesy of Dr. Jong Woo Lee.)*



14 and 6 Hz Positive Bursts

Ctenoids (comb/fish scale-like)



- All ages: Adolescence >> Others (1-40 yrs)
- Drowsy, Light sleep
- Two variants: 14 Hz(13-17) > 6 Hz(5-7)
- Burst of fast, arciform, comb-shaped, rhythmic
- Sharp-phase: positive ; Round-phase: negative
- Low to high voltage
- Duration: 0.5- 1 second
- Location:
  - Posterior temporal, occipital
  - Bilateral, but asynchronous or asymmetric

14 and 6 Hz Positive Bursts

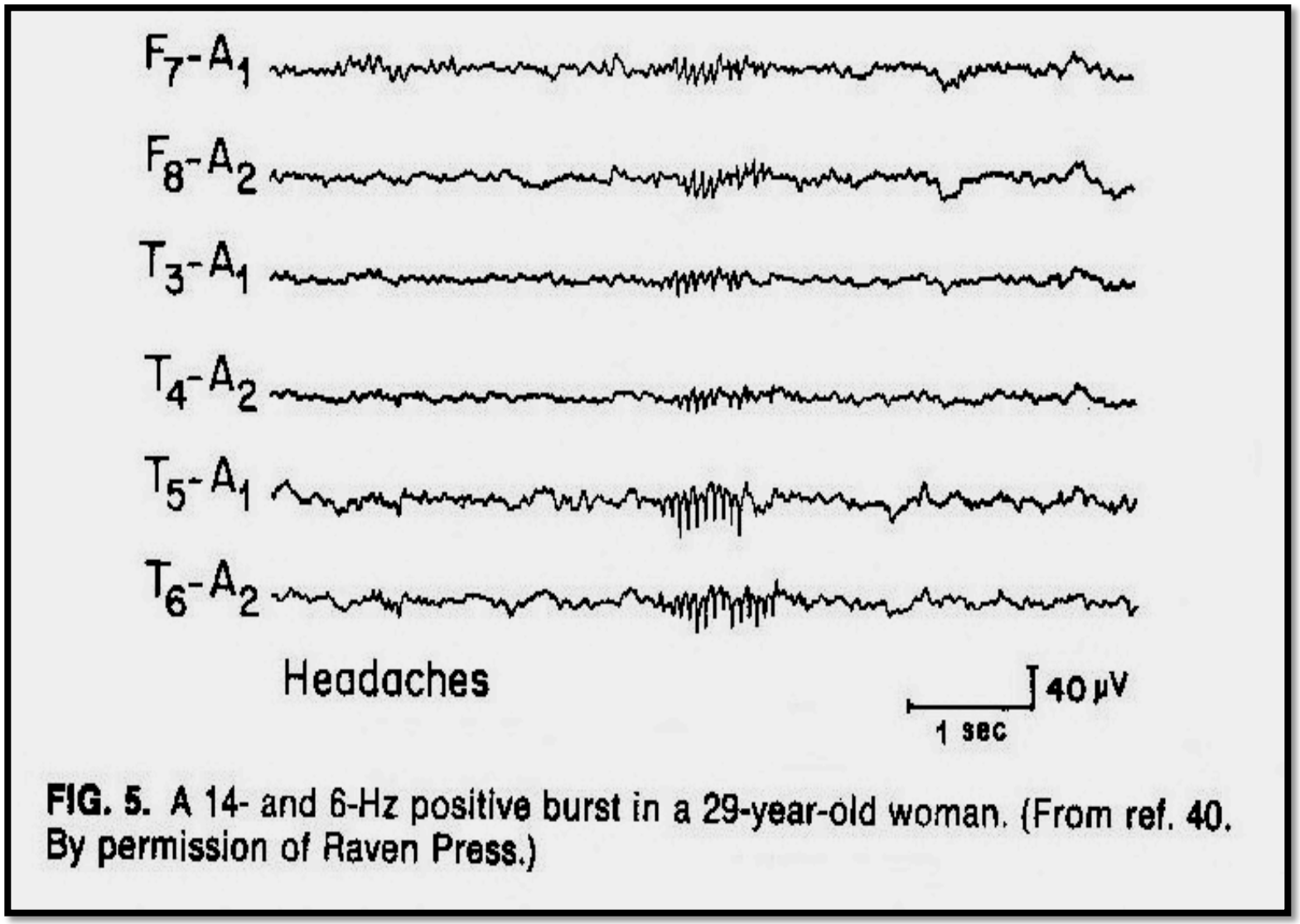
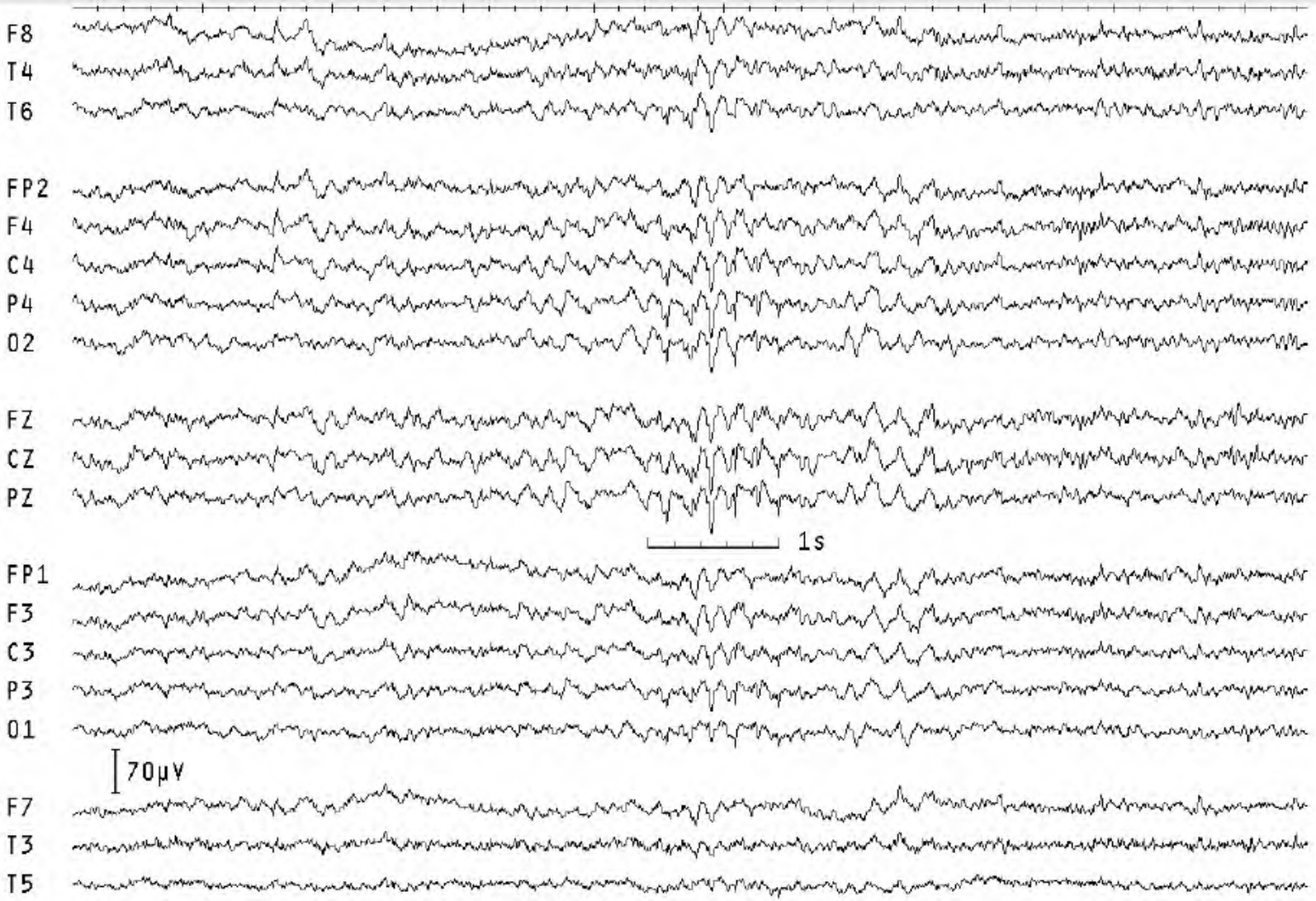


FIG. 5. A 14- and 6-Hz positive burst in a 29-year-old woman. (From ref. 40. By permission of Raven Press.)

14 and 6 Hz Positive Bursts



Psychomotor Variant / Rhythmic midtemporal theta bursts of drowziness (RMTD)

- Rhythmic Temporal Theta Bursts of Drowsiness
- Children and Adults (Adolescent, young adult)
- Drowsiness, light sleep
- Trains of sharply, notched 5-7 Hz activity
  - Rounded tops and sharpened bottoms
- Unilateral or bilateral
- "Variant" = resemble temporal lobe seizure discharge
  - vs Seizure:

    No variation in frequency, amplitude, or morphology

    Without evolution

Psychomotor Variant/RMTD

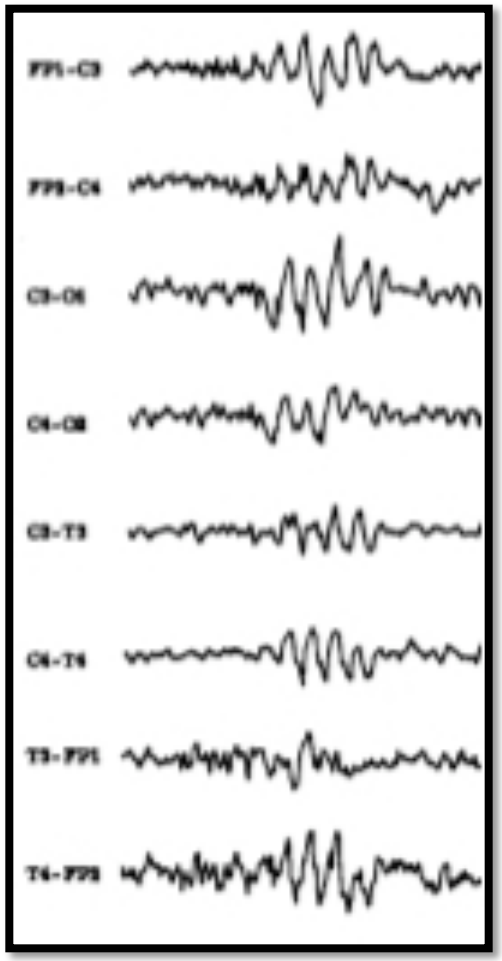
Figure 11-15 Rhythmic temporal theta bursts of drowsiness, also known as psychomotor variant or RMTD, is seen in each temporal area (arrows). The waves are sharp on one side and rounded or flat-topped on the other. The unchanging morphology and the constant frequency help to distinguish this from a seizure discharge—the "firing rate" is the same during the first second and the last second on the page.

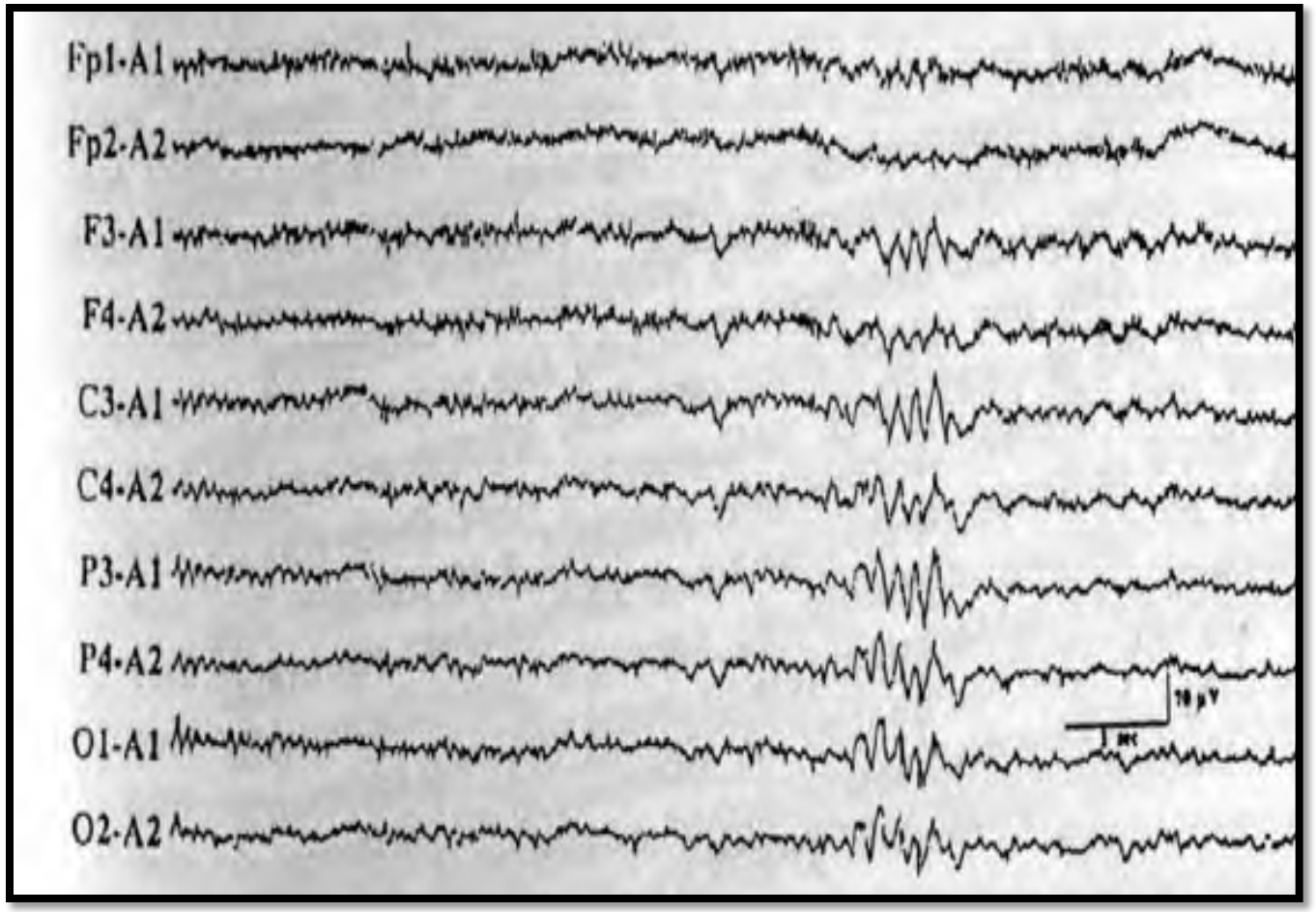
6-per-second (6 Hz) Spike-Wave Complex: Phantom Spike and Wave

- "Phantom" = short duration (<2s) or small spike
- Wakefulness and mild drowsiness; Disappear in deeper sleep
- Brief burst of 5 to 7 Hz generalized spike-wave
- Spike: intermittent, <25μV, <30msec
- Dichotomy (Hughes 1980):
  - WHAM = "Waking, High amplitude, Anterior, Male"
    - More likely to have epilepsy
  - FOLD = "Female, Occipital, Low amplitude, Drowsy"
    - More likely to have other disorders

      (headache, dizziness, vertigo, and psychological components)

6-per-second (6 Hz) Spike-Wave Complex: Phantom Spike and Wave





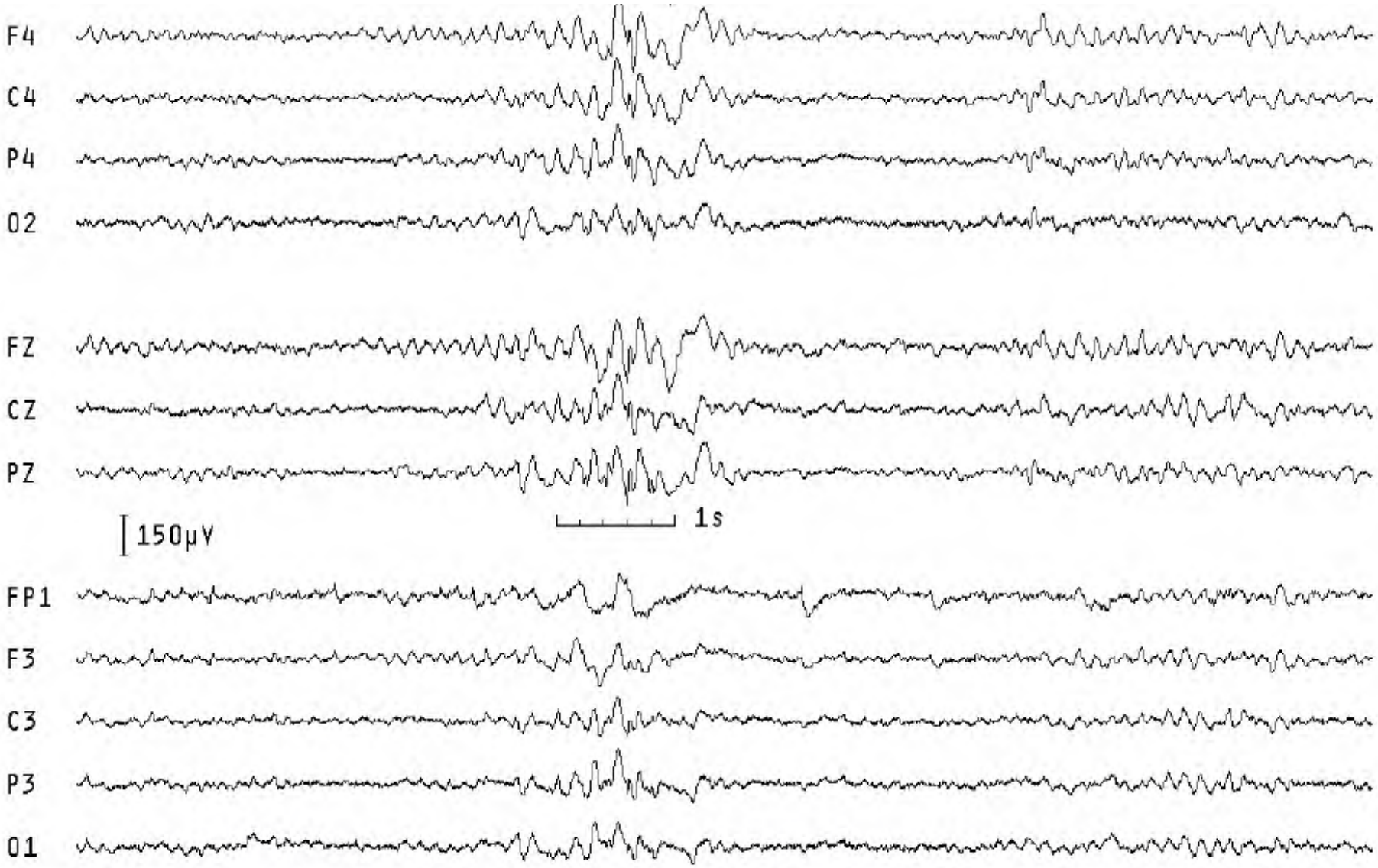


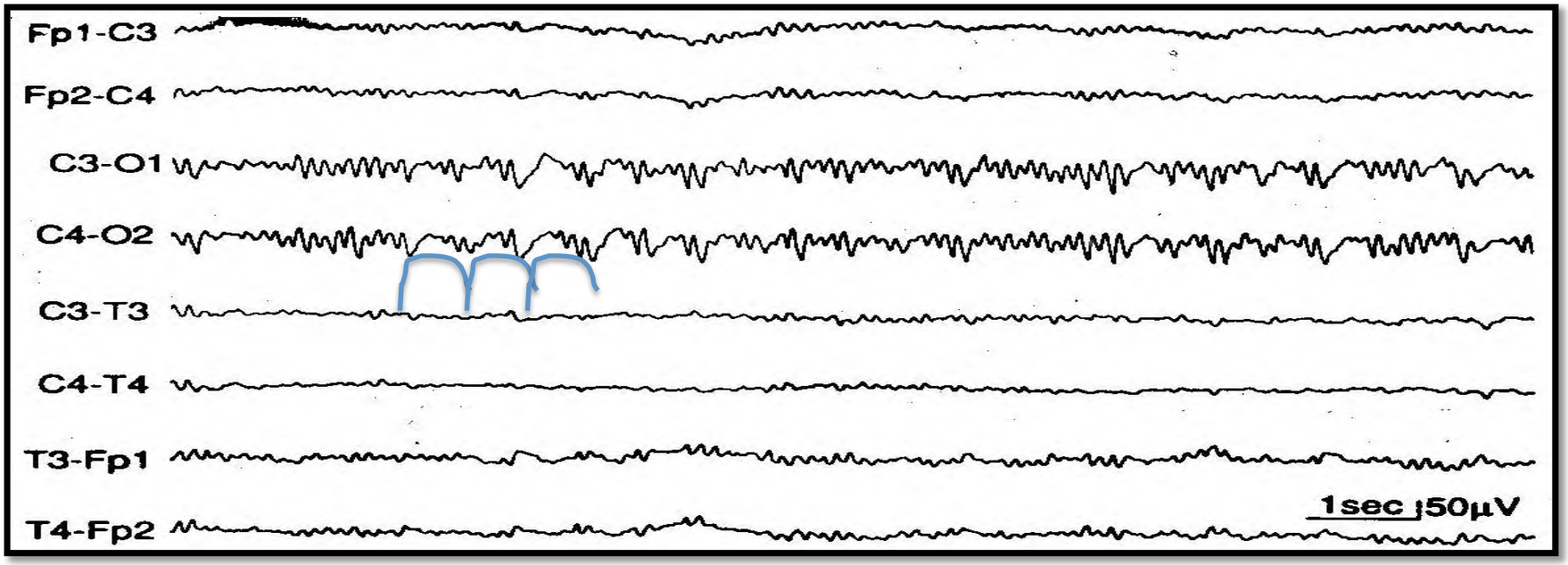
Figure 16. Six Hz "phantom" spike-and-wave, linked-ear (A_{12}) reference. The clinical diagnosis was psychiatric disturbance with no seizures.

OTHER NORMAL VARIANTS

Posterior Slow Waves of Youth

- 6-12 years (rare after 20 – may be abnormal)
- Theta/Delta slow waves
- Posterior, intermixed with alpha rhythm(PDR)
- Briefly interrupt sustained runs of PDR
- Suppress with eye-opening, reactive
- Amplitude: not greater than 50% of PDR (<120%of BG), Duration: 200-400msec
- Asymmetries not uncommon
- Rarely mimicking sharp-and-slow wave complex

Posterior Slow Waves of Youth



Posterior Slow Waves of Youth

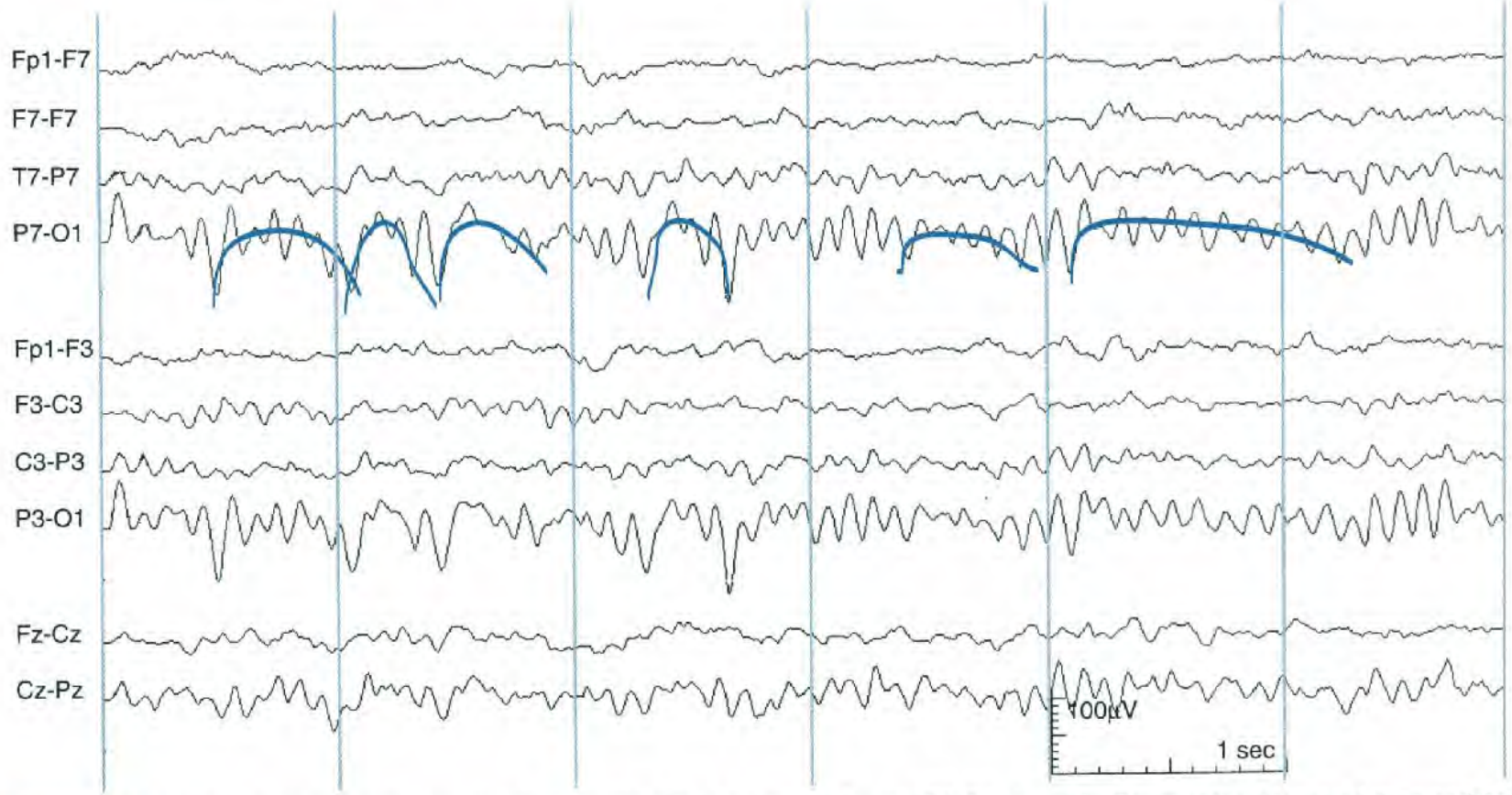
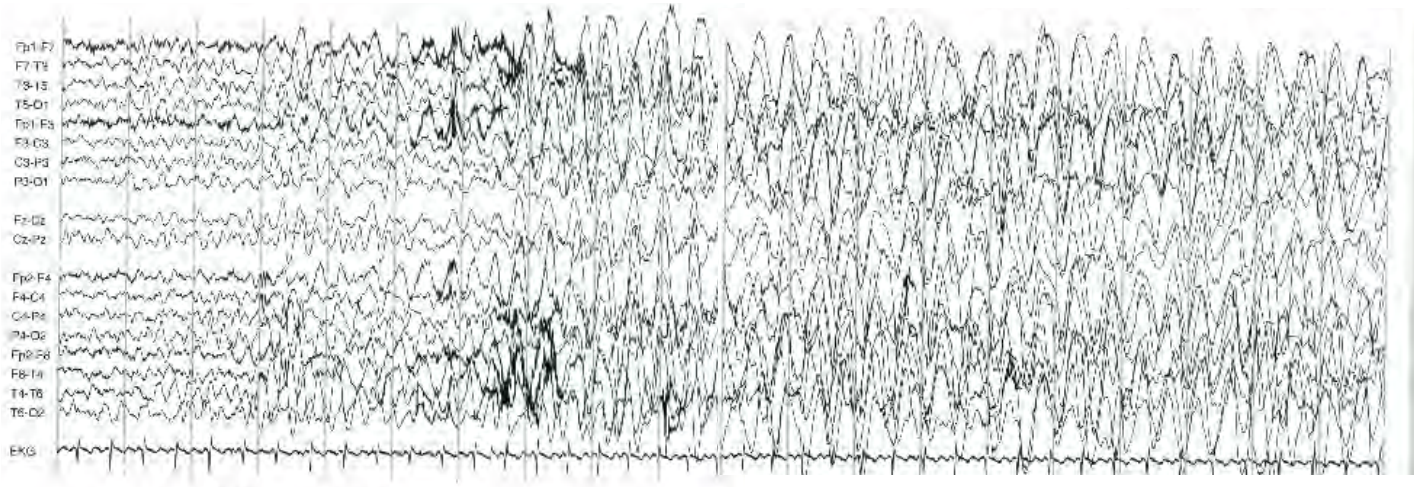


Figure 11-18 Posterior slow waves of youth are seen prominently in the P7-O1 and P3-O1 channels. Some of the intermixed delta and theta waves are marked with pencil in the P7-O1 channel to highlight the shifting baseline of the posterior rhythm caused by the posterior slow waves.

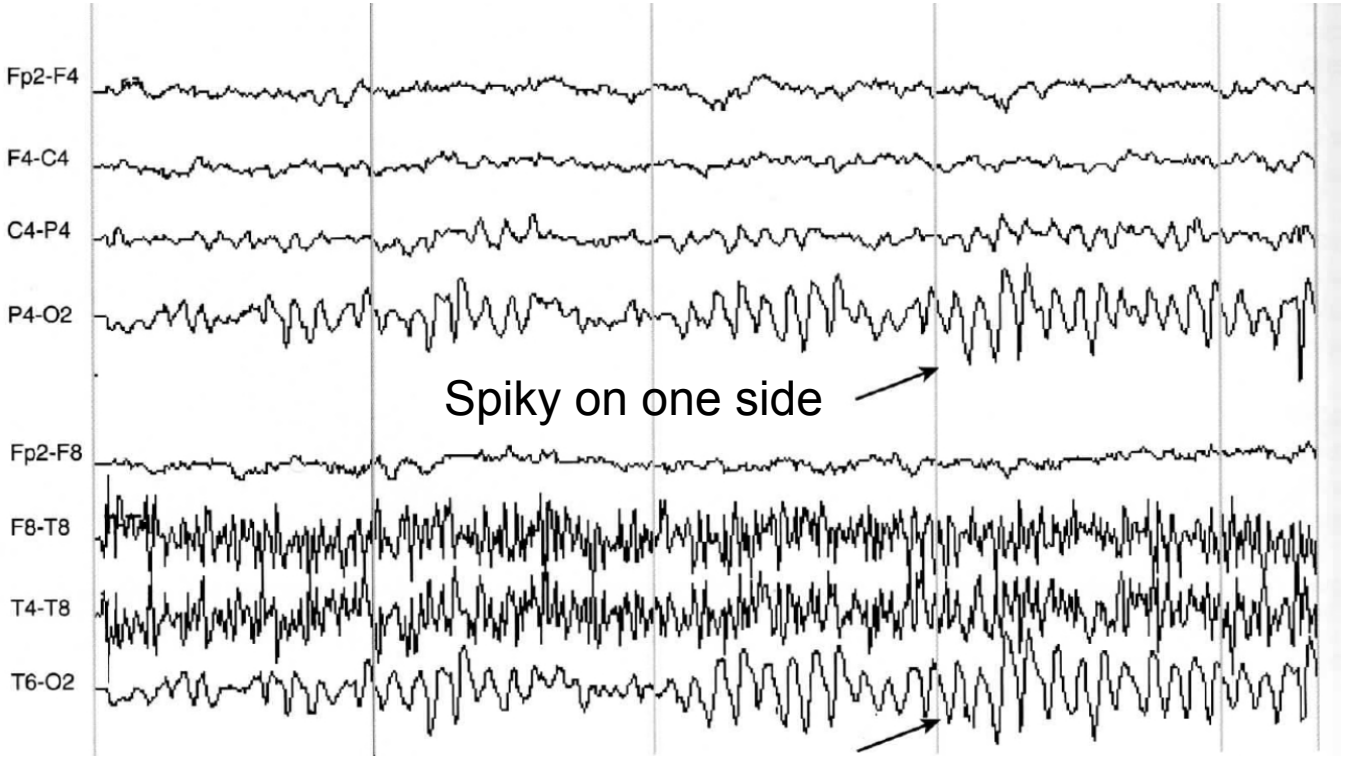
Activation Procedures

- **Exaggerated Hyperventilation Response**
  - High amplitude rhythmic slow waves “build up”
  - More dramatic in children than adults and also with lower blood sugar(hypoglycemia)
  - Synchronous and symmetric; no voltage maximum



Posterior Alpha Rhythm Variants

- **Spiky alpha**: arciform – careful with fragments
  ↔ occipital spike

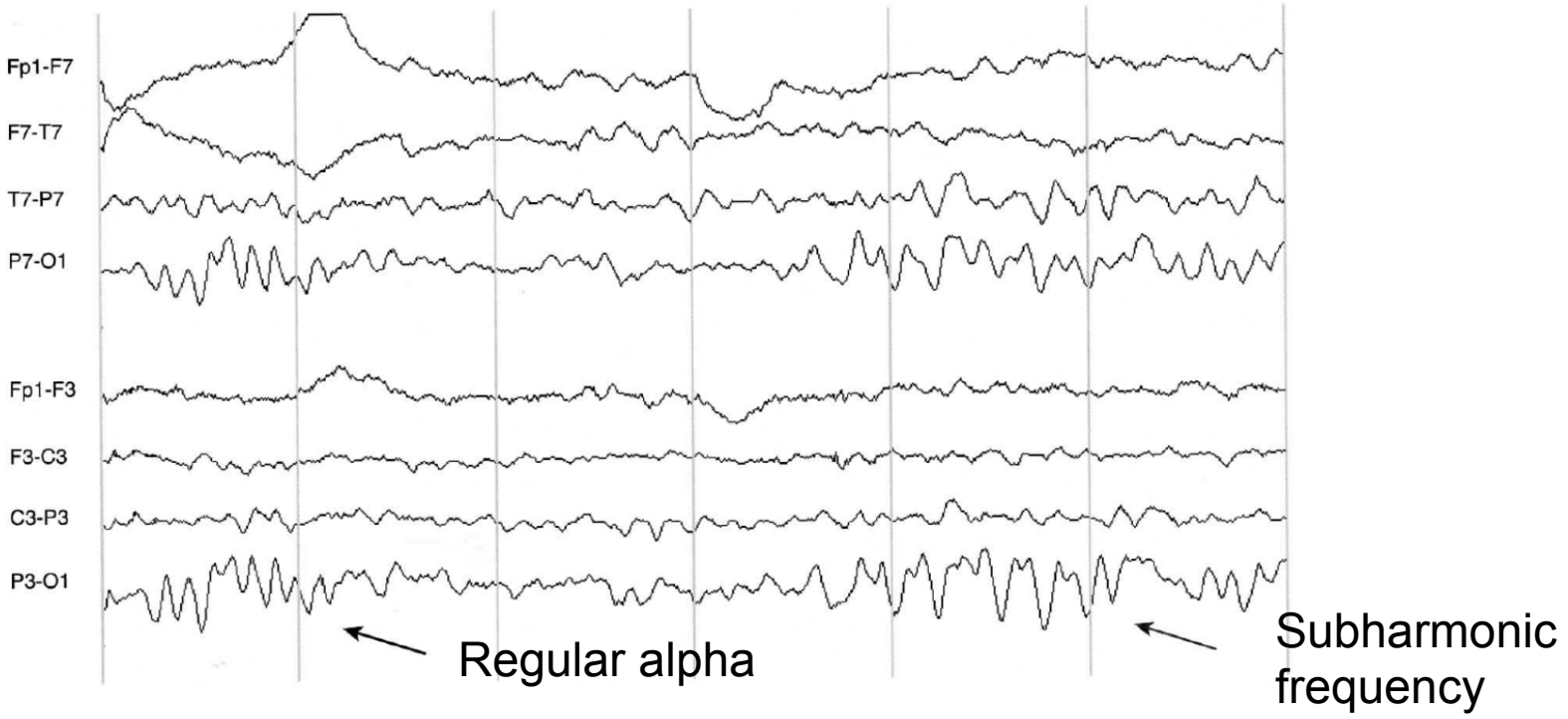


Posterior Alpha Rhythm Variants

- **Slow alpha variant**: subharmonic frequency of PDR

  ½ frequency of PDR (4-5Hz)

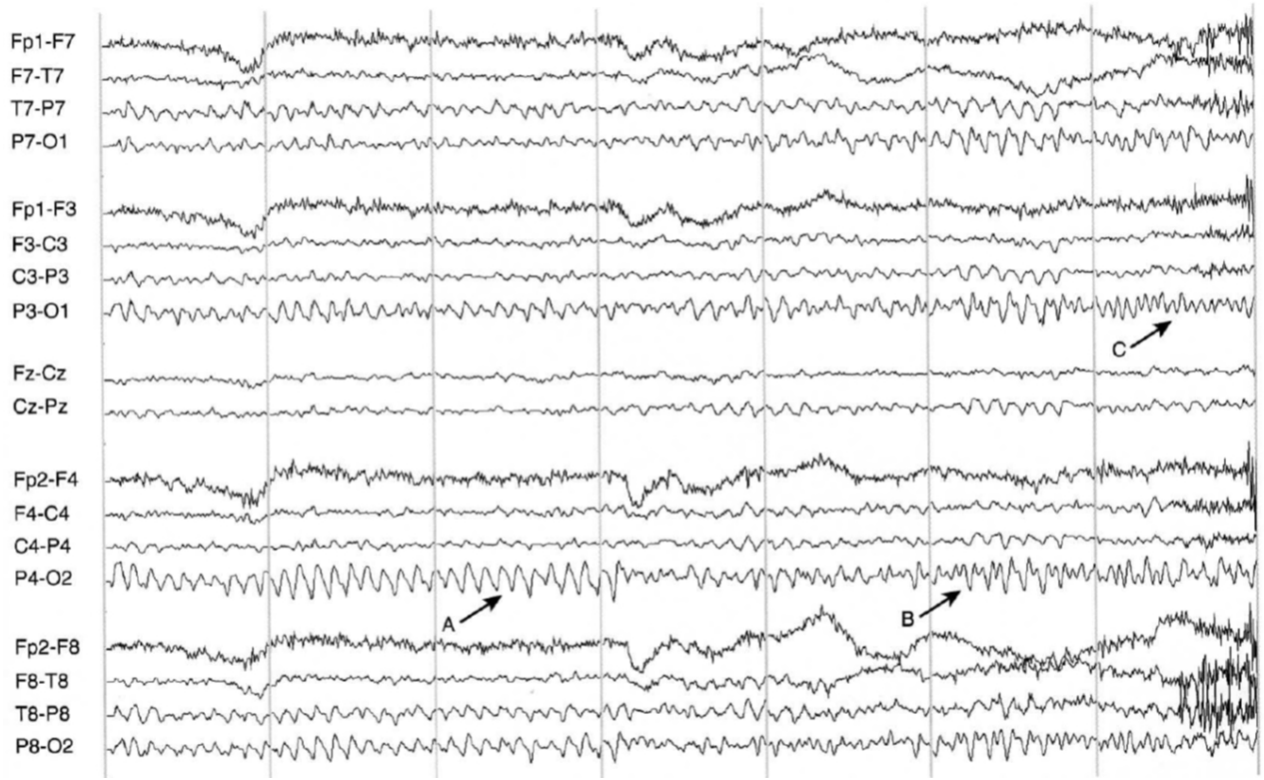
  alternate or superimposed with regular alpha



Posterior Alpha Rhythm Variants

- **Fast alpha variant**: supraharmonic frequency of PDR

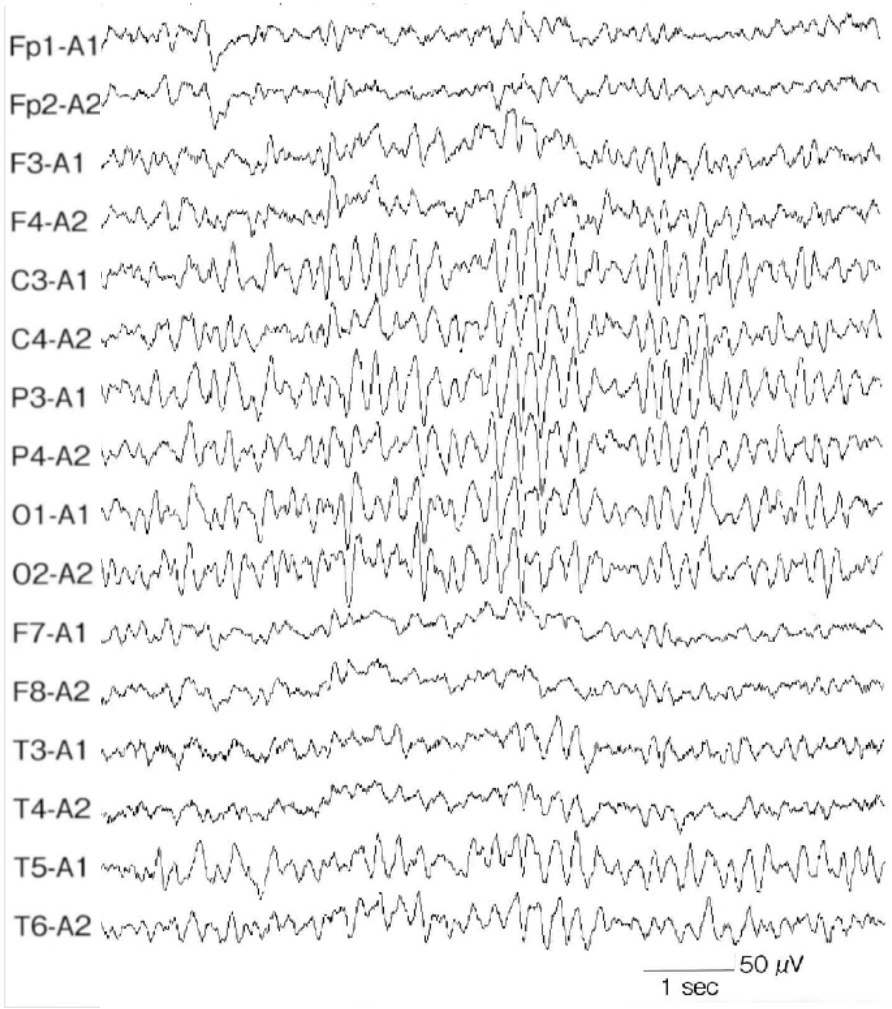
  2X frequency of PDR (16-20Hz)



* Blocked with eye opening

Sleep Variants

- **Hypnogogic** (on falling asleep) &
  Hypnopompic (on arousal) **Hypersynchronies**
  - Transition into sleep or on arousal
  - 3months~up to 12-13years (rare after 11)
  - Highly rhythmic, paroxysmal slow burst
  - Medium to high voltage
  - Diffuse, predominance with precentral/central
  - Watch with respect to sleep transitions and monorhythmicity (vs seizure)



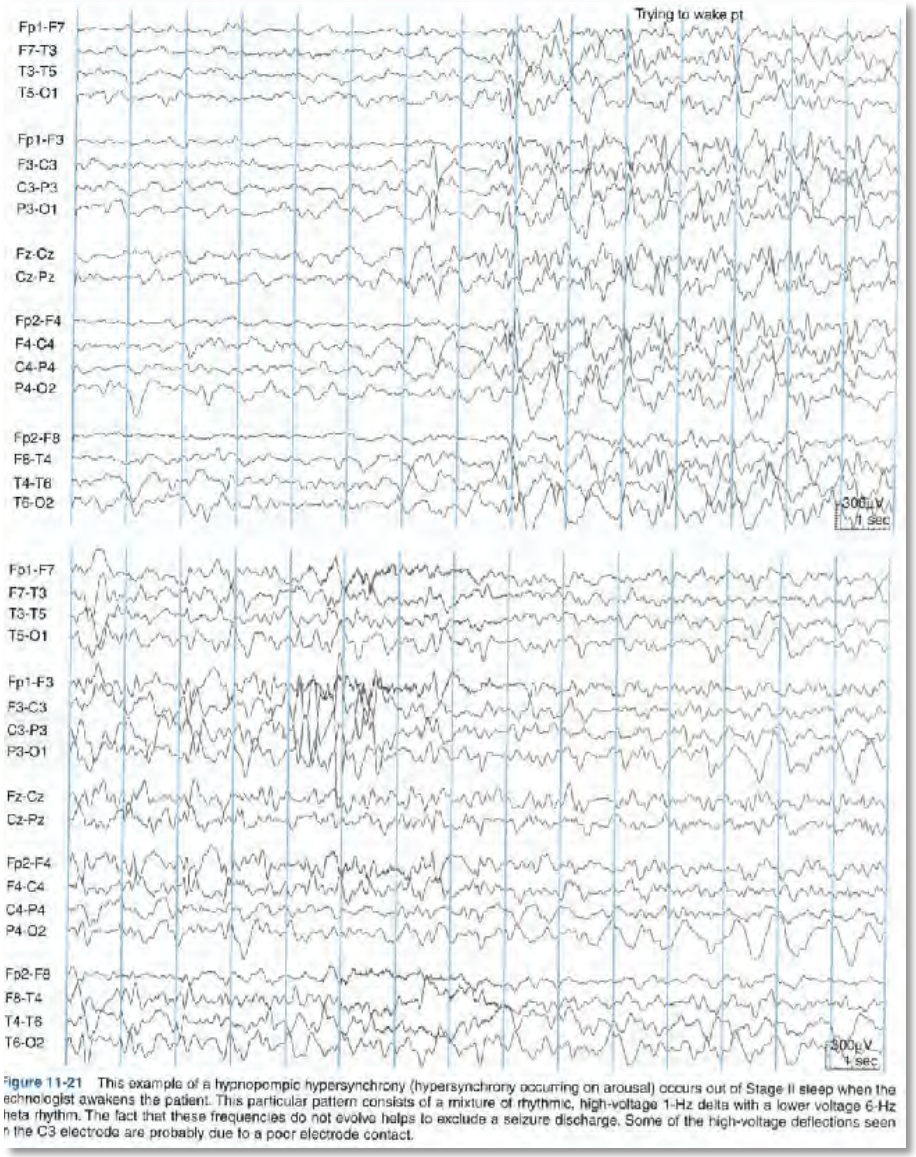


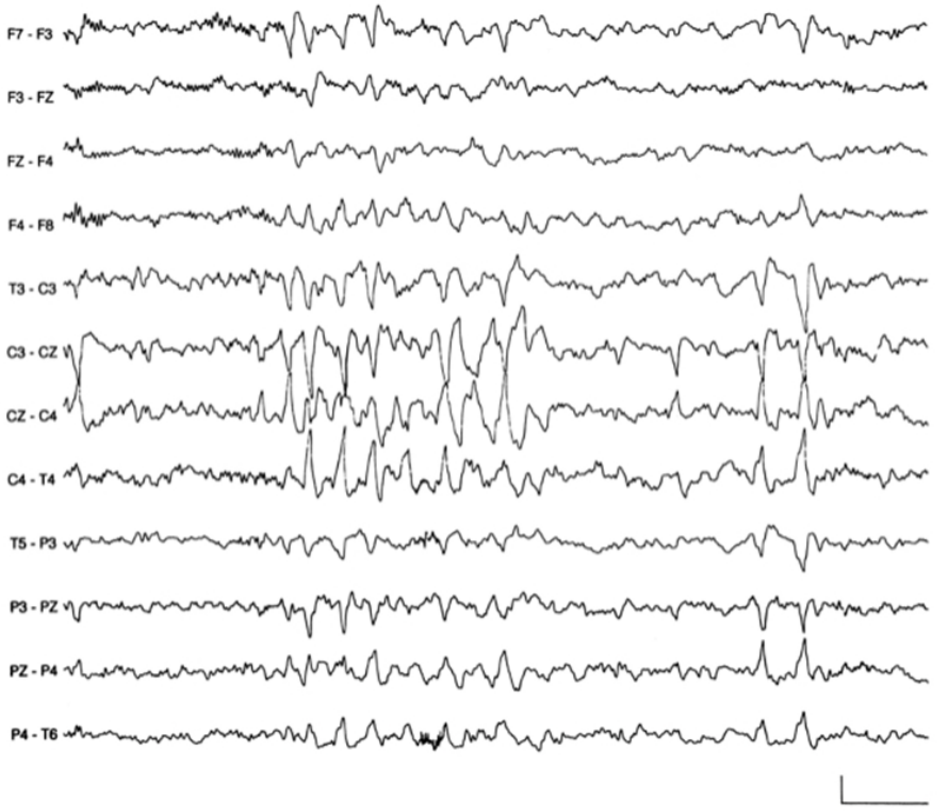
Figure 11-21 This example of a hypnopompic hypersynchrony (hypersynchrony occurring on arousal) occurs out of Stage II sleep when the echnologist awakens the patient. This particular pattern consists of a mixture of rhythmic, high-voltage 1-Hz delta with a lower voltage 6-Hz heta rhythm. The fact that these frequencies do not evolve helps to exclude a seizure discharge. Some of the high-voltage deflections seen n the C3 electrode are probably due to a poor electrode contact.

Hypnogogic Hypersynchrony
(on falling asleep)

Hypnopompic Hypersynchrony
(on arousal)

Sleep Variants

- **Cascading Vertex Waves**
  - Repetitive fashion - “cascading”
  - +/- sleep spindle
  - Stage II sleep



Take Home Messages

Approximately 30% of patients seen at epilepsy centers for refractory seizures do not have seizures and have been misdiagnosed !!!

'Looking too hard' syndrome:

Reader is 'trying too hard' to find abnormalities because the patient had a 'seizure' (history bias)

Always ask our self:

Brain generated? Artifact?

Epileptiform vs non- Epileptiform?