

Normal EEG in children

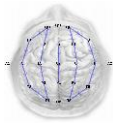
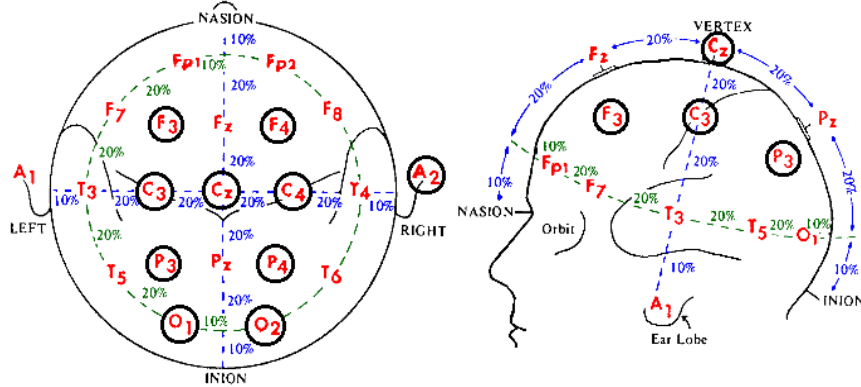
EEG workshop

Sorawit Viravan

Electrode placement

- **International 10-20 system**
 - Minimum 21 electrodes
 - Odd-numbered electrodes are placed on the left side of the head, and even-numbered electrodes are placed on the right side of the head
 - Specific letters designate the anatomical area; for example “F” means frontal

International 10-20 system

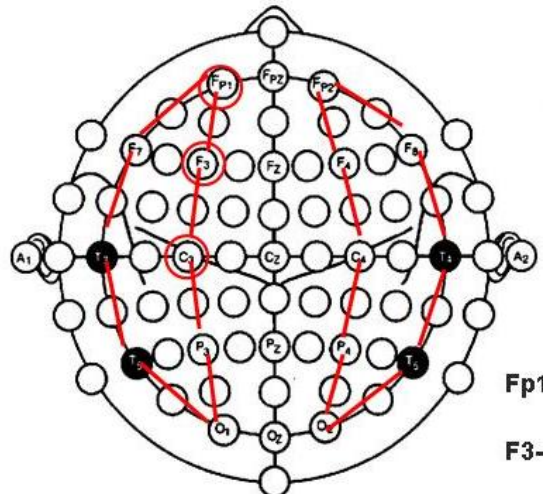


Common Montage types

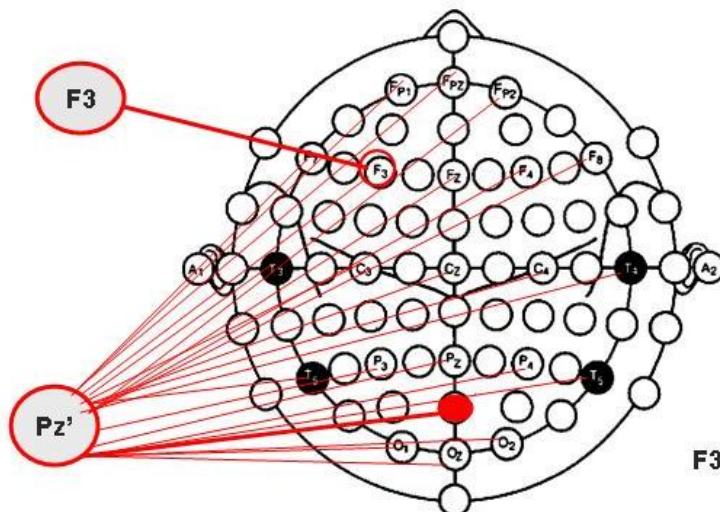
The difference in voltage between two electrodes

- **Bipolar:**
 - Each channel represents difference between 2 adjacent electrodes
 - AP bipolar
 - Coronal / transverse bipolar
- **Referential:**
 - Each channel represents the difference between a certain electrode and the designated reference position
 - ipsilateral ear
 - average
 - midline, etc.

AP bipolar montage (double banana): for localization



Referential montage: for amplitude measurement



EEG activity

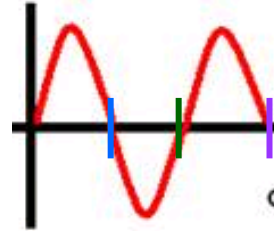
- Waveform
- Frequency
- Amplitude
- Polarity
- Timing

Wave form

- Spike
 - Sharply contoured, duration 20-70 msec
- Sharp wave
 - Sharply contoured, duration 70-200 msec
- Sharp transient
 - Sharply contoured waveform
- Other morphology
 - spindles, arciform, saw-tooth

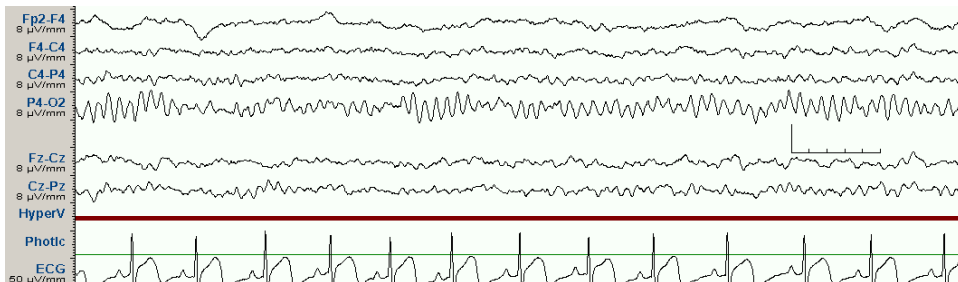
Wave form

- Monophasic wave
 - Single deflection: up or down
- Diphasic wave
 - 2 components on opposite sides
- Polyphasic wave
 - 2 or more components of different direction



Frequency

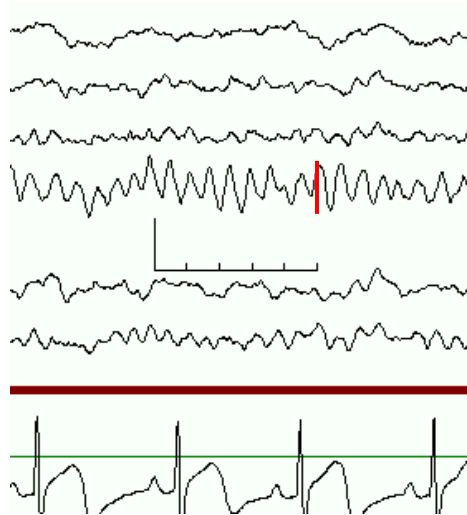
- Delta wave < 4 Hz
- Theta wave 4-7 Hz
- Alpha wave 8-13 Hz
- Beta wave > 13 Hz



Amplitude

Total vertical distance of wave

- Low < 20 μV
- Medium 20-50 μV
- High > 50 μV



Affected by barriers

Distribution

- Generalized / diffuse
- Lateralized
- Focal / localized

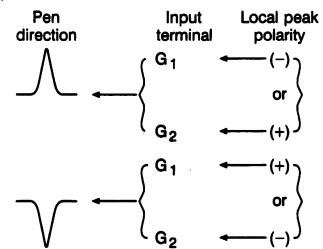
Polarity

Bipolar (input 1 – Input 2)

- Upward pen deflection
 - when input 1 is more negative than input 2
 - when input 2 is more positive than input 1
- Downward deflection
 - when input 1 is more positive than input 2
 - when input 2 is more negative than input 1

Referential (Input 1 – Ref)

- negative is up and positive is down



Timing

- Synchronous
- Bilaterally synchronous
- Asynchronous
- Independent

Pediatric EEG

EEG in newborn

- Post conceptional age
- Duration at least 60 minutes
- Awake / Active sleep / Quiet sleep

- Continuity / Synchrony
- Symmetry / Reactivity
- Normal specific EEG pattern

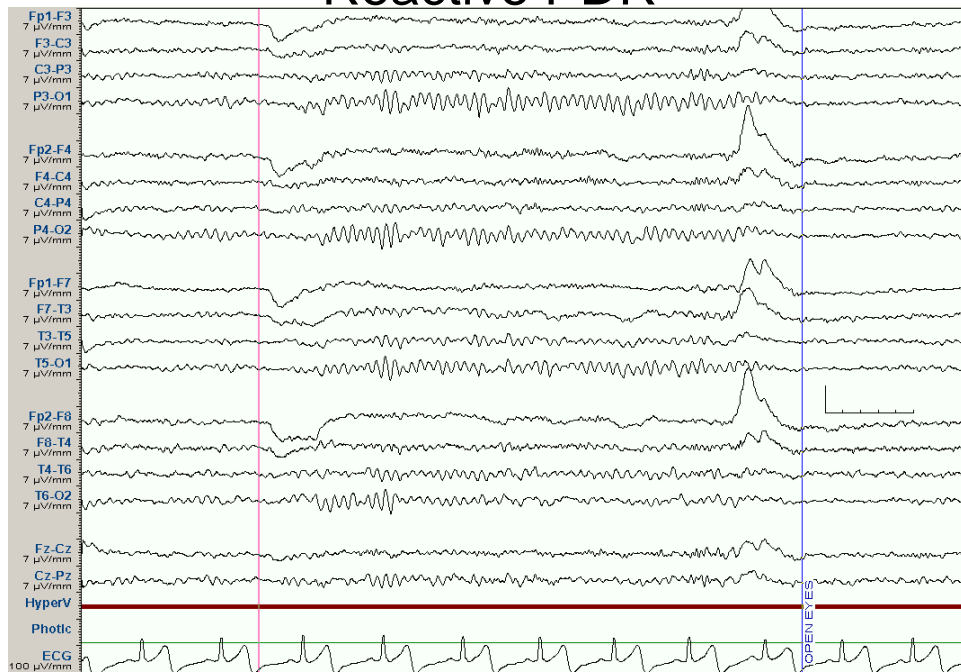
Awake

- Posterior dominant rhythm (PDR)
 - Posterior slow wave of youth (PSWY)
 - Mu rhythm
 - Beta activity
 - Lambda wave
-
- Eye movement
 - Artifact

PDR

- Alert, eye-closed, in rest state
- First seen at 3 months of age
- Maximum posterior head region
- Reactivity
 - Attenuation with eye opening, \pm anxiety

Reactive PDR



PDR

- Higher amplitude over right hemisphere
($< 50\%$ difference)
due to asymmetric skull thickness
- Amplitude $\sim 50-100$ uV
- Decreasing amplitude with increasing age
due to increased bone density of the skull

PDR

Frequency in Children

3-4 months:	4 Hz
12 months:	5-6 Hz
2 years:	7 Hz
3 years:	8 Hz
9 years:	9 Hz
15 years:	10 Hz

PSWY

- Slow activity intermixed with PDR
- Moderate voltage (<120% of normal alpha rhythm voltage)
- May be asymmetry
- Best seen in 8-14 years

- Block with eye opening
- Disappear with the alpha rhythm during drowsiness and light sleep

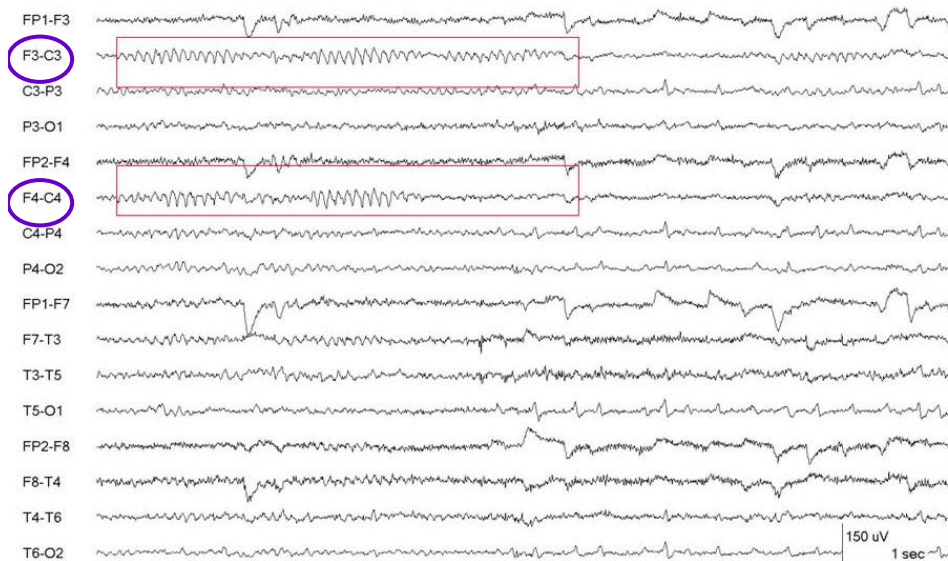
PSWY



Mu

- central arch-like rhythm of alpha frequency (usually 8-10 Hz)
- May be related to the functions of the sensorimotor cortex at rest
- Best seen between 8-16 years
- Asymmetrical
- Blocked unilaterally with movement of the contralateral extremity
- Not blocked by eye opening

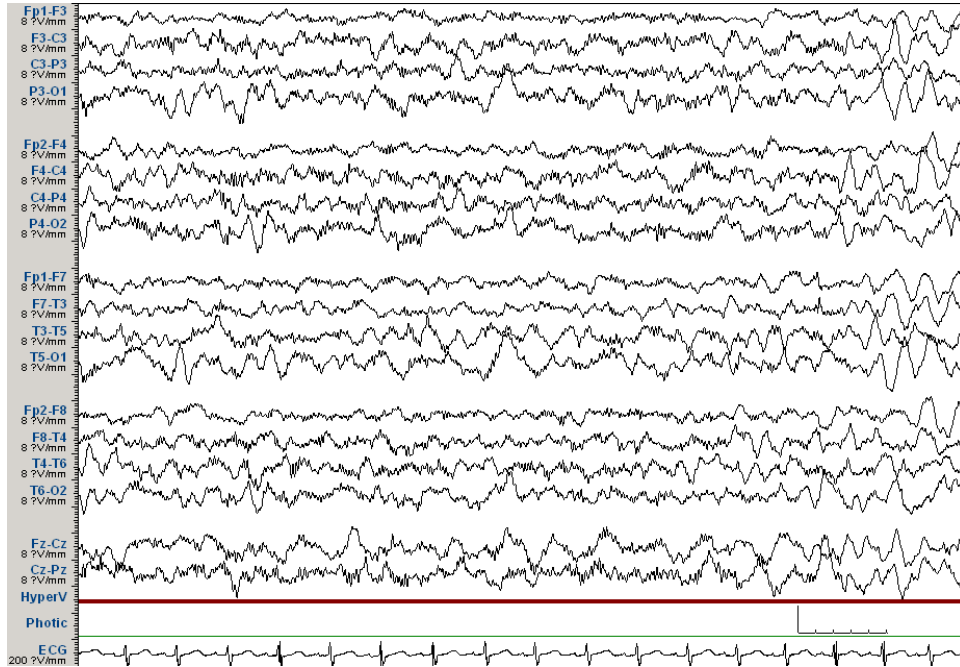
Mu rhythm



Beta

- Frequencies more than 13 Hz
- Amplitude < 20 uV, usually < 10 uV
- Three band
 - 18-25 Hz band (common)
 - 14-16 Hz band (less common)
 - 35-40 Hz band (rare)
- Increased by
 - Drugs eg. barbiturate, benzodiazepine, chloral hydrate (18-25 Hz > 14-16 Hz)

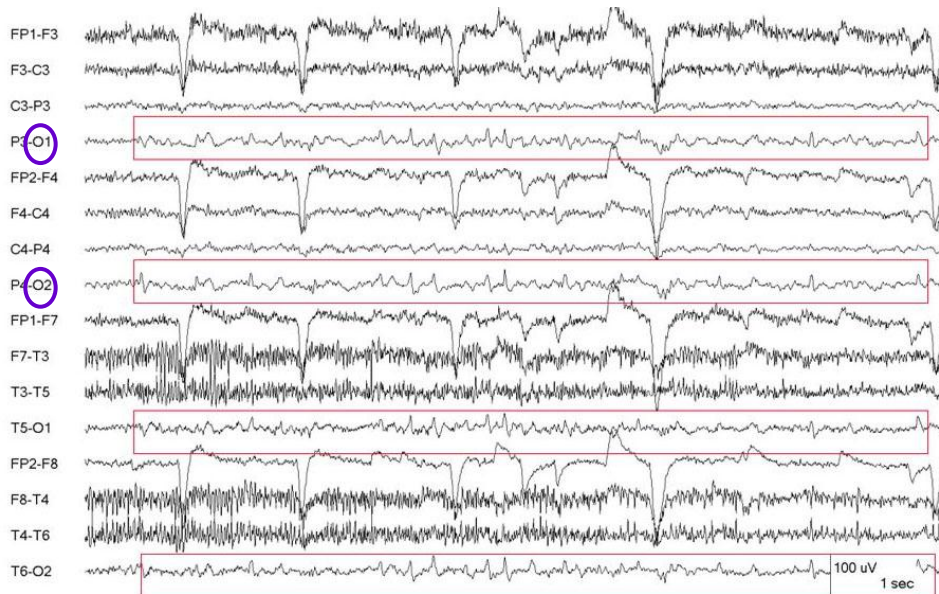
Beta due to medication



Lambda wave

- Surface positive, check mark-like wave
- Occipital region
- During eye opening
- Visually scanning at complex picture (ceiling, TV etc.) with saccadic eye movement
- Best seen in 2-15 years
- May be asymmetrical

Lambda



Eye movement (EM)

Vertical EM (Fp1, Fp2)

- Eye opening
- Eye closure
- Eye blinking

Horizontal EM (F7, F8)

- To the left
- To the right

Eye movement (EM)

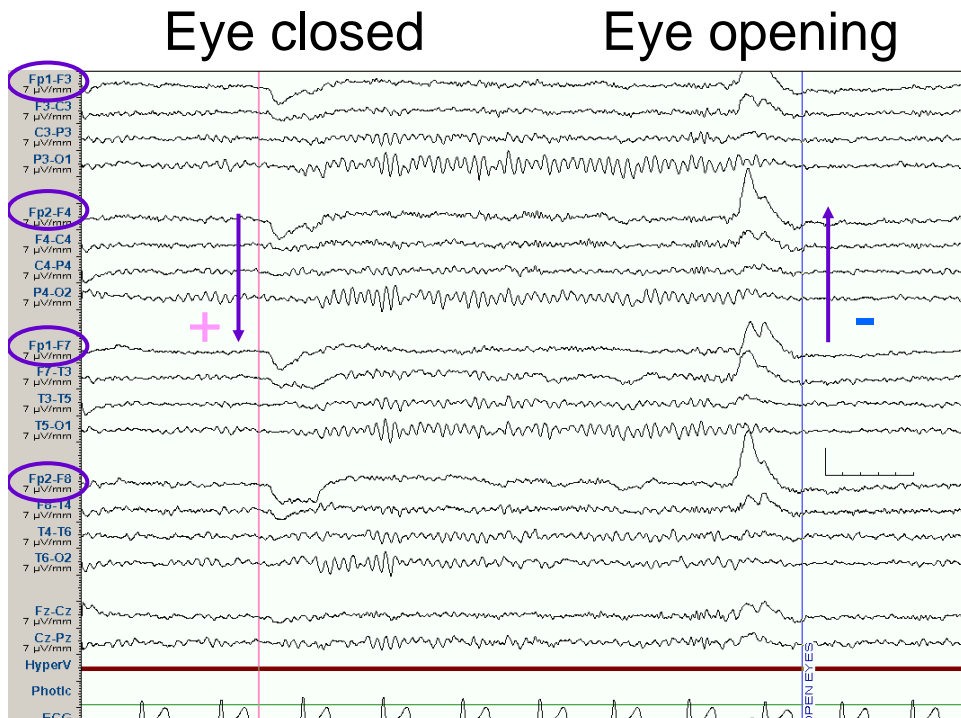
- Cornea → positivity
- Retina → negativity

- Nearest electrode of the direction of EM will pick up positivity, the opposite electrode will pick up negativity

Vertical EM

- Eye closure (relatively eyes go up)
 - Fp1 and Fp2 pick up positivity
 - downward deflection at Fp1-F7, Fp2-F8

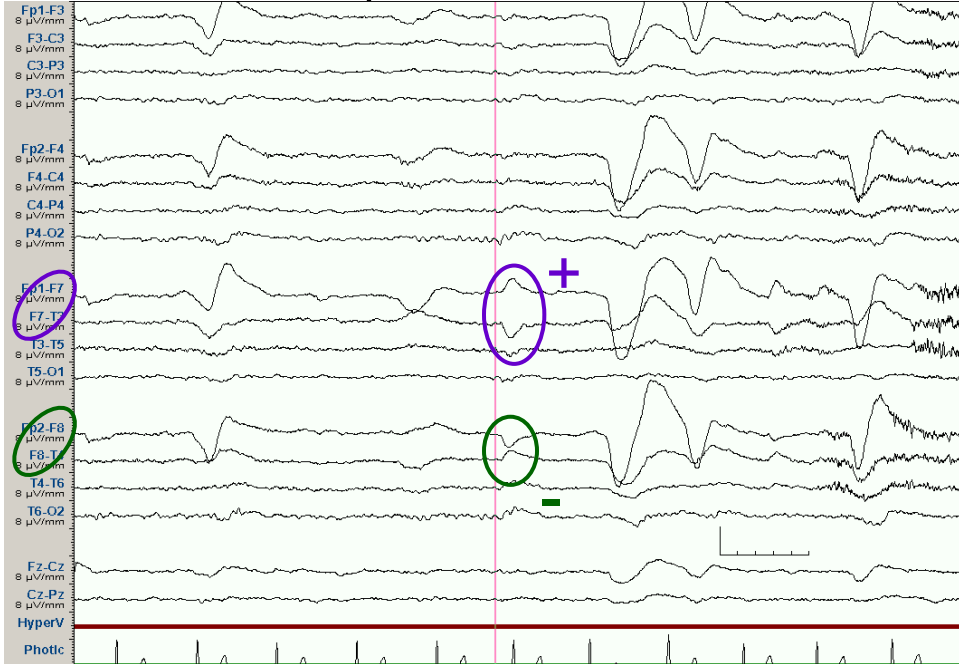
- Eye opening (relatively eyes go down)
 - Fp1 and Fp2 pick up negativity
 - upward deflection at Fp1-F7, Fp2-F8



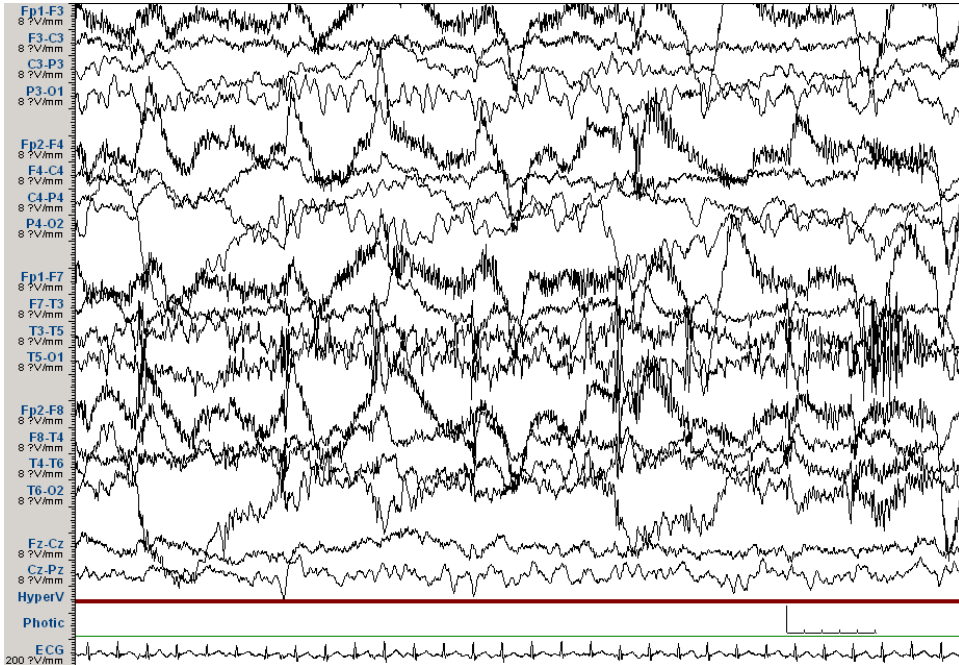
Horizontal EM

- Eye turn to the left
 - F7 pick up positivity, F8 pick up negativity
 - positive phase reversal at F7 (Hole)
 - negative phase reversal at F8
- Eye turn to the right
 - F8 pick up positivity, F7 pick up negativity
 - positive phase reversal at F8 (Hole)
 - negative phase reversal at F7

Eye to the left



Artifacts



Sleep

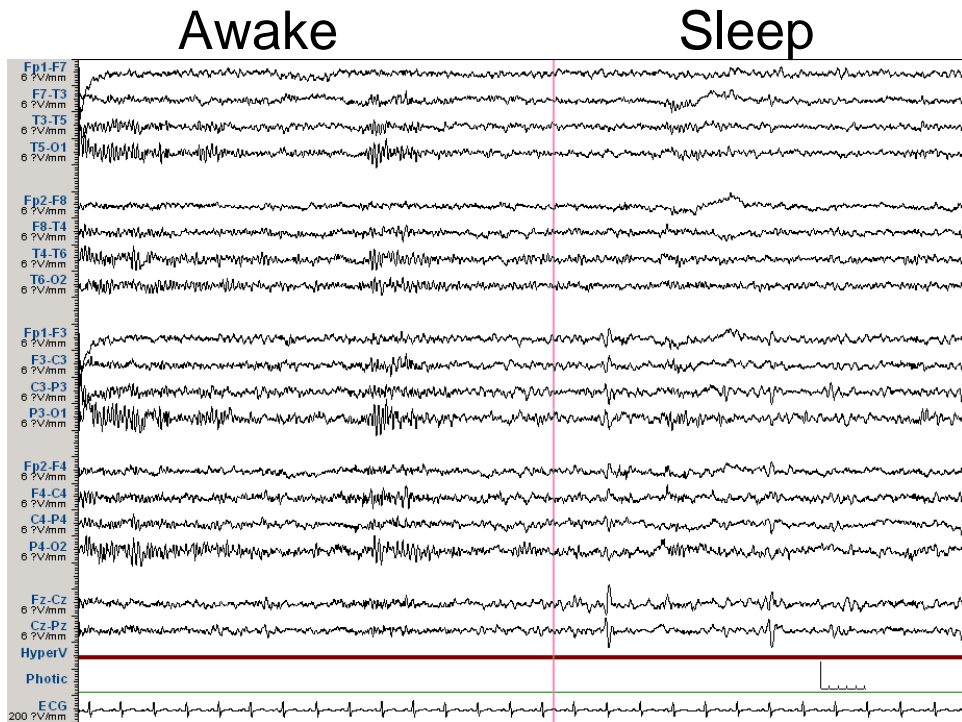
Non-REM sleep

- Stage 1 (drowsiness)
- Stage 2
- Stage 3 & 4

REM sleep

Stage 1

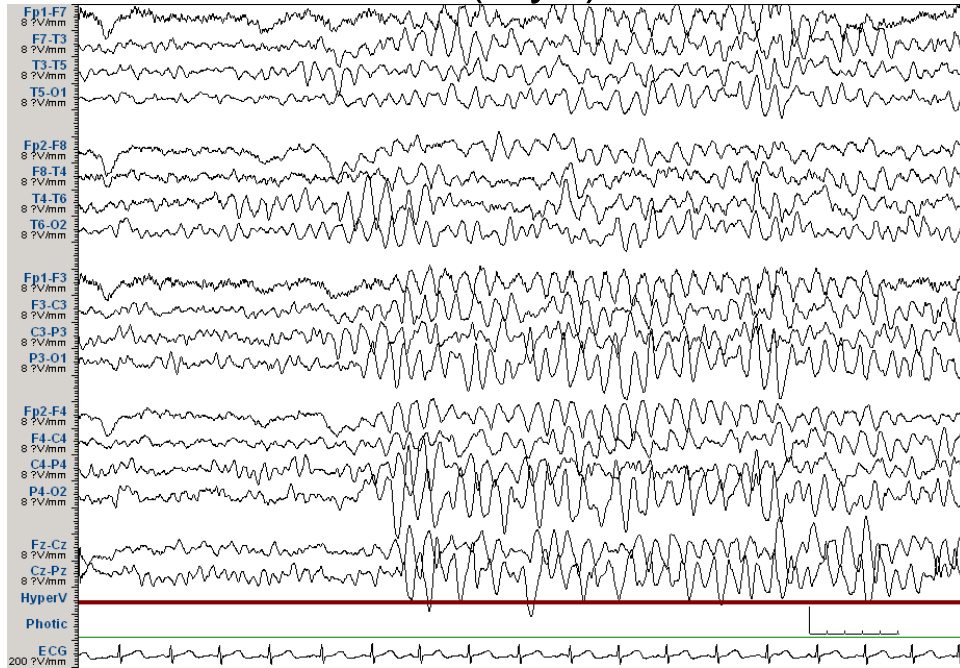
- Alpha drop out
- Hypnagogic hypersynchrony
- POSTs
- Beta activity
- Vertex wave



Hypnagogic hypersynchrony

- Burst of generalized high voltage 3-5 Hz
- Maximum fronto-central
- Awake → sleep
- Begin 6 months
- Best seen 1-5 years
- Rare after 11-12 years
- Hypnapompic: sleep → awake

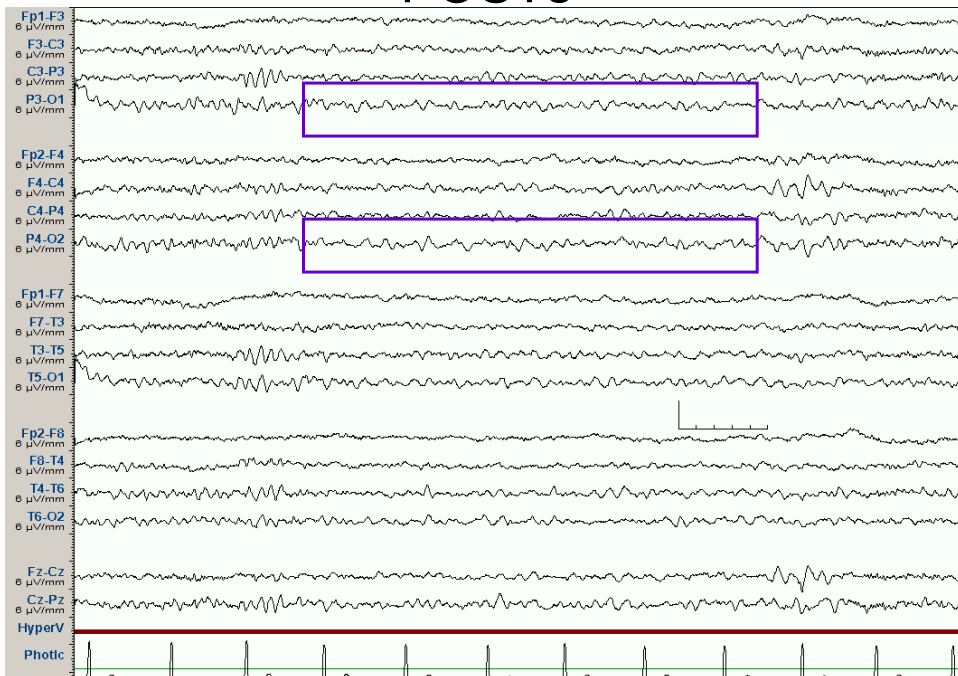
HH (2 yo)



POSTs

- Positive occipital sharp transients of sleep
 - 4-5 Hz, checkmark-like, isolated or in trains
 - Esp. daytime nap, arousal → return to sleep
 - Commonly asymmetry
-
- Age 4-50 years
 - Best seen 15-35 years

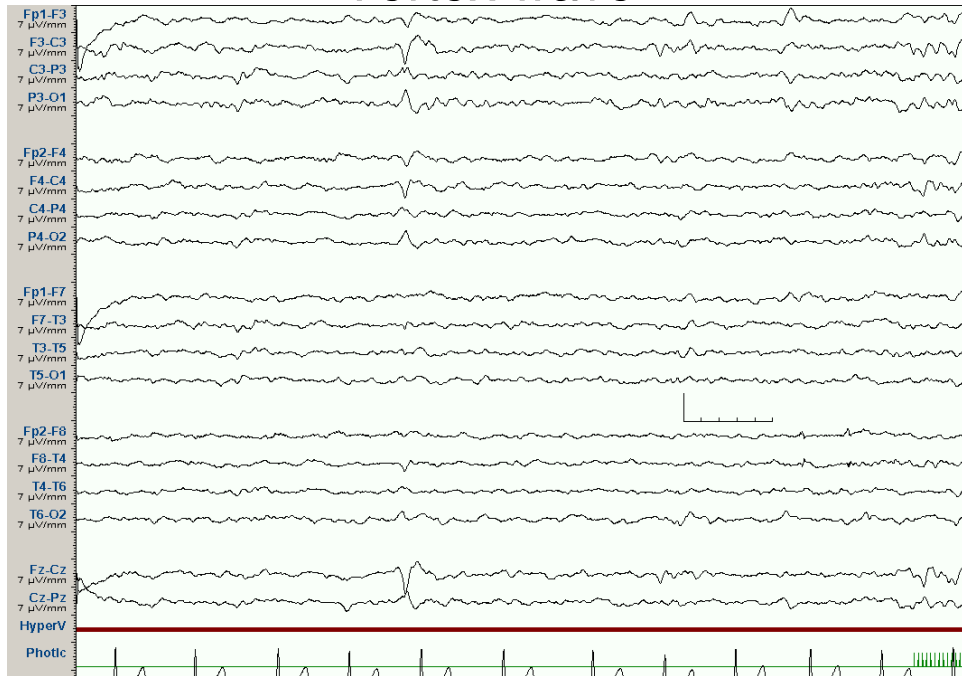
POSTs



Vertex wave

- Sharp transient maximum Cz (vertex)
- Begin 8 weeks post term
- Age 1-4 years; spiky and high amplitude
- Runs of vertex

Vertex wave



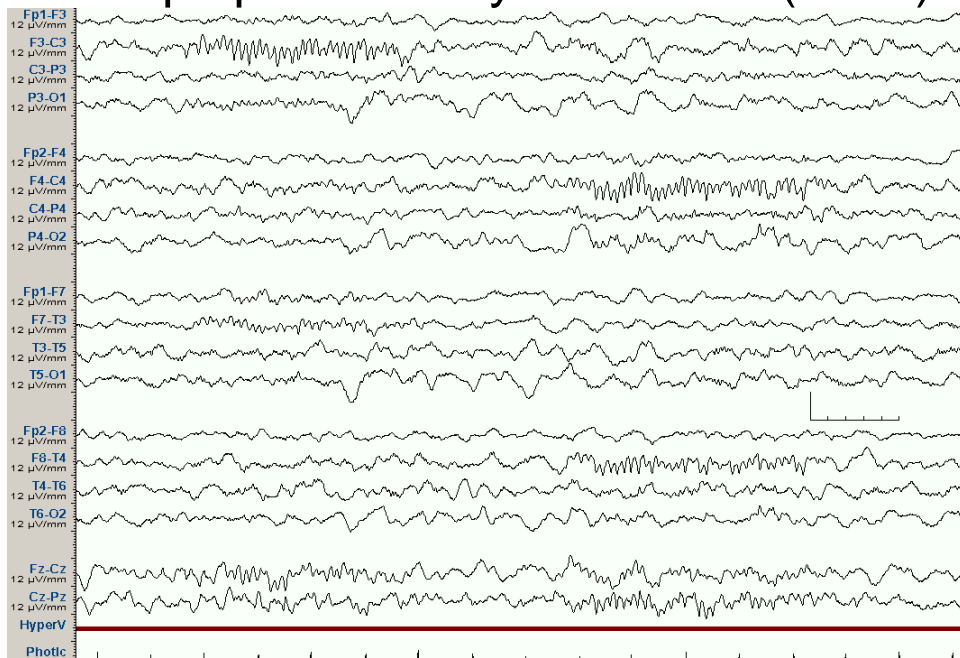
Stage 2

- Sleep spindles
- K-complex
- Delta wave
- (Vertex, POSTs)

Sleep spindles

- 11-14 Hz
- Maximum central, frontal (Cz, C3C4, F3F4)
- 2-5 seconds duration, may be spiky
- Lack of fusiform shape as in adult
- Begin 6-8 weeks post term; asynchronous but symmetrical
- Age 2 years; synchronous

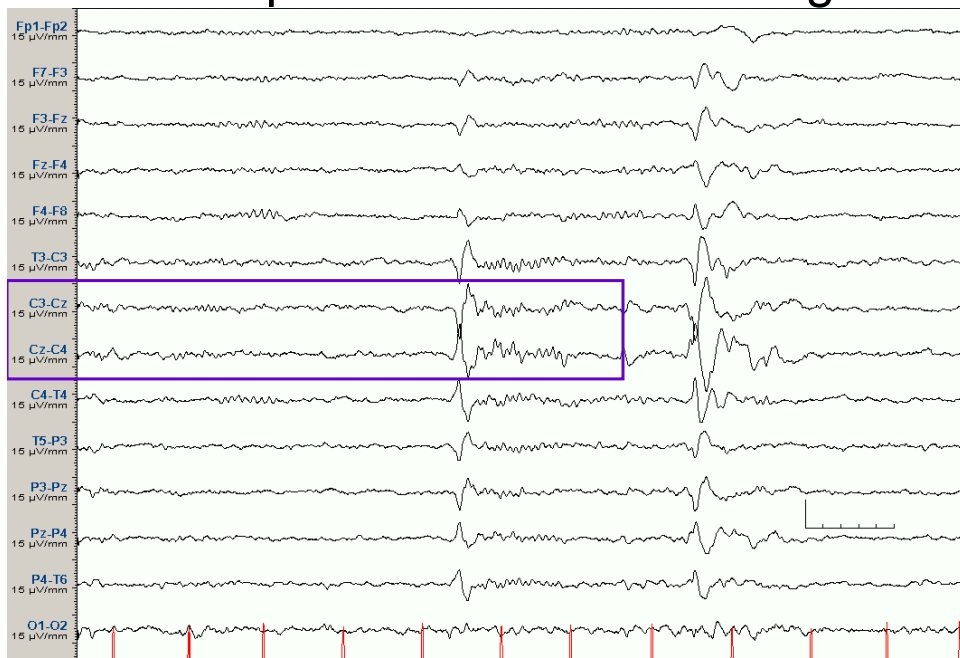
Sleep spindles: asynchronous (8 mo)



K-complex

1. Vertex + spindles
 2. Biphasic high amplitude slow wave
> 0.5 seconds duration
- Maximum Cz (vertex)
 - Begin 5 months

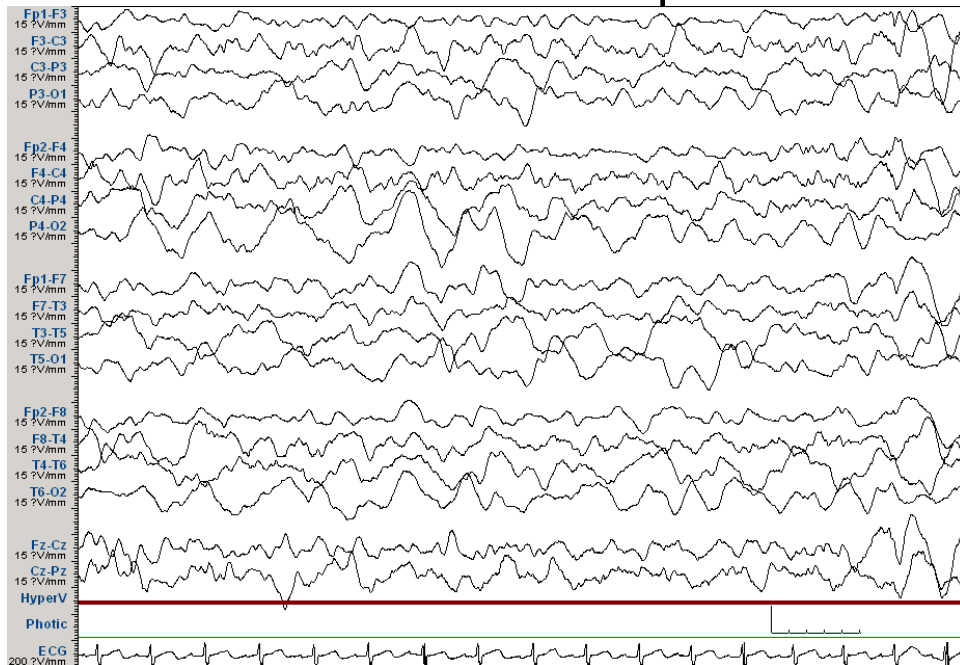
K-complex: transverse montage



Stage 3 & 4

- Delta activity
 - 20-50% → stage III
 - > 50% → stage IV
- (Sleep spindles)

Slow wave sleep



REM

- Sleep onset in newborn until 2.5 months, then NREM onset
- Rapid eye movement
- Relatively absent EMG
- Intermixed delta/theta, saw tooth appearance
- Rarely seen in routine pediatric EEG

Arousal

- Brief arousal period from sleep
- Abrupt change of the background
- Biphasic slow wave: begin 3 mo
- 4-5 Hz: begin 7 mo
- 8-10 Hz: adolescent
- Usually 4-5 seconds or longer

Photic stimulation

Done in dimly lit room, 30 cm away from eyes

Frequency 1-30 Hz

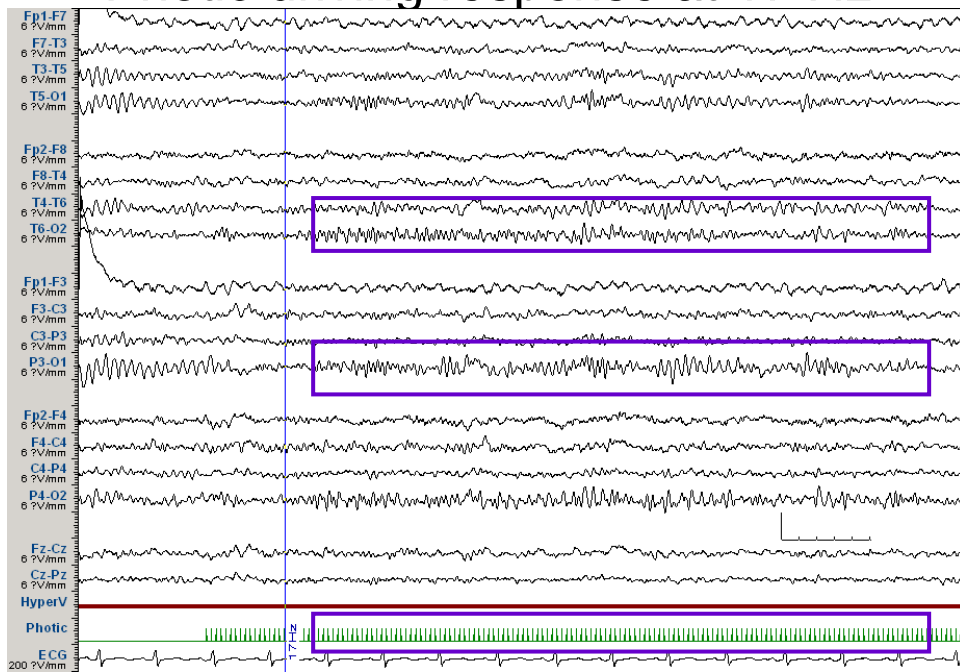
- Visual evoked response
- Photo myogenic response
- Photic driving response

Photic driving response

- Usually > 3 Hz
- Posterior head region
- Related to stimulus frequency

- Asymmetry is not associated with structural brain disease in the absence of other abnormalities

Photic driving response at 17 Hz



Hyperventilation test

- Duration 3 minutes; adequate
- Normal response: build up of diffuse, synchronous high voltage delta activity
- More prominent posteriorly in age < 8 yrs
- Change usually resolve within 60 seconds

HV response (11 yo)

