Normal EEG in adult

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Scope

- Definition of normal/abnormal EEG
- Descriptors of EEG activity
- Normal EEG of wakeful resting adults (20-60 years)
- Normal sleep EEG of adults (over 20 yr)
- Normal EEG of the elderly (over 60 yr)
- Activation procedures

Definition of normal/abnormal EEG

Definition

- EEG usually called "normal"
  - Not because it contains normal patterns
  - Because it lacks abnormal patterns
- EEG called "abnormal"
  - Contain abnormal components
  - Regardless of whether contain normal components

Definition

- A wide "variety" of normal EEG patterns seen
  - between persons of the same age
  - greater among different age groups
  - more in waking than in sleep record

Definition

- There are only a few definitely abnormal EEG components in any age group
  - Spikes, sharp waves
  - abnormal slow waves
  - abnormal amplitude changes

Definition

- Normal EEG not guarantee the absence of brain pathology
  - Not all brain pathology / dysfunction produce EEG abnormalities
- Abnormal EEG not always indicate cerebral abnormality
  - Few specific mild EEG abnormalities seen in some instances in normal persons

Descriptors of EEG activity

Descriptors of EEG activity

- Wave form
- Repetition
- Frequency
- Amplitude
- Distribution
- Phase relation
- Timing
- Persistence
- Reactivity

Wave form

Wave form

- Wave = any change in difference of electrical potential between two recording electrodes
- Sequence of waves = activity

Wave form

- Monophasic wave
  - Single deflection: up or down
- Diphasic wave
  - 2 components on opposite sides ☺
- Triphasic wave
  - 3 components alternating about baseline ☺
- Polyphasic wave
  - 2 or more components of different direction

Wave form

- Transient wave
  - Single wave or complex waves
  - Clearly standing out against background
  - Regarding "not definitely abnormal"
- Sharp transient
  - Sharply contoured waveform
  - Not abnormal epileptiform waveform ☺

Wave form

- Paroxysmal activity
  - One or more wave
  - Begin abruptly
  - Reach maximum amplitude abruptly
  - Disappear suddently
  - Clearly standing out of background
  - Usually abnormal

Wave form

- Spike
  - Sharply contoured, duration 20-70 msec ☺
- Sharp wave
  - Sharply contoured,duration 70-200msec ☺
- Spike and wave complex ☺
- Polyspikes ☺
- Polyspike and wave ☺

Repetition

Repetition

- Regular or rhythmic repetitive waves
  - Similar intervals between individual waves
  - Often, similar sharp ☺
- Irregular or arrhythmic repetitive waves
  - Variable, irregular intervals between individual waves
  - Sequence of waves of different frequency
  - Often, irregular shape ☺

Regular or rhythmic repetitive waves

- Sinusoidal waves
  - Sine-wave shape ☺
- Spindles
  - Gradually increase and then decrease in amplitude ☺

Frequency

Frequency

- Number of times a repetitive wave recurring in one second
- Frequency of a single wave
  - Calculated from wave length
- Periodic wave or complex
  - "Period" being calculated from "time interval" between them

Frequency bands

- Delta frequency band
  - Under 4 Hz ☺
- Theta frequency band
  - From 4 to under 8 Hz ☺
- Alpha frequency band
  - From 8 to 13 Hz ☺
- Beta frequency band
  - Over 13 Hz ☺

Frequency

- Fast activity
  - Over 13 Hz
- Slow activity
  - Under 8 Hz
- Frequency not regarded as cerebral activity
  - Less than 0.5 Hz
  - More than 20 Hz

Amplitude

Amplitude

- Measured in microvolt (μV)
- Measuring total vertical distance of wave
- Range
  - Low, under 20 μV
  - Moderate or medium, 20-50 μV
  - High, over 50 μV

Amplitude

- Asymmetry
  - Comparing between corresponding parts of two sides
  - Simultaneous time
  - Abnormal
    - If persist
      - For alpha rhythm; different more than two times

Amplitude

- Affected by
  - Spacing
  - Impedance

Distribution

Distribution

- Occurrence of electrical activity recorded by electrodes positioned over different parts of head
- Practically used distribution
  - Widespread, diffuse or generalized ☺
  - Lateralized ☺
  - Focal or localized ☺

Phase relation

Phase relation

- Refer to timing and polarity of components of waves in one or more channels
- In phase
- Out of phase
- Expressed with angle
  - 180° out of phase
- Phase reversal ☺

Timing

Timing

- Timing of waves in different areas
  - Similar
    - Simultaneous: broadly precise coincidence
    - Synchronous: definitely precise coincidence
      - Bilaterally synchronous or bisynchronous
  - Different
    - Asynchronous
    - Independent

Persistence

Persistence

- To describe how often activity occurs
  - Occasionally
  - Intermittently
  - Throughout
  - Persistent
  - Sporadic: irregular and infrequent
  - Periodic
- May be calculated as "index"

Reactivity

Reactivity

- Changes produced by various maneuvers
  - Increased
  - Diminished
  - Blocked

Reactivity

Maneuvers

- Opening or closing eyes
- Hyperventilation
- Photic stimulation
- Sensory stimulation
- Changes in level of alertness
- Movements, e.g. arm movement
- Others, e.g. simple calculation

Normal EEG of wakeful resting adults (20-60 years)

Normal EEG of wakeful resting adults (20-60 years)

Composed of various types of activity alone or in combination

- Alpha rhythm
- Beta rhythms
- Mu rhythm
- Lambda waves
- Vertex sharp transient
- Kappa rhythm
- Intermittent posterior theta rhythms
- Low voltage activity

Alpha rhythm

defined by frequency, distribution and reactivity

- Frequency : alpha activity, 8-13 Hz
  - Fairly constant
  - Equal in both sides
- Distribution : posterior part
  - Greatest amplitude and most persistent in occipital and parietal areas
  - Seen in temporal and central in the young
- Reactivity : blocked by eye opening, sudden alerting, attention and mental concentration

☺

Alpha rhythm

- Wave form : regular, often sinusoidal
- Phase relation : may vary over different parts
- Timing : simultateous on both sides
- Persistence :
  - Vary among normal subject
  - Prominent, waxes and wanes, rare occurrence, complete absence
  - Decrease with age

Beta rhythms ☻

- Defined by only frequency: over 13 Hz
- Distribution
  - Frontal beta rhythms
  - Widespread beta rhythm
  - Posterior beta rhythm or fast alpha variant
- Reactivity: disappear in drowsiness/sleep

Beta rhythms

- Amplitude :
  - Usually lower than alpha activity
  - Symmetry, different less than 35% in amplitude
- Persistence : increase with age

Mu rhythm

- Arch-shaped waves at 7-11 Hz
- Appear in trains of a few seconds
- Over central or centro-parietal regions
- Often, intermittent and asynchronous
- Blocked by movement, intention to move, tactile stimuli
- Not blocked by eye opening

Mu rhythm

- Facilitated by scaning visual image
- Paradoxical mu rhythm
  - Induced by contralateral movement or touch after drop out during drowsiness

Lambda waves ☺

- Sawtooth shape, positive polarity sharp transient
- Over occipital regions
- Elicited by looking at image containing visual detail
- Asymmetry in amplitude = abnormal
- Presence or absence = no meaning

Vertex sharp transients (V waves)

- Sharp transients, negative polarity
- Occur very rarely at vertex following sudden loud noise or other unexpected stimuli

Normal posterior theta rhythms

- Rare
- Distribution and reactivity resemble that of alpha rhythms
- Two patterns
  - Slow alpha variant:
    - half the frequency of alpha rhythm
    - alternating with alpha rhythm
  - Rhythmic slow waves of about 4-5 Hz

Low voltage EEG

- No activity over 20 μV from any parts
- At high sensitivity, a wide range of frequency can be distinguished.
- Found in tense subject
- More common in advancing age
- Must be distinguished from electrocerebral inactivity

Normal sleep EEG of adults (over 20 yr)

Normal sleep EEG of adults
(over 20 yr)

Elements of sleep EEG

- Slow wave ☺
- Sleep spindles ☺
- Positive occipital sharp transients of sleep (POSTs) ☺
- Vertex sharp wave ☺
- K complexes ☺

Normal sleep EEG of adults
(over 20 yr)

Eye movements during sleep

- Slow lateral eye movements ☺
- Rapid eye movement ☺

Normal sleep EEG of adults
(over 20 yr)

Sleep stages

- Drowsiness ☺
- Stage I
- Stage II ☺ €
- Stage III
- Stage IV
- Stage REM ☺

Normal EEG of the elderly (over 60 yr)

Normal EEG of the elderly (over 60 yr)

Similar to that of younger adults **except**

- Alpha rhythm
  - May be slower, less persistent, less reactive
- Beta activity
  - Often more prominence
- Sporadic generalized slow wave
  - Slightly more common

Normal EEG of the elderly (over 60 yr)

- Intermittent temporal slow waves
  - Appear in some apparently normal subjects
- Sleep
  - Less deep, more often interrupted by wakefulness

Activation procedures

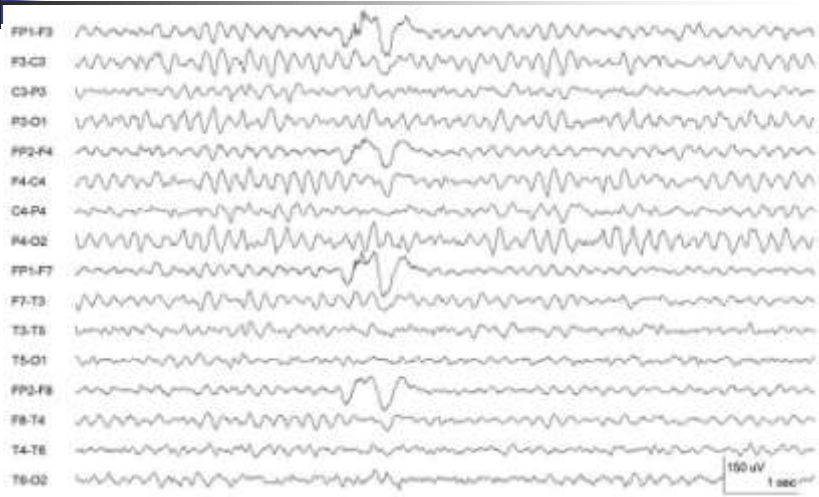
Activation procedures

- To induce, enhance or better define abnormal EEG patterns
- However, they may induce normal patterns that are not seen in spontaneous EEG.

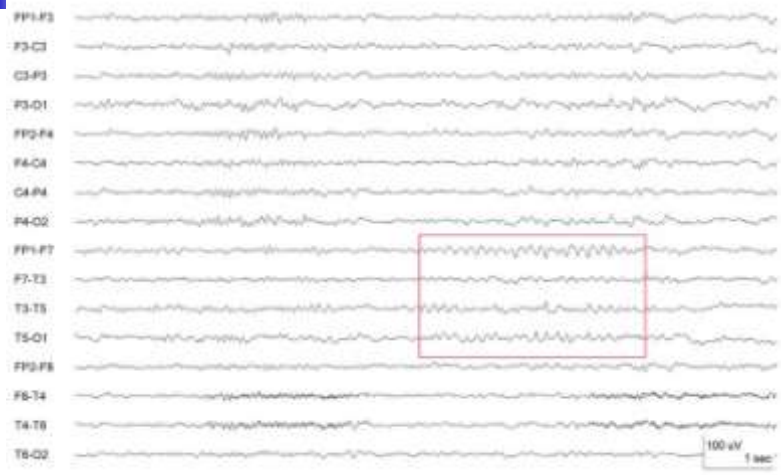
Activation procedures

- Hyperventilation
- Photic stimulation
- Sleep recordings
- Other stimuli, e.g. patterned light, startling noise, musical sounds, reading, tactile stimuli, etc.

Regular or rhythmic repetitive waves



Regular or rhythmic repetitive waves



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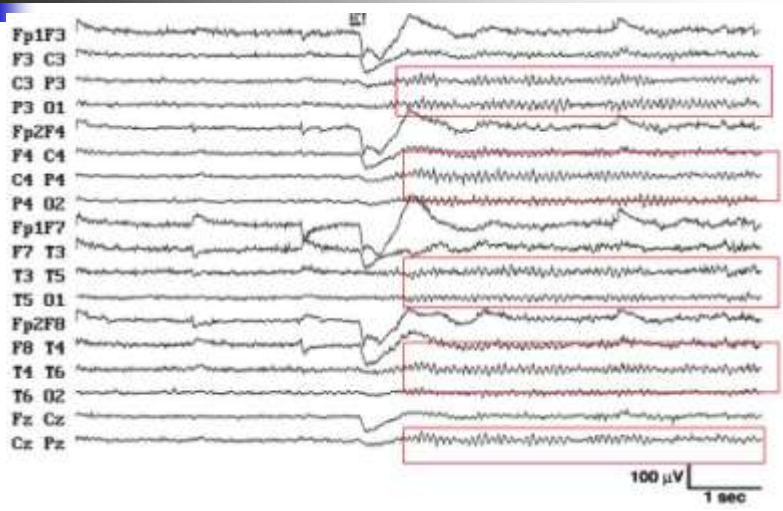
Alpha rhythm



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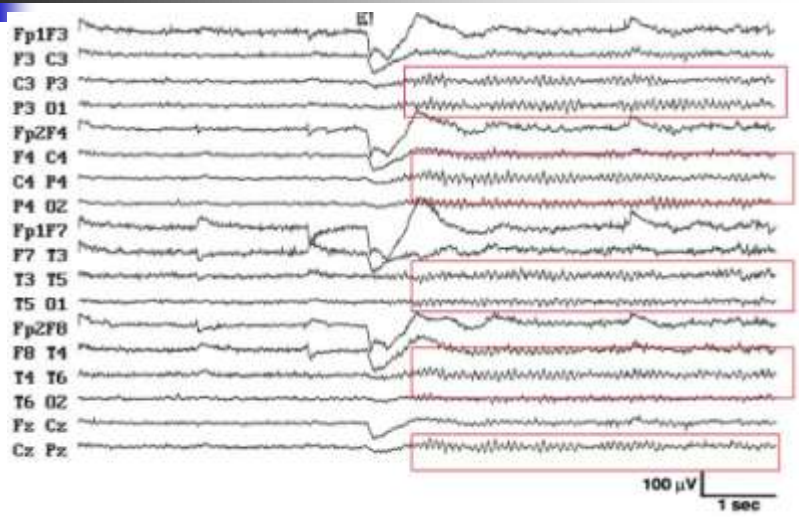
Sinusoidal wave form



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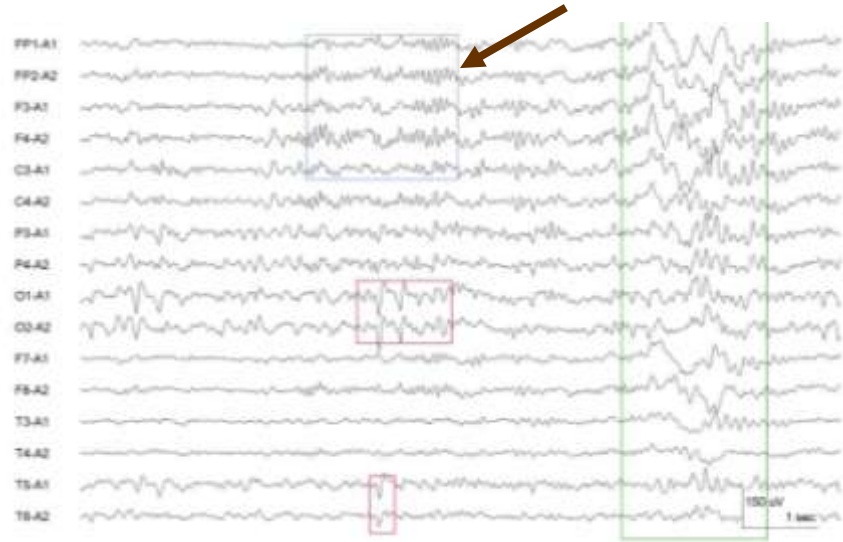
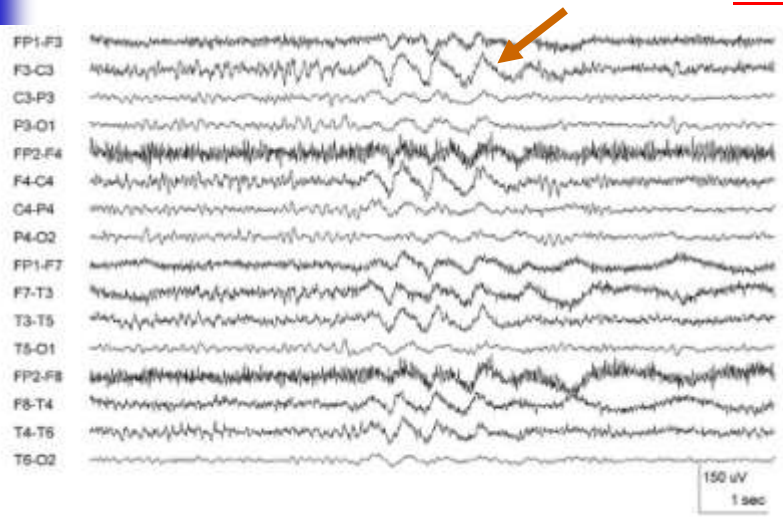
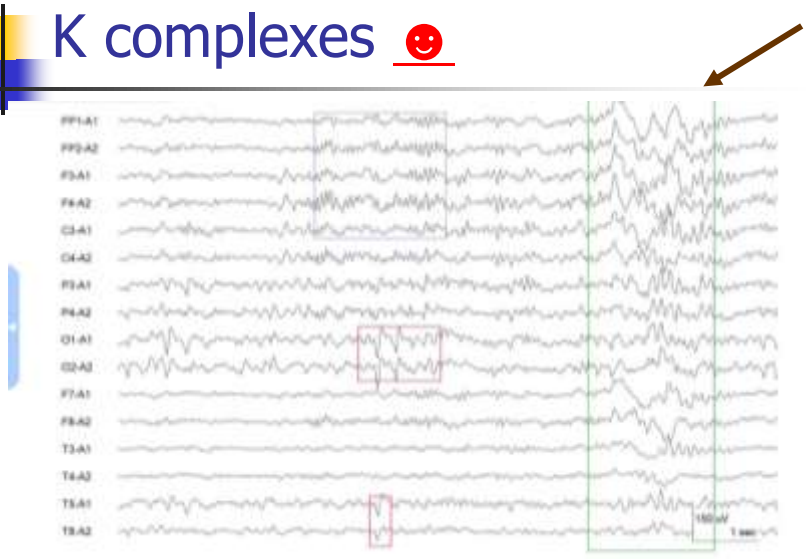
Spindles



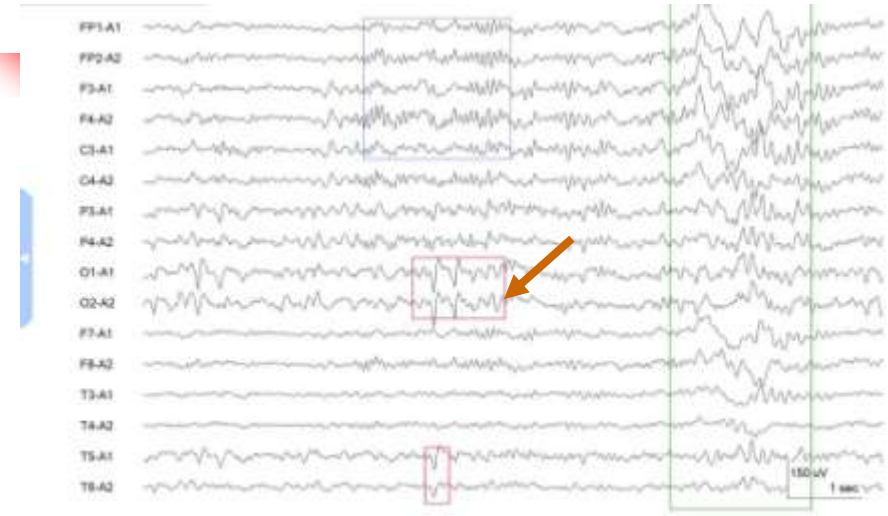
Delta waves



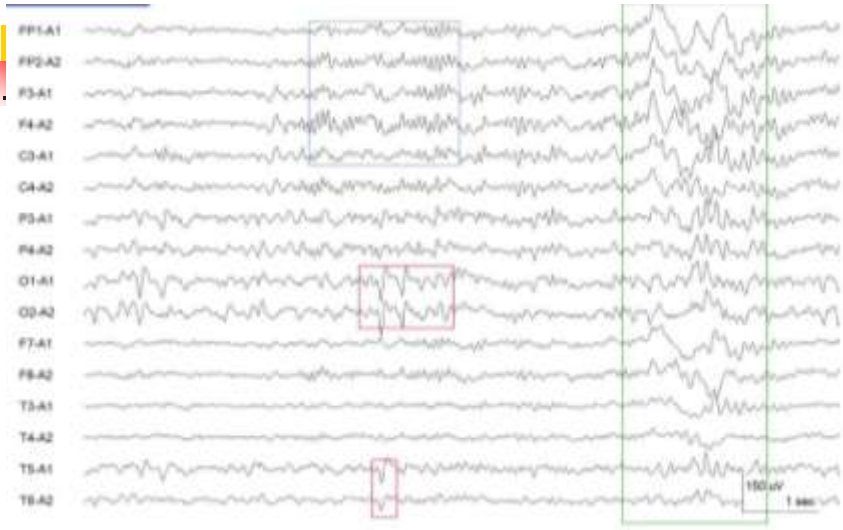
K complexes



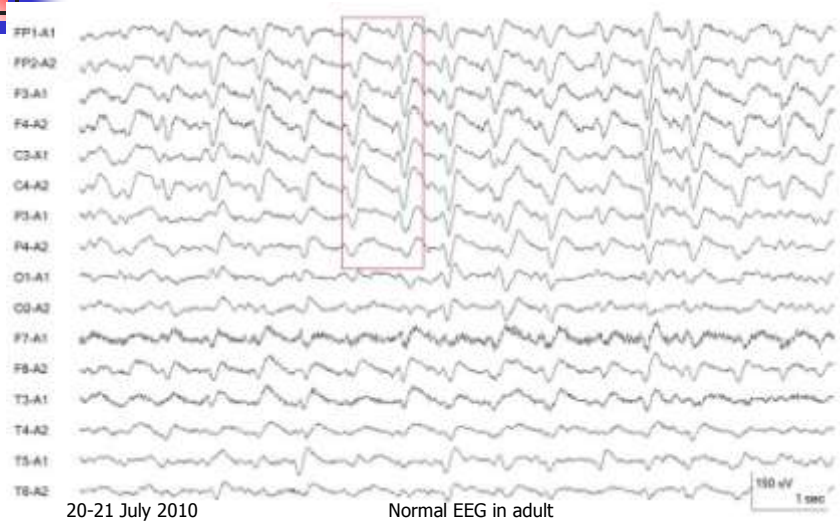
POSTs ☻



Sleep stage II ☻

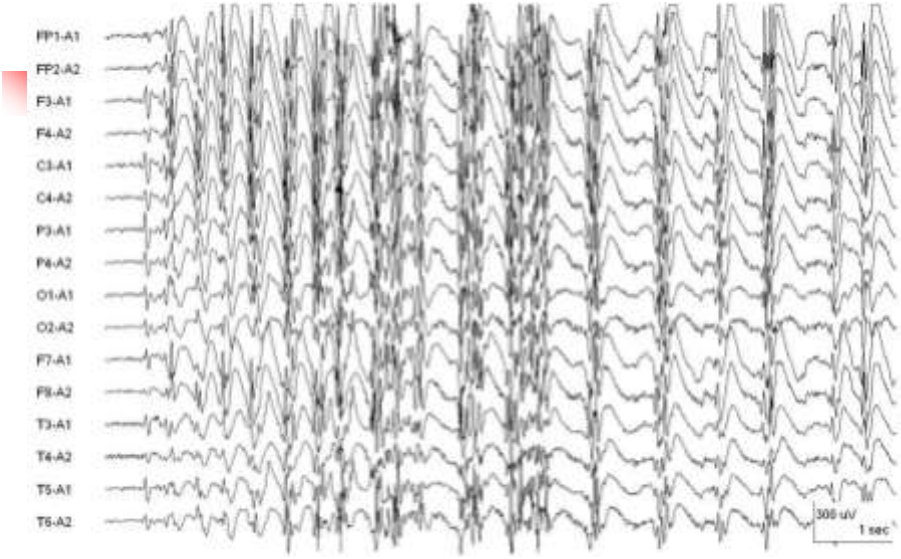


Triphasic wave ☻

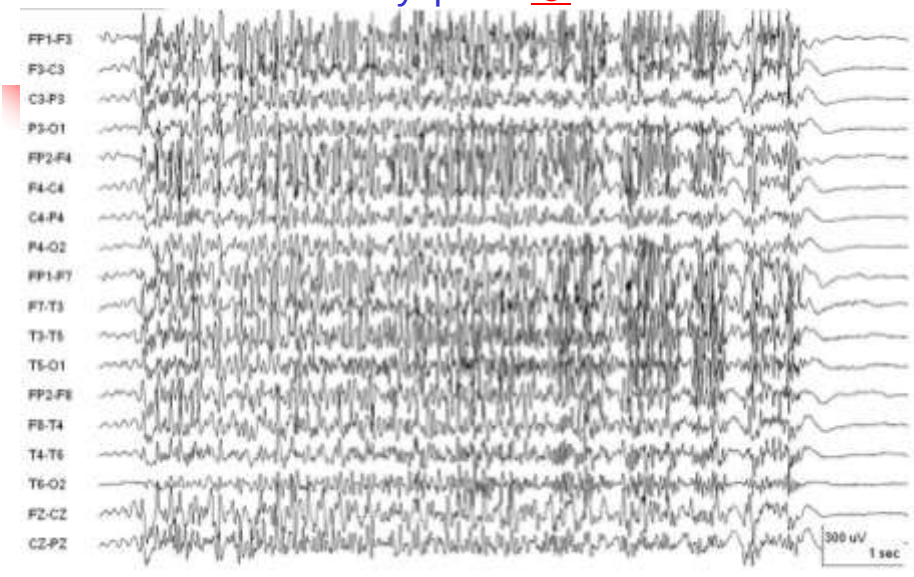


Diphasic wave ☻

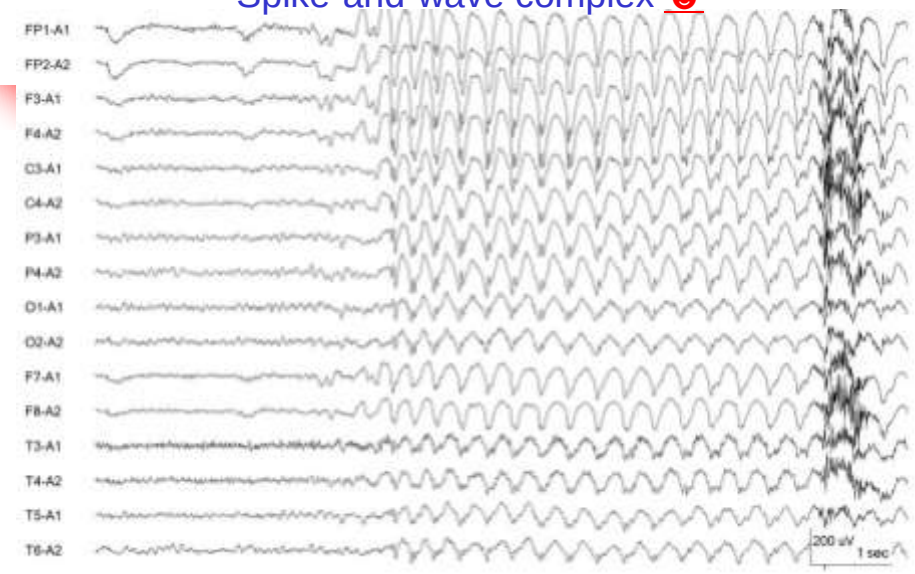
Polyspike and wave



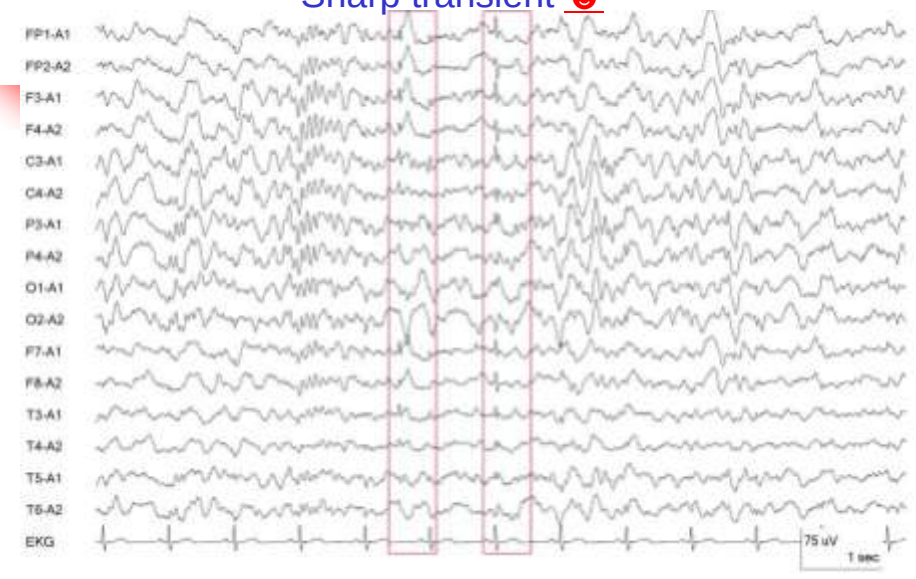
Polyspikes



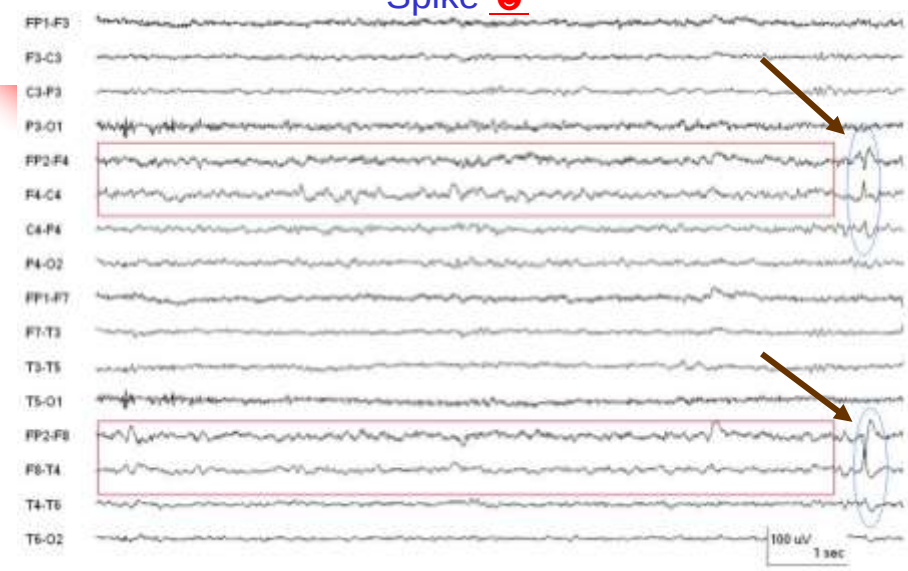
Spike-and-wave complex ☻



Sharp transient ☻

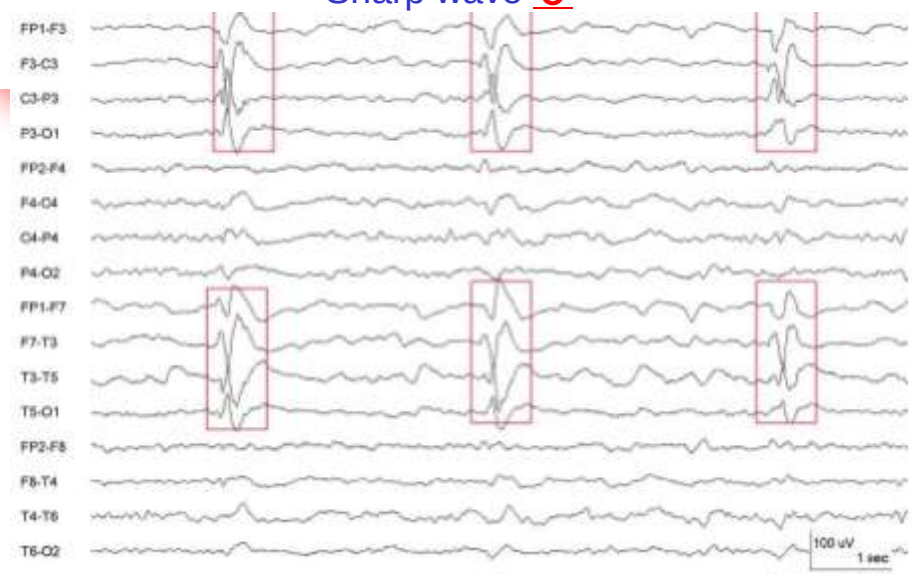


Spike ☻



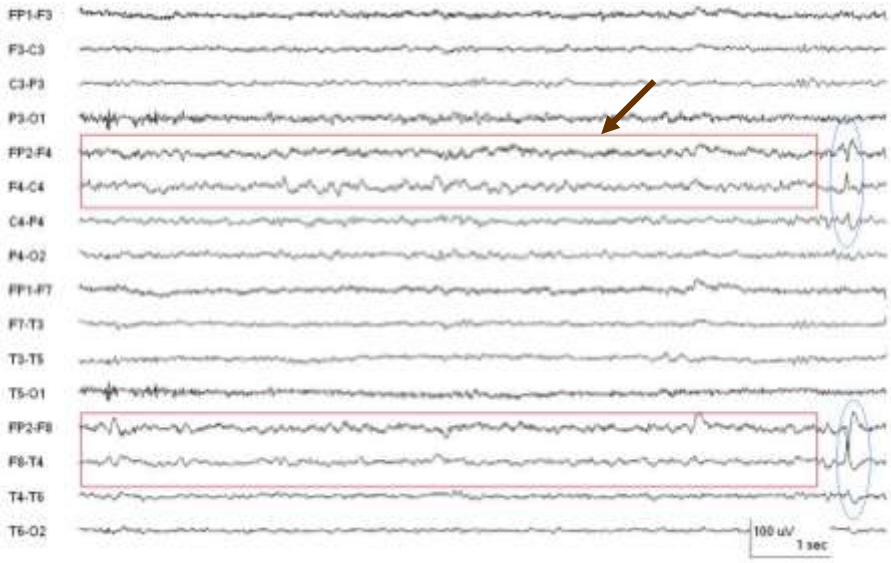
20-21 July 2010 Normal EEG in adult 75

Sharp wave ☻

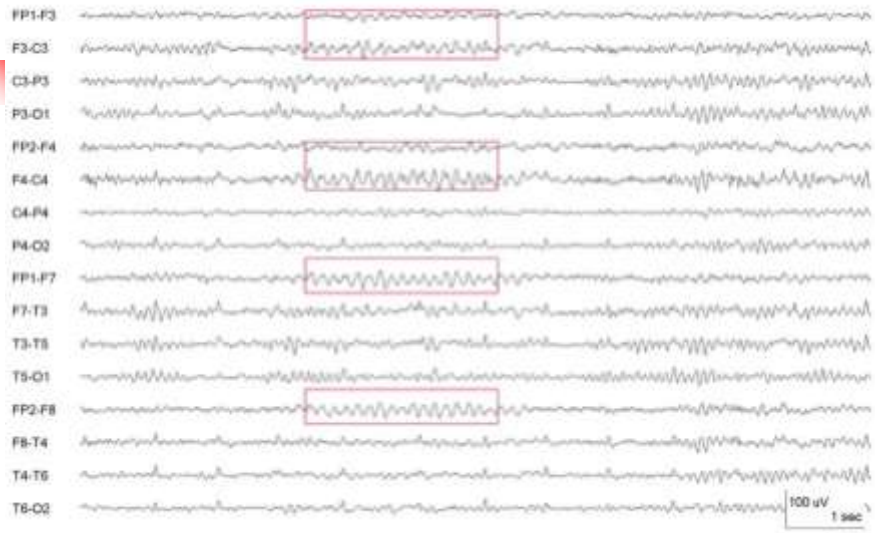


20-21 July 2010 Normal EEG in adult 76

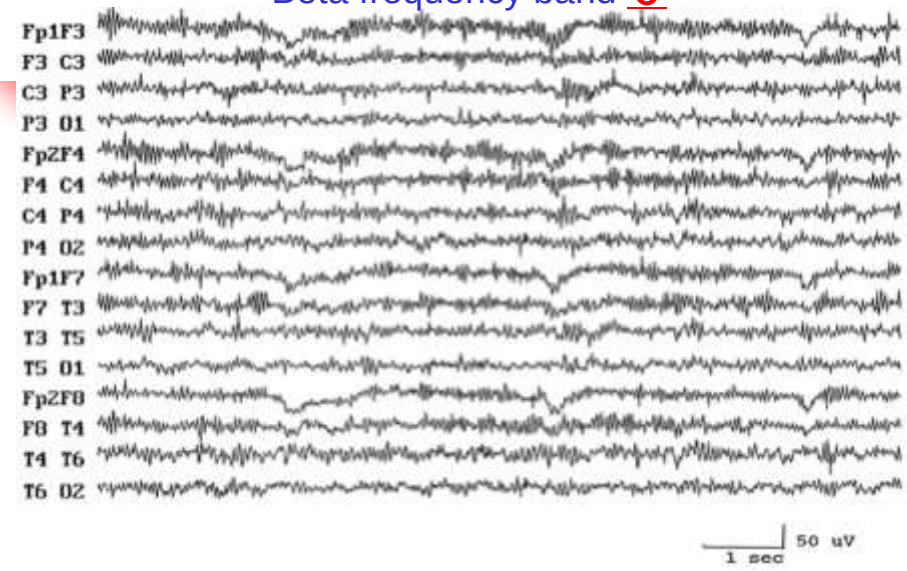
Irregular or arrhythmic activity ☻



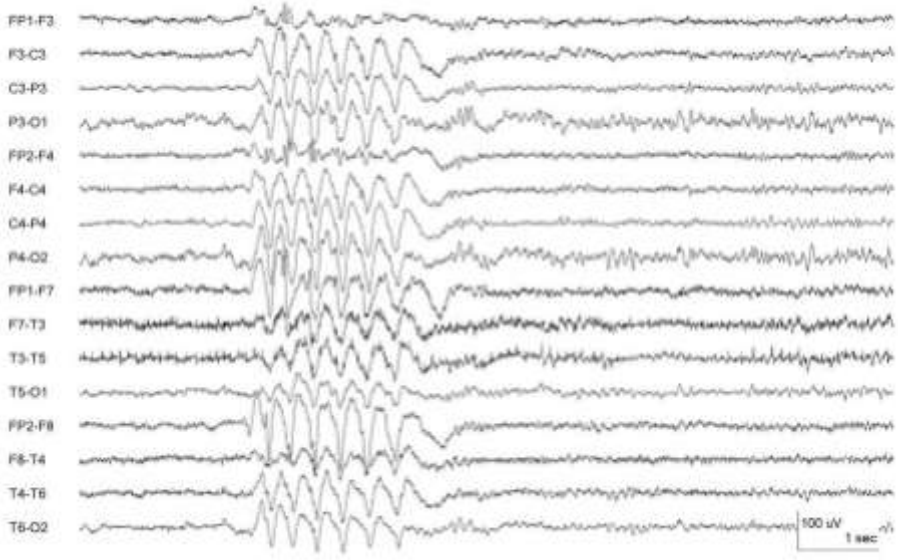
Theta frequency band ☻



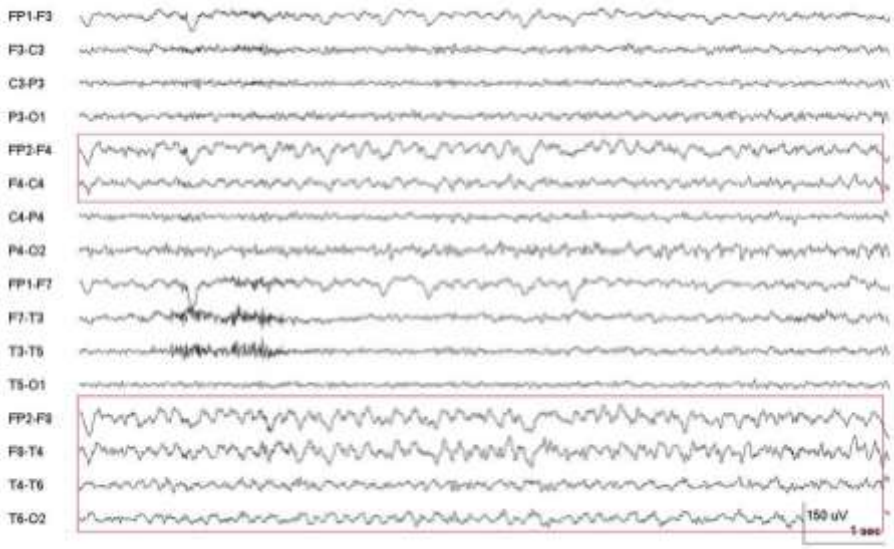
Beta frequency band ☻



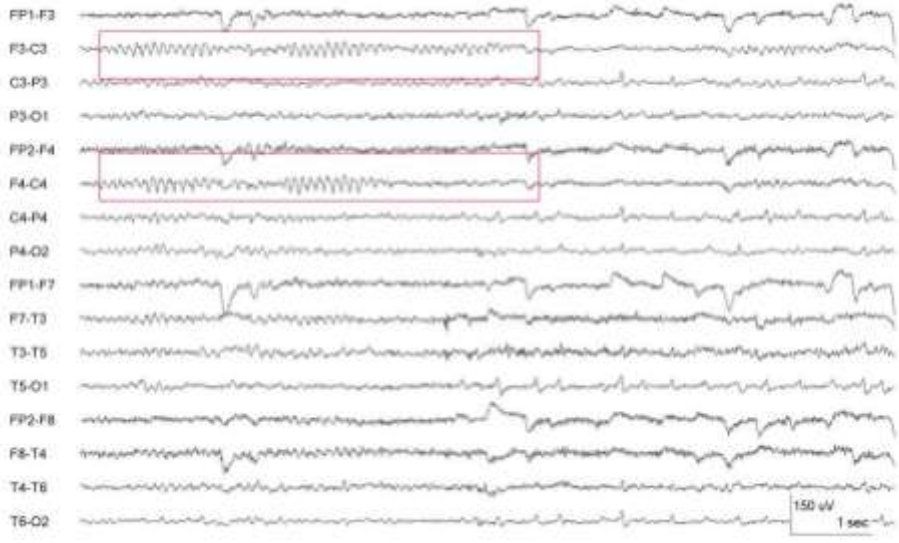
Wide spread or generalized distribution ☻



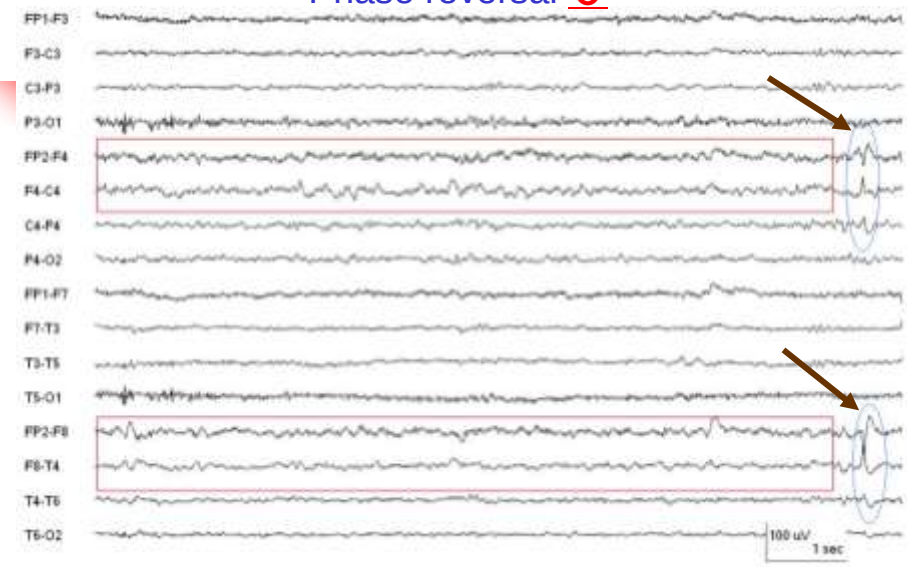
Right hemisphere, lateralized distribution ☻



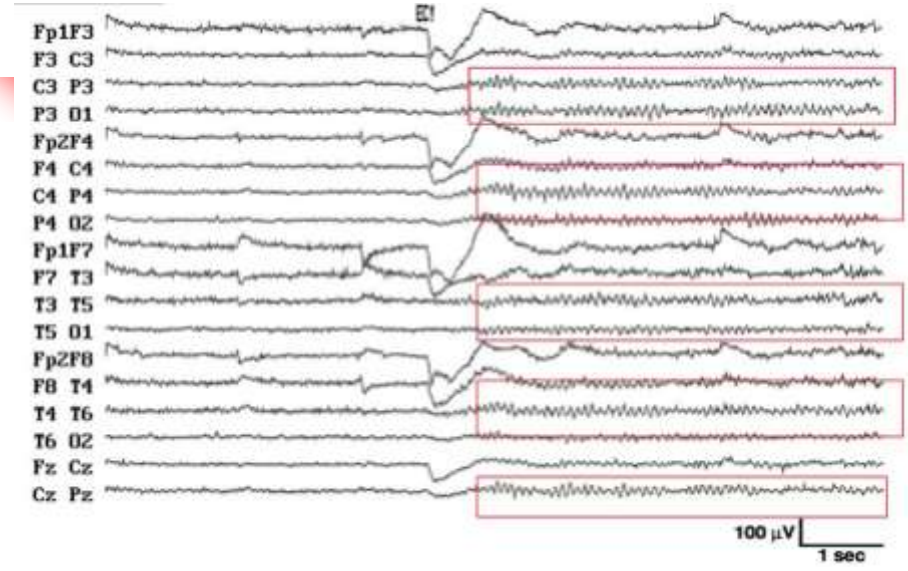
Localized distribution, central area ☻



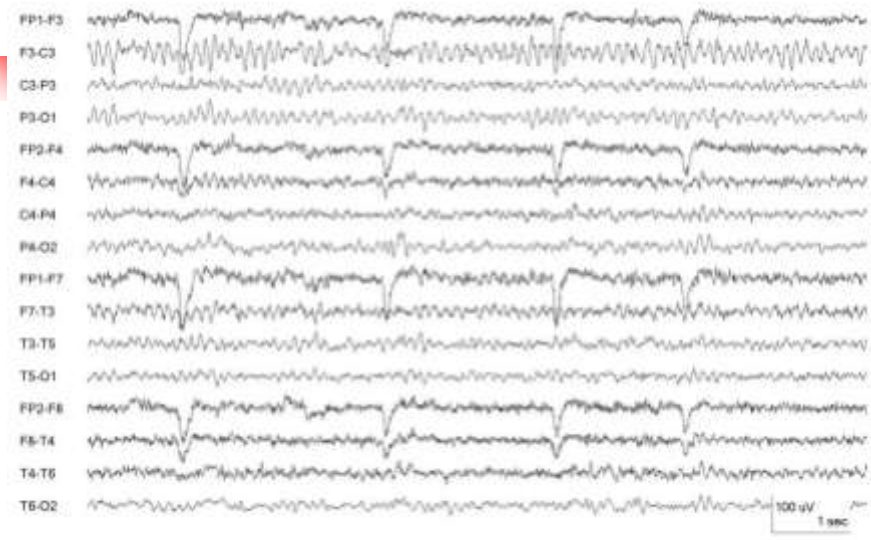
Phase reversal ☻



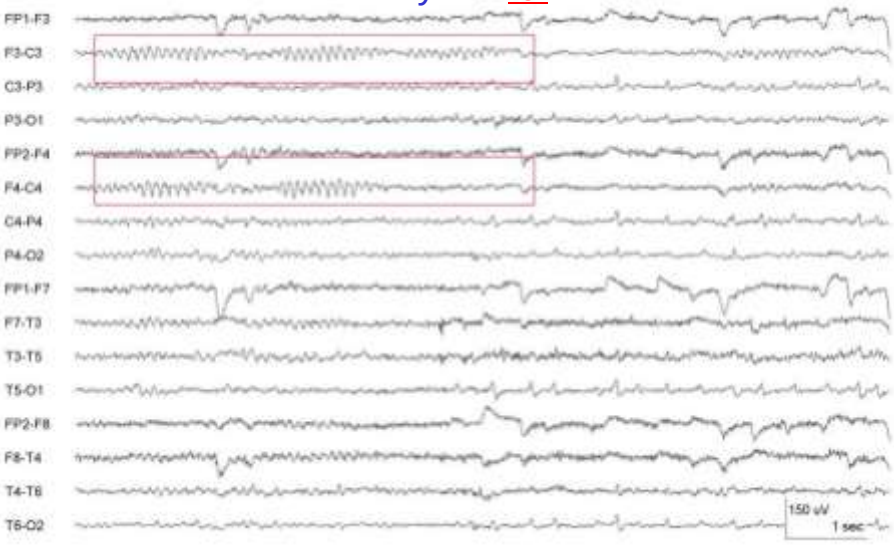
Alpha rhythm blocked by eye opening ☻



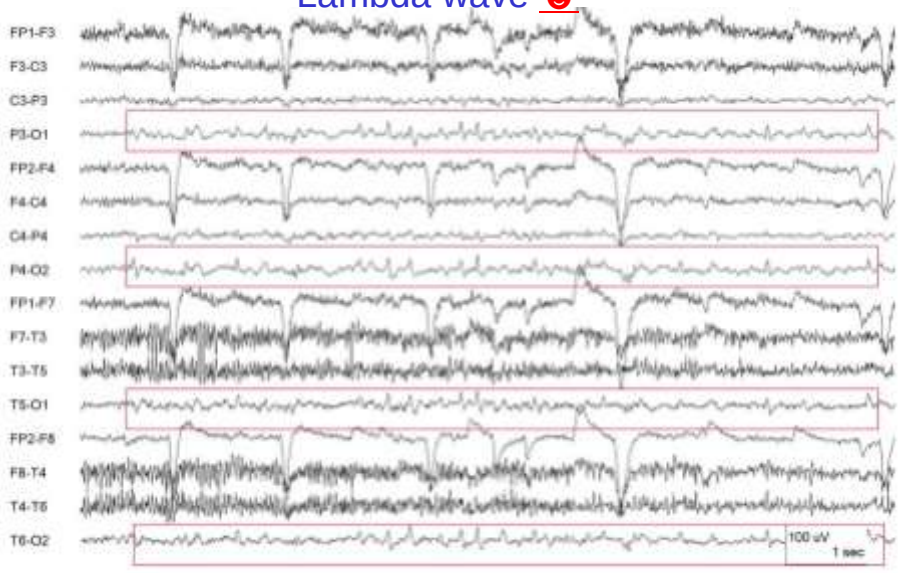
Beta activity in both frontal areas ☻



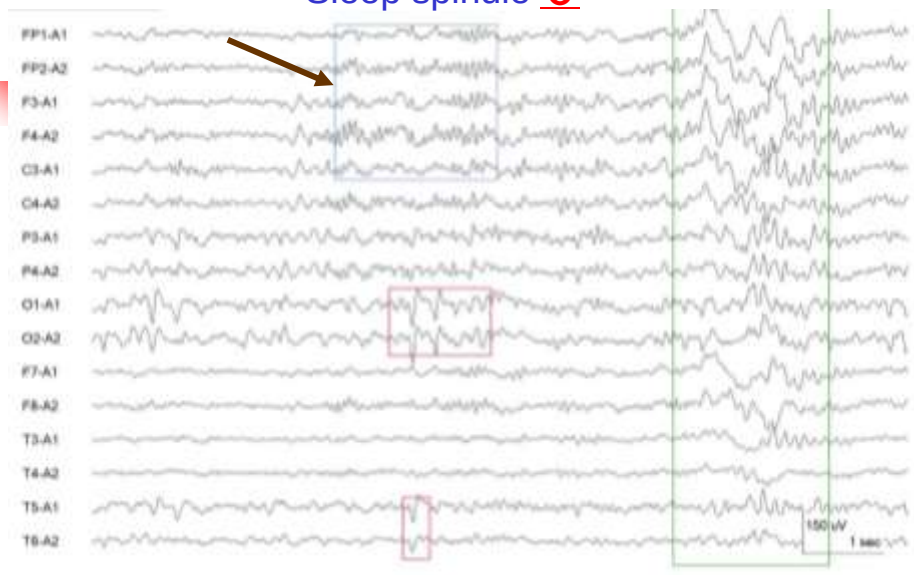
Mu rhythm ☻



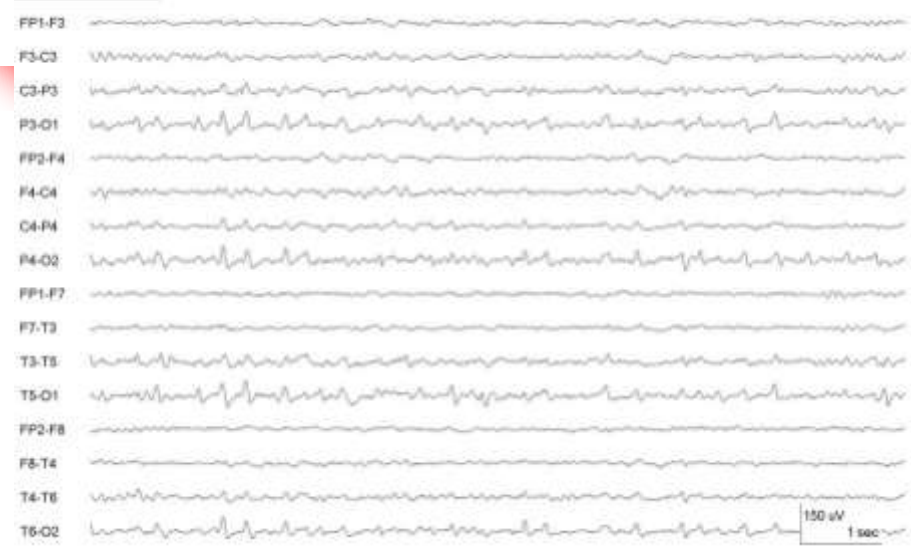
Lambda wave ☻



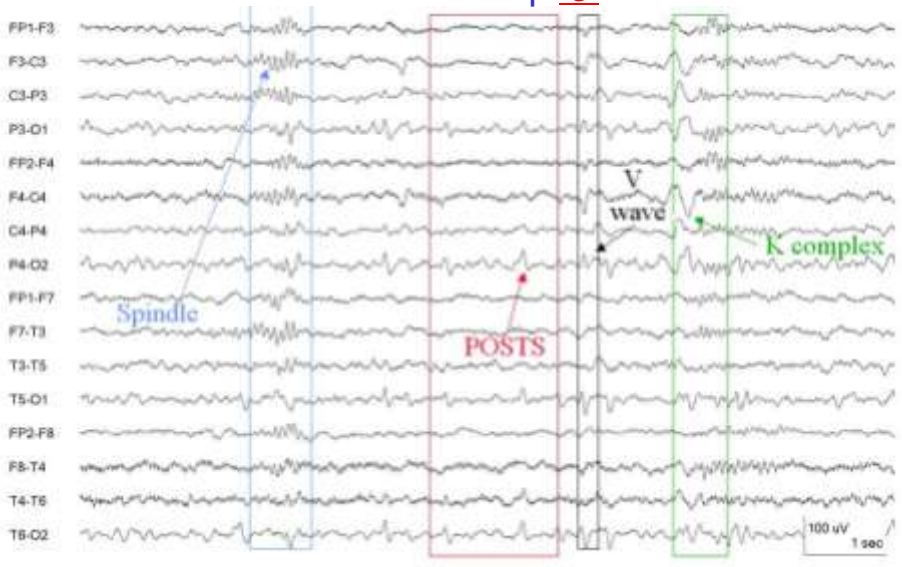
Sleep spindle ☻



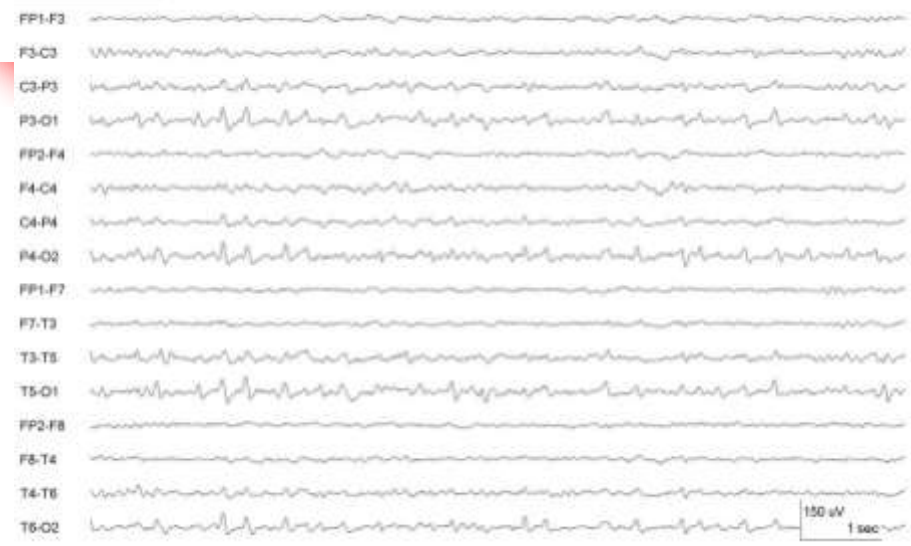
Slow waves in NREM sleep ☻



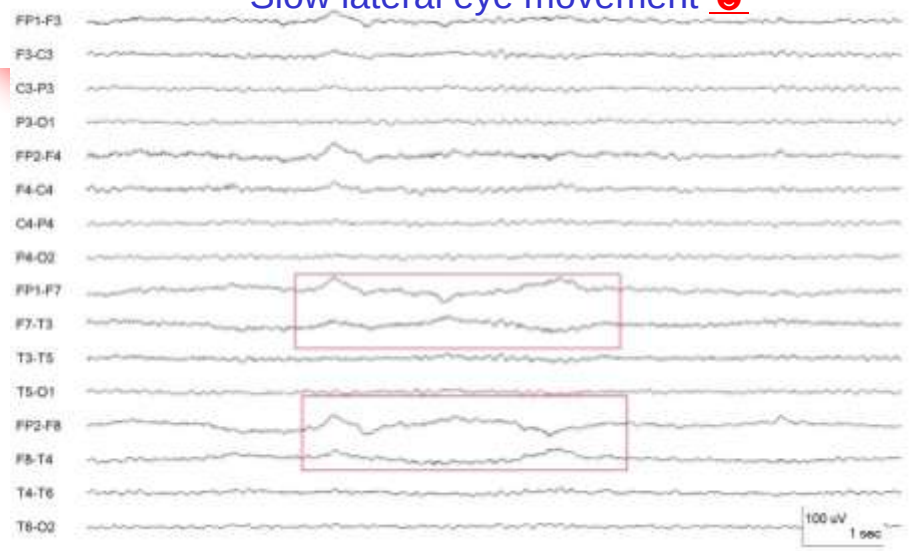
Non-REM sleep ☻



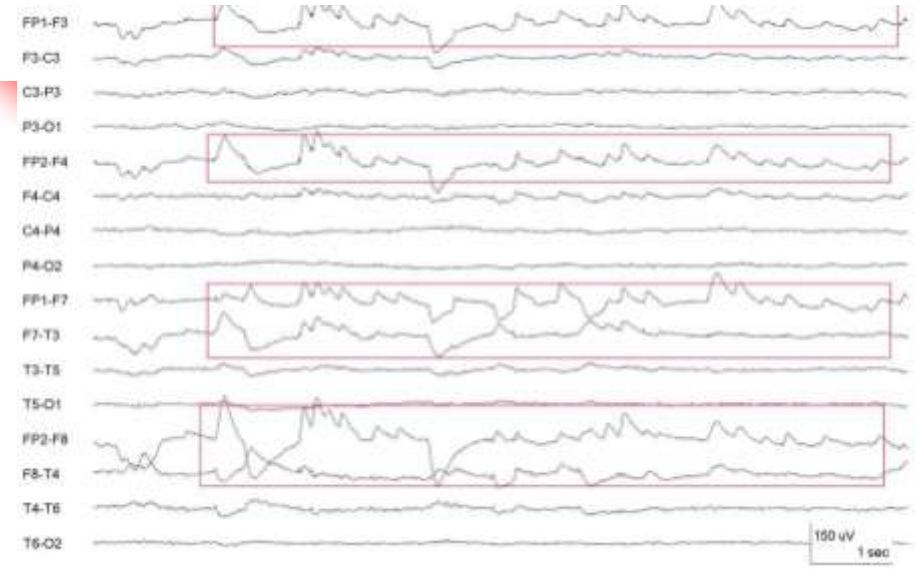
Sleep stage II, Bipolar montage ☻



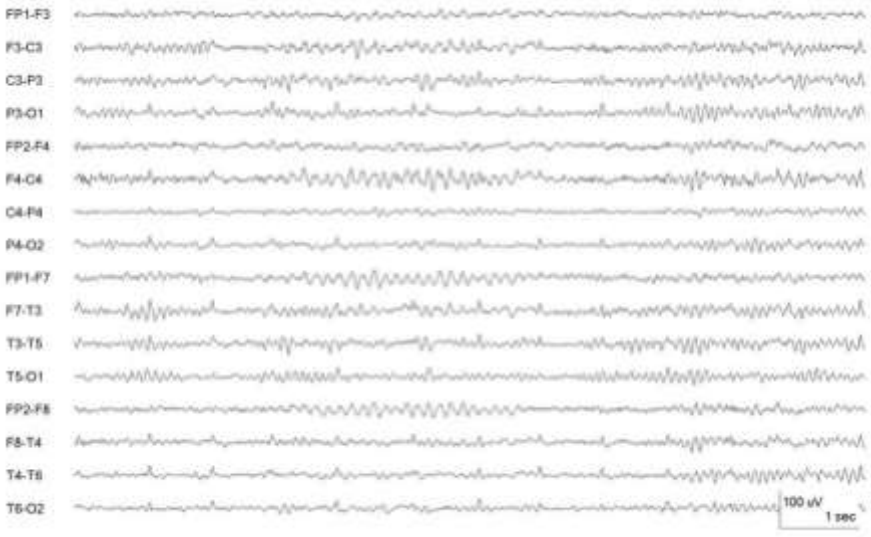
Slow lateral eye movement ☻



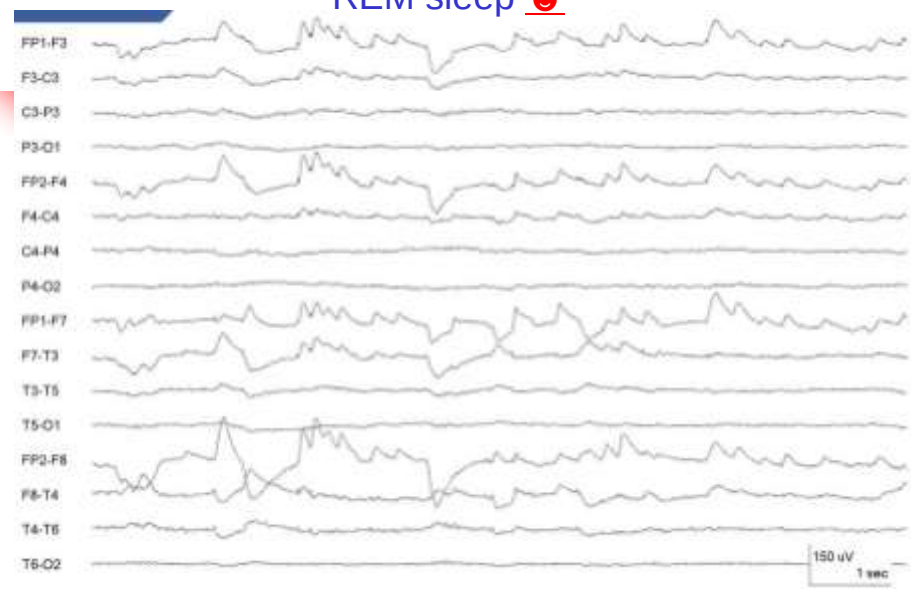
Rapid eye movement ☻



Drowsiness ☻



REM sleep ☻



Intermittent posterior theta rhythm (alpha variant)