

# Normal EEG in adult

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## Talk

- 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

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### 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

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## Definition

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- 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
- Normal variants

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## Definition

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

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## Definition

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- 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

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## Descriptors of EEG activity

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## Descriptors of EEG activity

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

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## Wave form

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## Wave form

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

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## 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

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## 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 😊

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## Wave form

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

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# Repetition

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## Repetition

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

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## Regular or rhythmic repetitive waves

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

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## Frequency

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## 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 😊

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## 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 😊

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## Frequency

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- 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

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## Amplitude

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## Amplitude

- Measured in microvolt ( $\mu\text{V}$ )
- Measuring total vertical distance of wave
- Range
  - Low, under 20  $\mu\text{V}$
  - Moderate or medium, 20-50  $\mu\text{V}$
  - High, over 50  $\mu\text{V}$  😊

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## Amplitude

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

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## Amplitude

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- Affected by
  - Spacing
  - Impedance

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## Distribution

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## Distribution

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

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## Timing

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## Timing

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

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## Persistence

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## Persistence

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

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## Reactivity

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## Reactivity

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

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## Reactivity

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### 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

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

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## 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

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## 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

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## Alpha rhythm

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

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## 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

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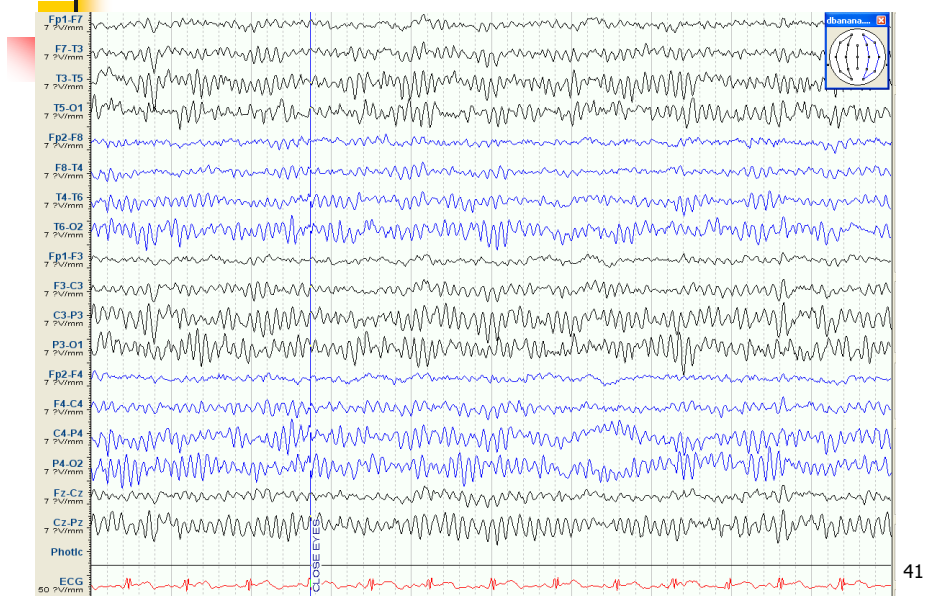
## Beta rhythms

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

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คลื่นไฟฟ้าสมองปกติขณะพักและหลับตา (alpha rhythm,  
posterior slow wave of youth, frontal beta activity)



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## Normal sleep EEG of adults (over 20 yr)

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## Normal sleep EEG of adults (over 20 yr)

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### Elements of sleep EEG

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

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## Normal sleep EEG of adults (over 20 yr)

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### Eye movements during sleep

- Slow lateral eye movements 😊
- Rapid eye movement 😊

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## Normal **sleep** EEG of adults (over 20 yr)


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### Sleep stages

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

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## Normal EEG of the **elderly** (over 60 yr)

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## 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

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## 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

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## Activation procedures

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## Activation procedures

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

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## Activation procedures

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

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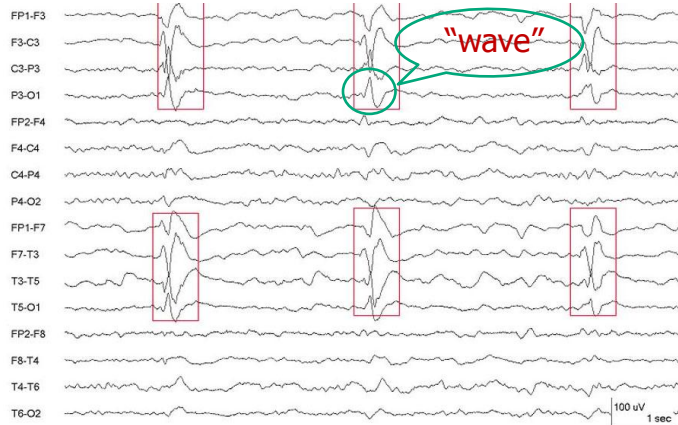


## EXAMPLE OF EEG

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**Wave** = any change in difference of electrical potential between two recording electrodes 😊



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**Activity** = Sequence of waves 😊



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# Monophasic wave (Single deflection: up or down) ☹️



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# Diphasic wave 😊



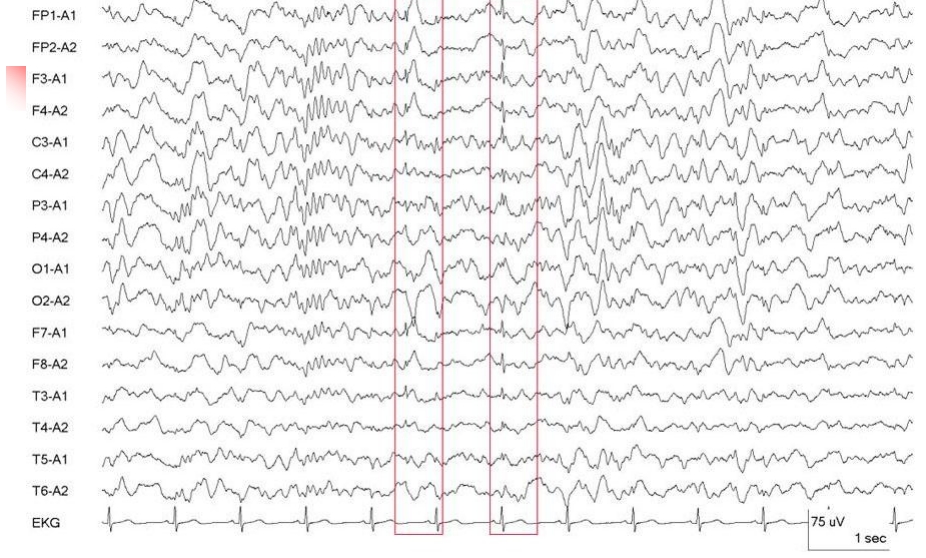
56

# Triphasic wave ☹️



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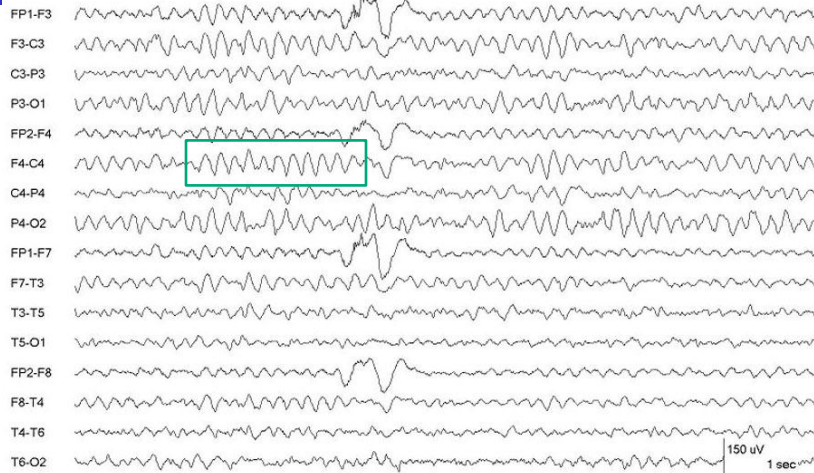
# Sharp transient ☹️



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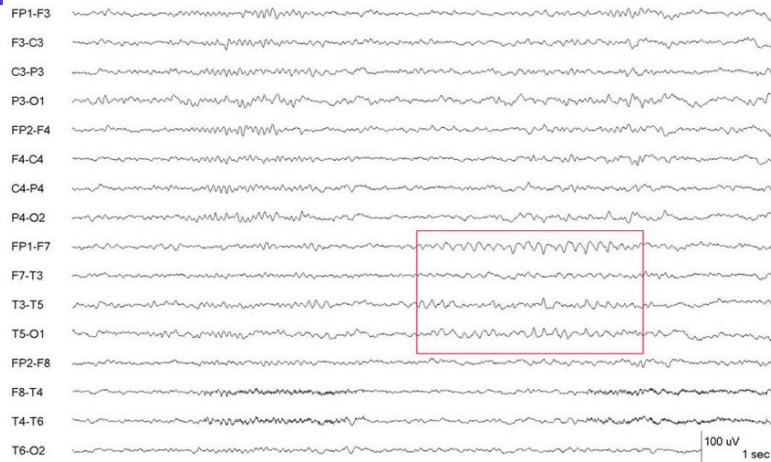
## Regular or rhythmic repetitive waves



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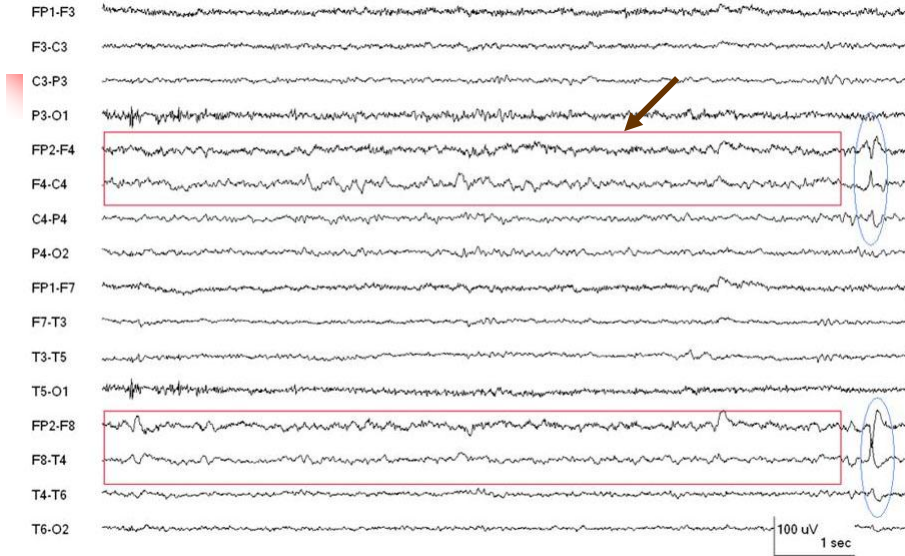


## Regular or rhythmic repetitive waves



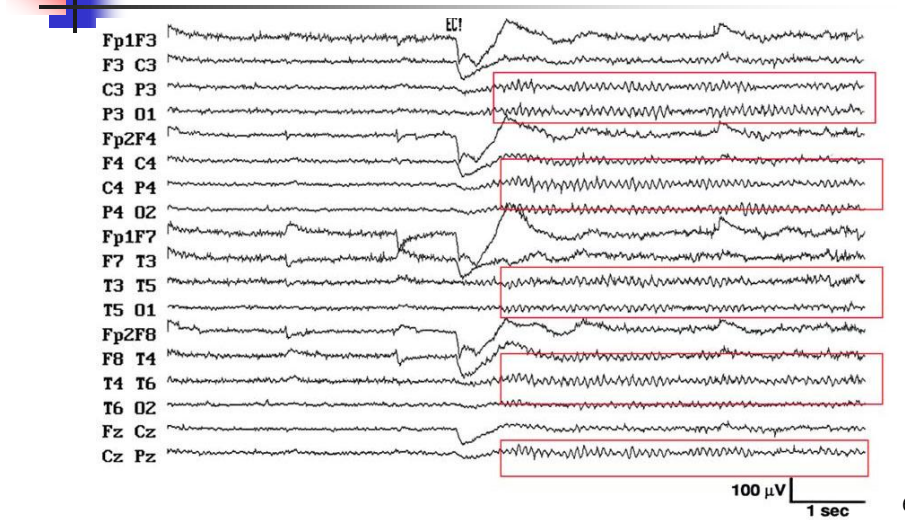
60

### Irregular or arrhythmic activity 😞



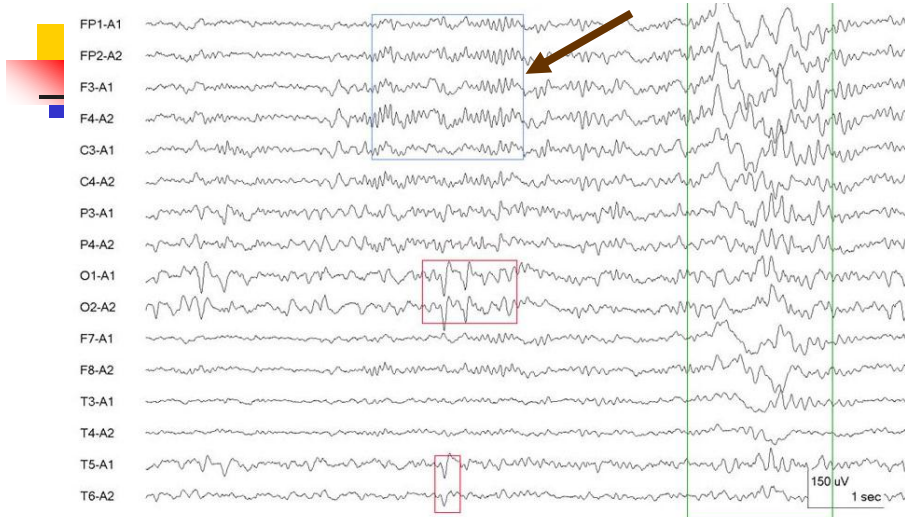
61

### Sinusoidal wave form 😊



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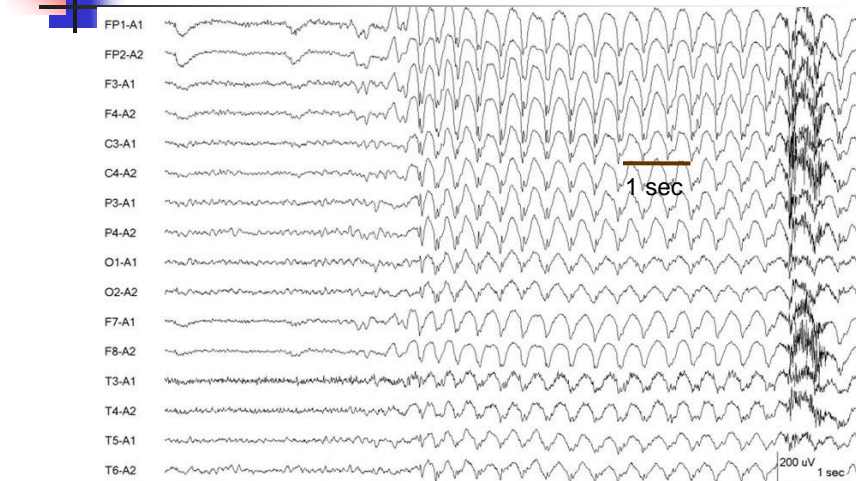
# Spindles ☹️



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Frequency is number of times a repetitive wave recurring in one second. ☹️

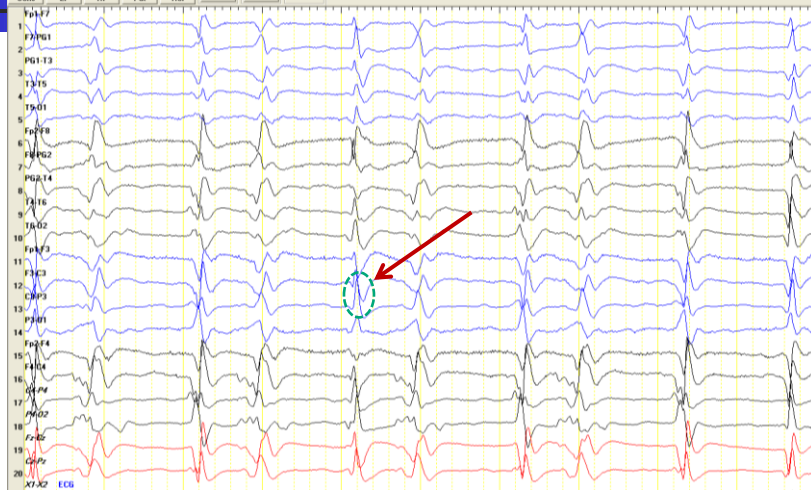


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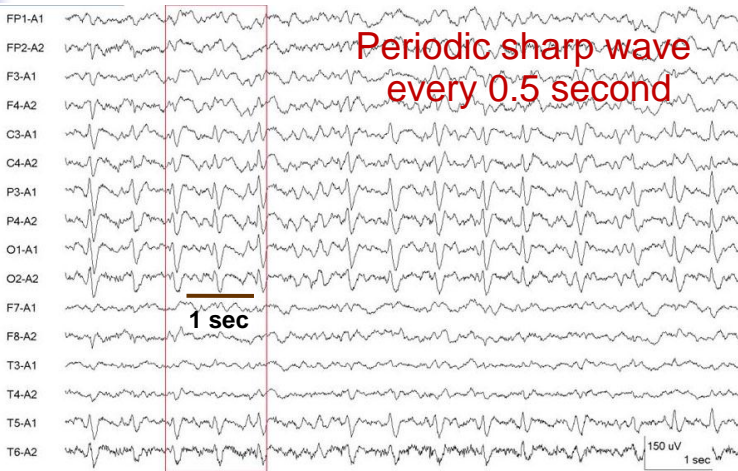
# Frequency of a single wave is calculated from wave length. ☹️



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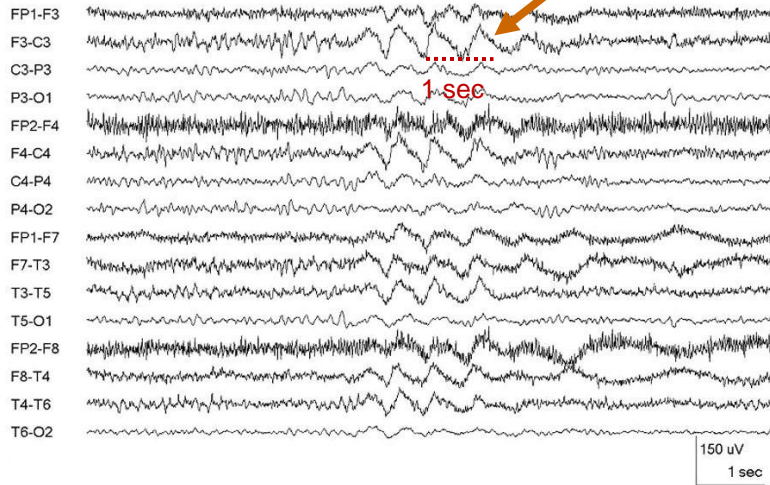
# Periodic wave or complex "Period" being calculated from "time interval" between them ☹️



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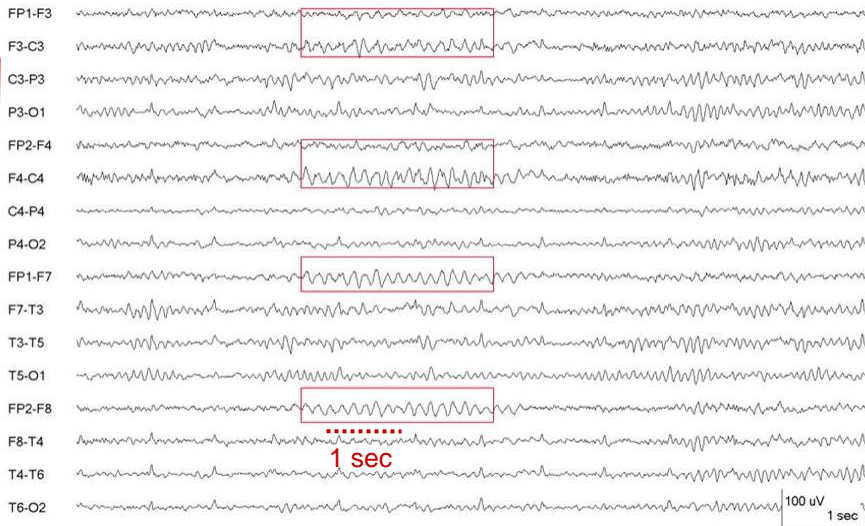
66

# Delta frequency band ☺



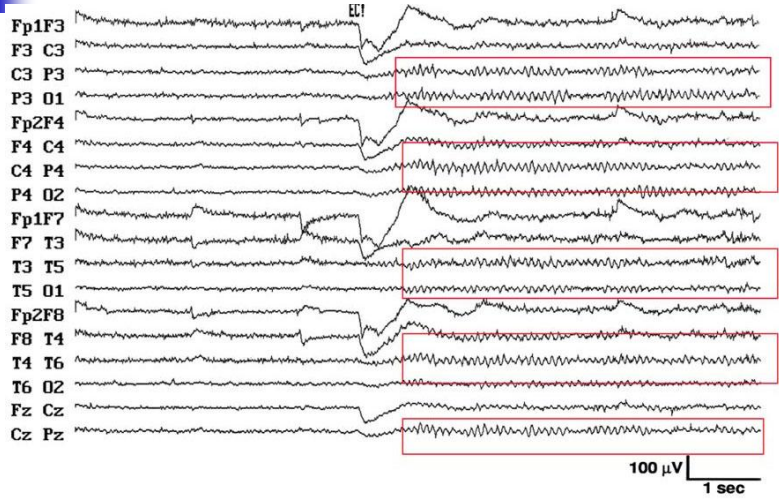
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# Theta frequency band ☹



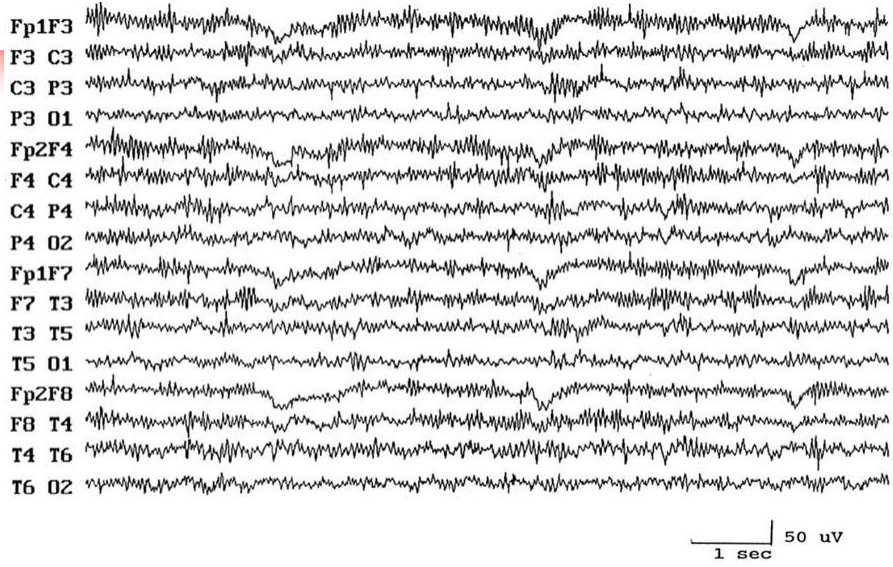
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# Alpha frequency band ☺



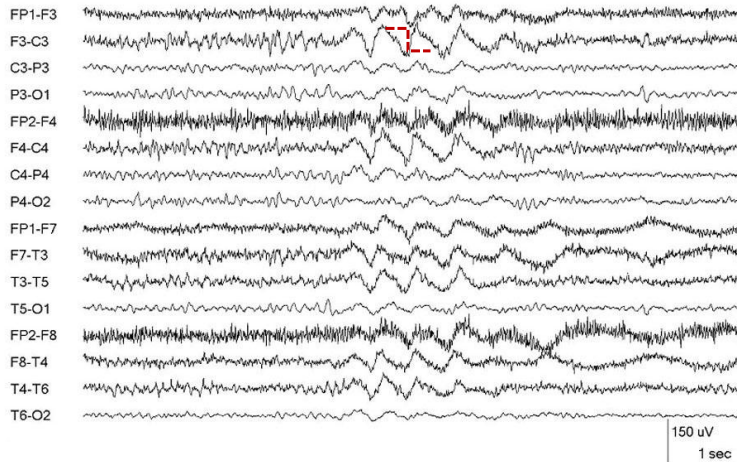
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# Beta frequency band ☹



70

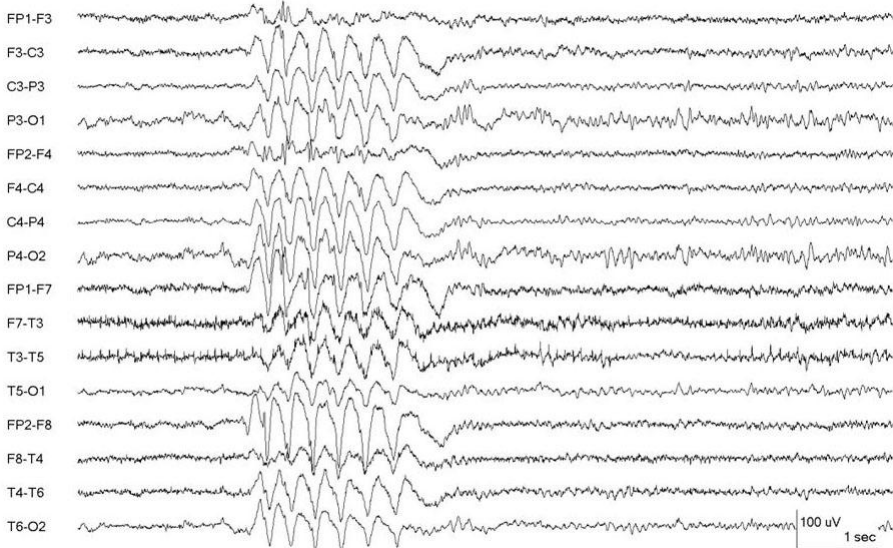
# Amplitude measurement



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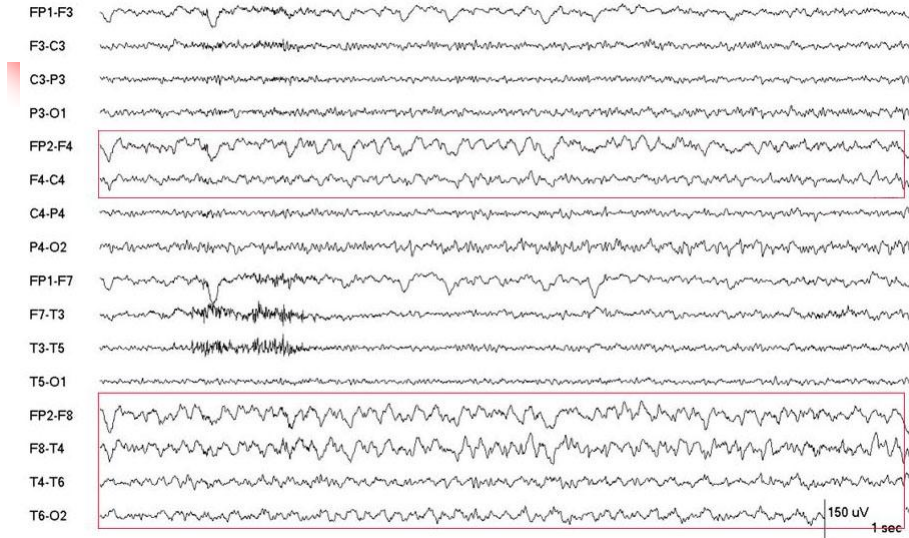
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# Wide spread or generalized distribution



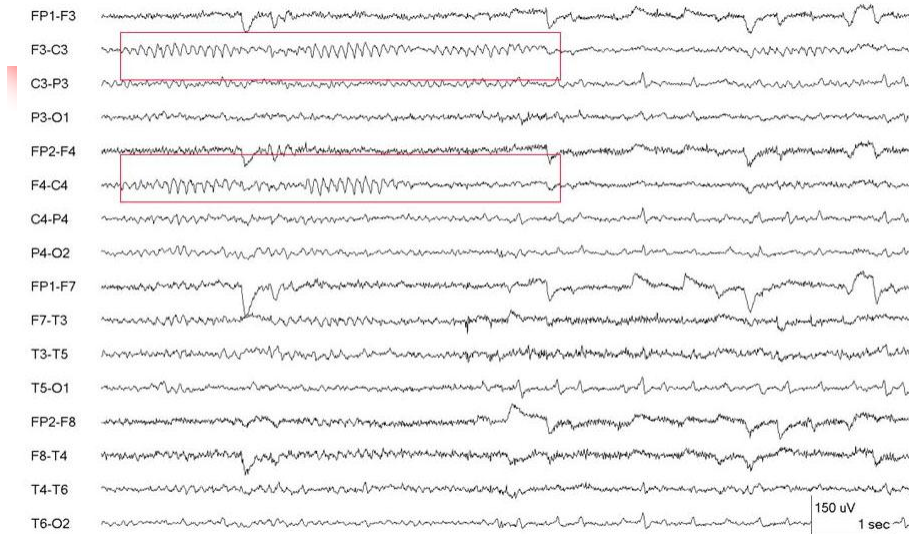
72

## Right hemisphere, lateralized distribution ☹️



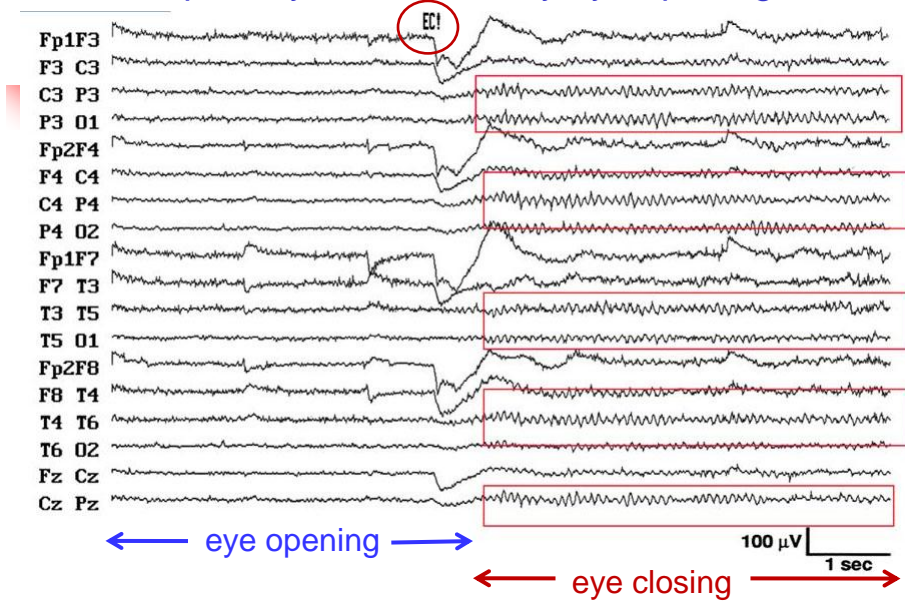
73

## Localized distribution, central area ☹️



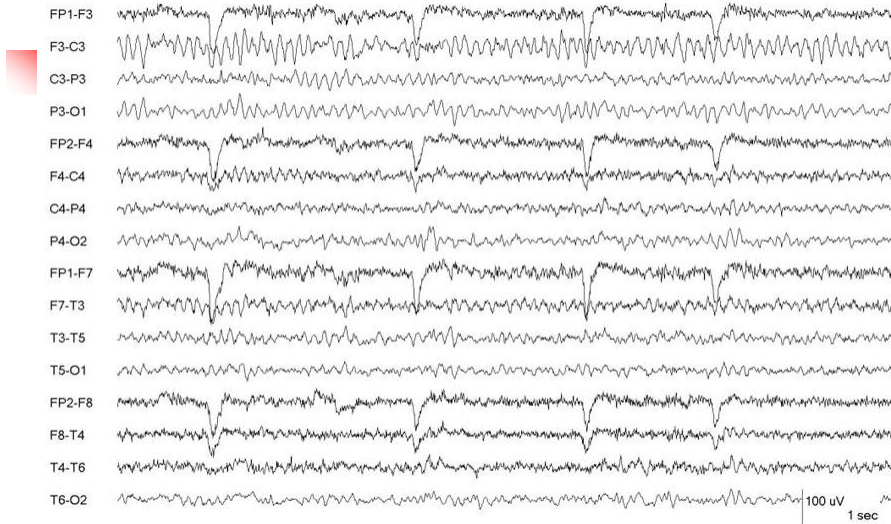
74

### Alpha rhythm blocked by eye opening 😞



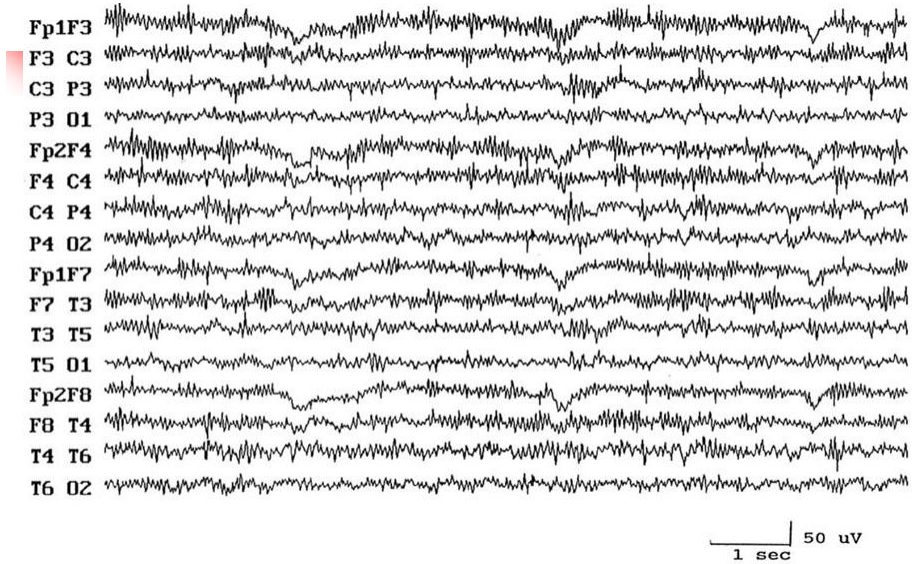
75

### Beta activity in both frontal areas 😞



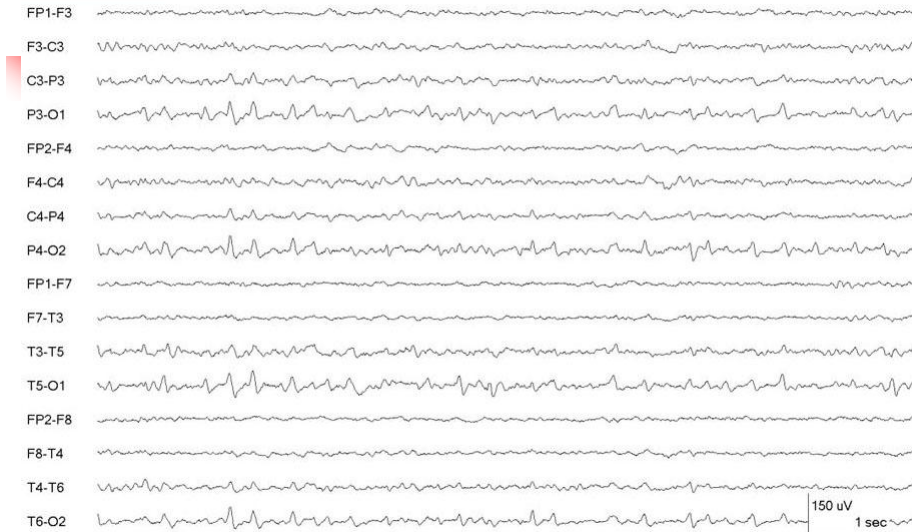
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# Widespread beta activity 😊



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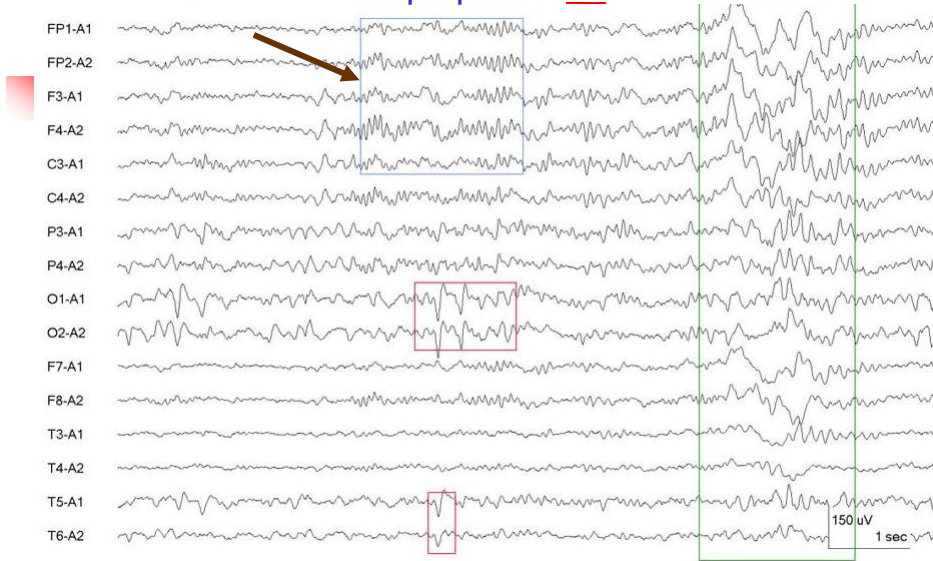
# Slow waves in NREM sleep 😊



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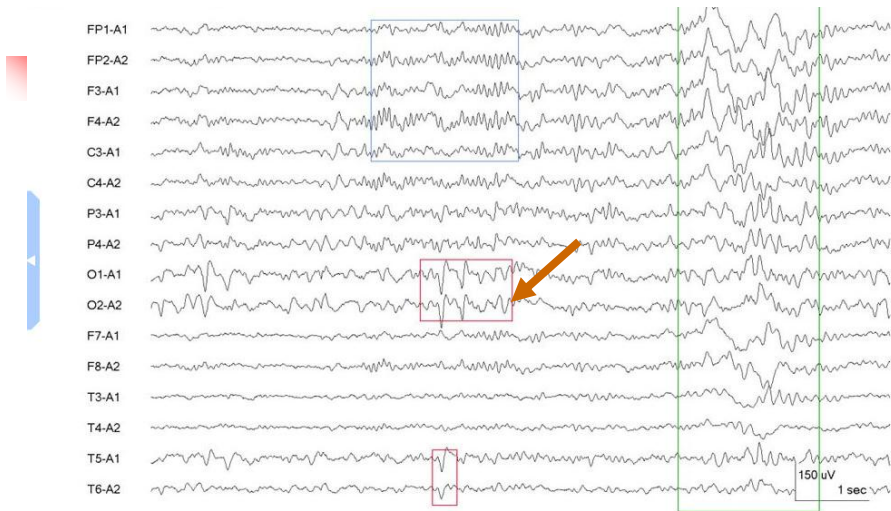
### Sleep spindle 😊



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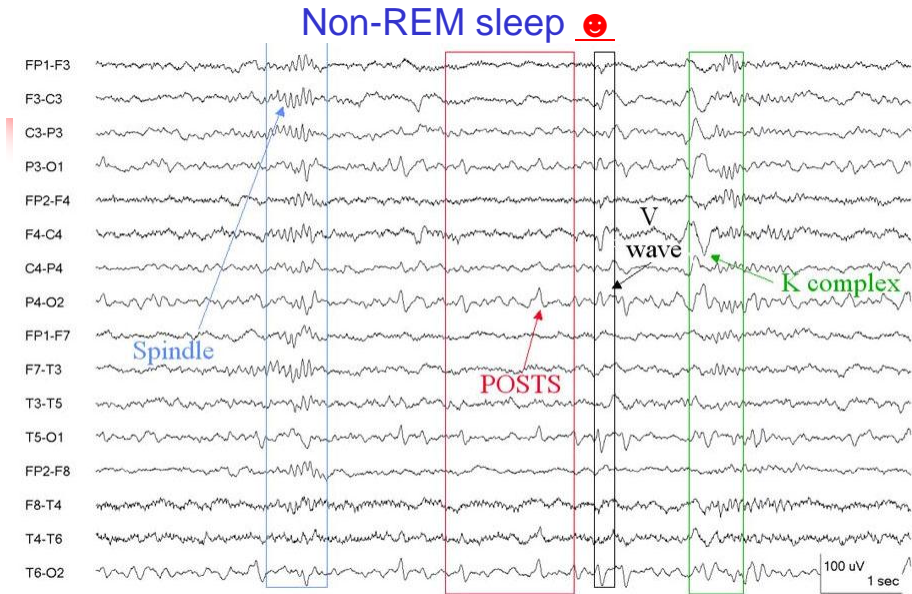
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### POSTs 😞



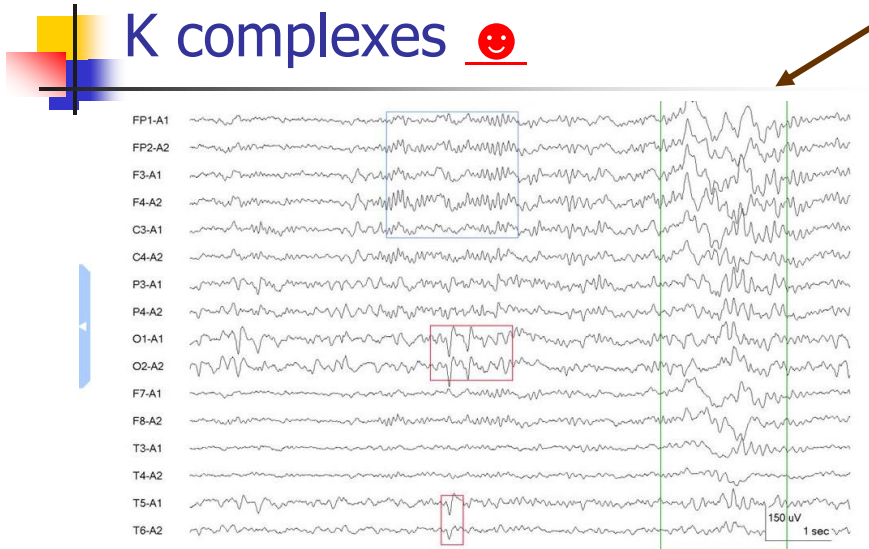
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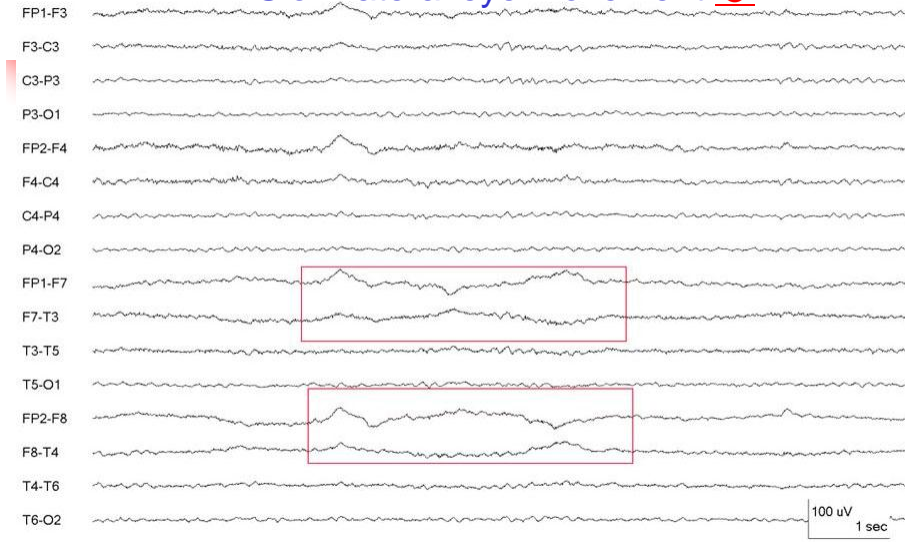
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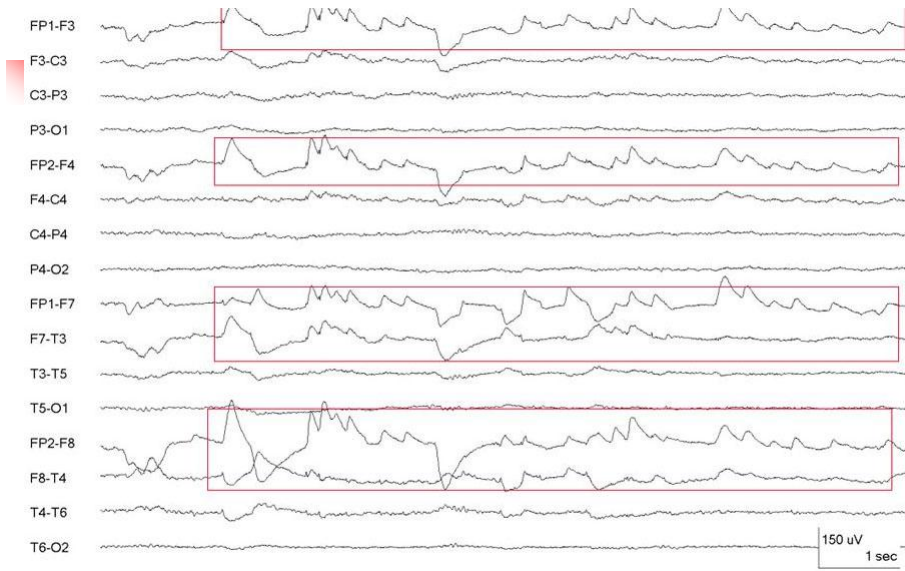
### Slow lateral eye movement 🙄



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### Rapid eye movement 🙄

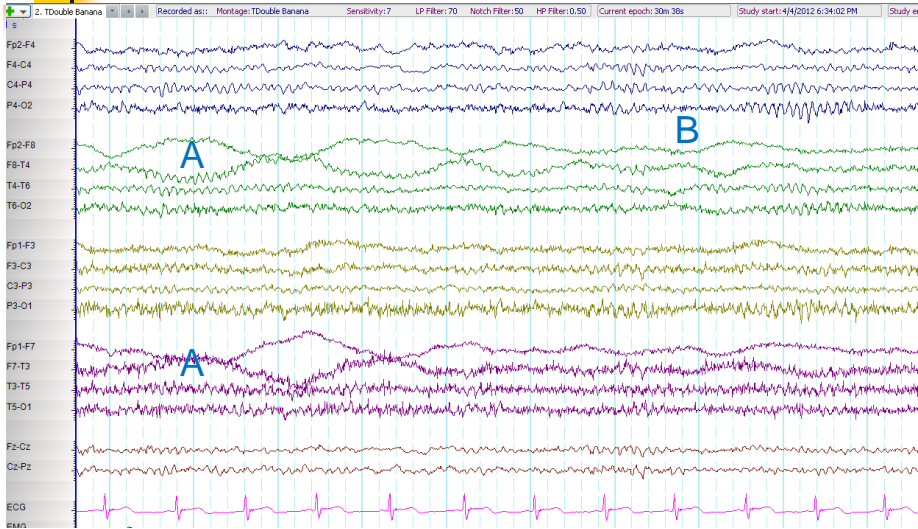


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### EEG in drowsiness :

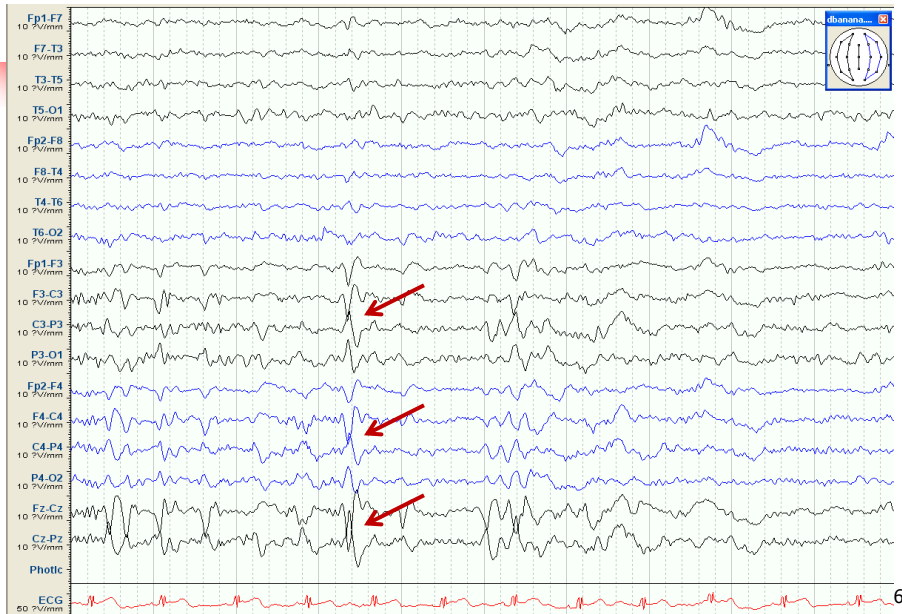
- A. Slow lateral eye movement and
- B. Waxing and waning of posterior alpha rhythm



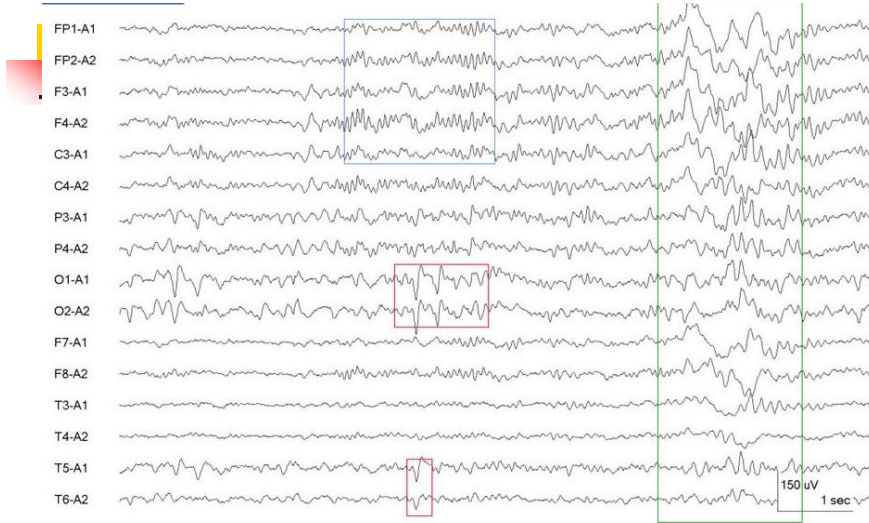
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### Sleep stage 1: sleep vertex sharp wave

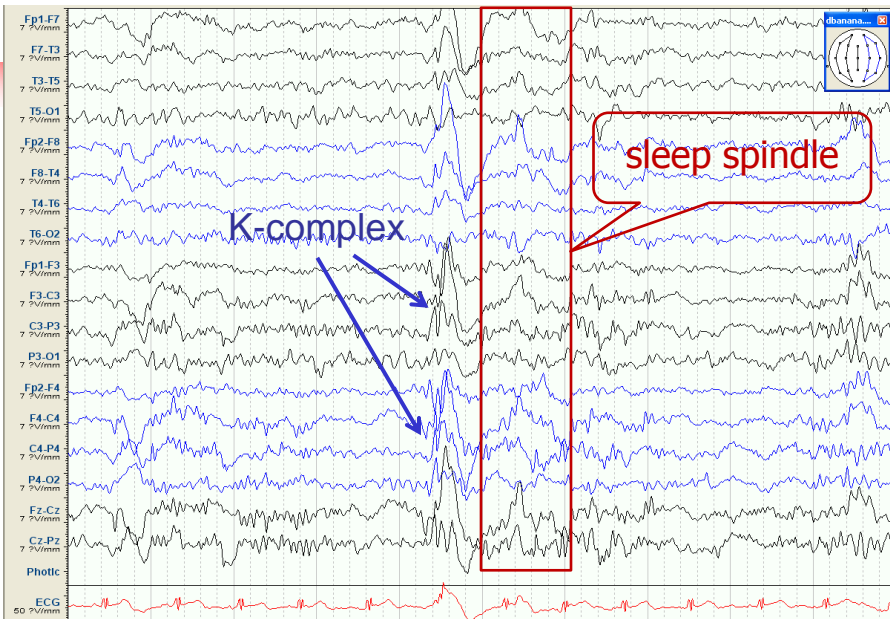


## Sleep stage II ☺

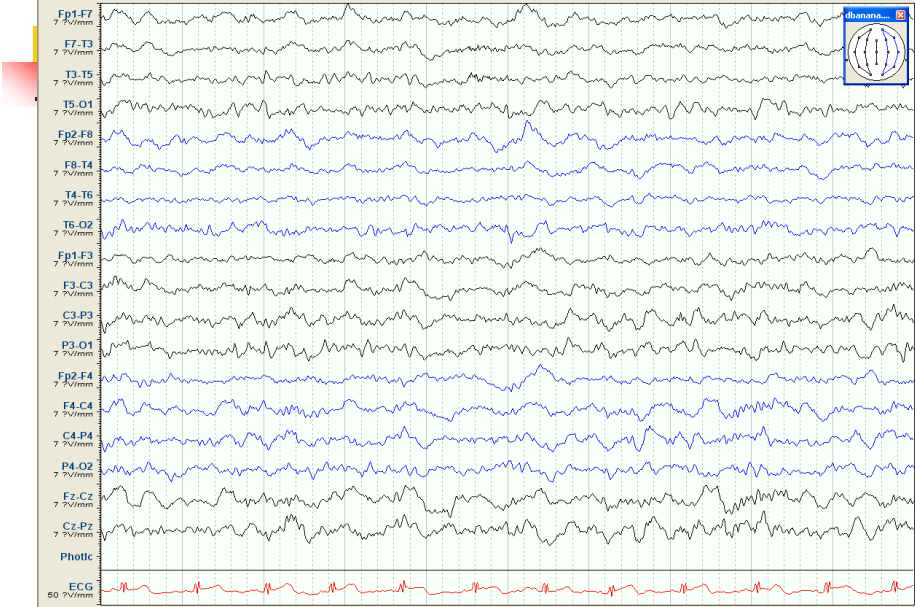


87

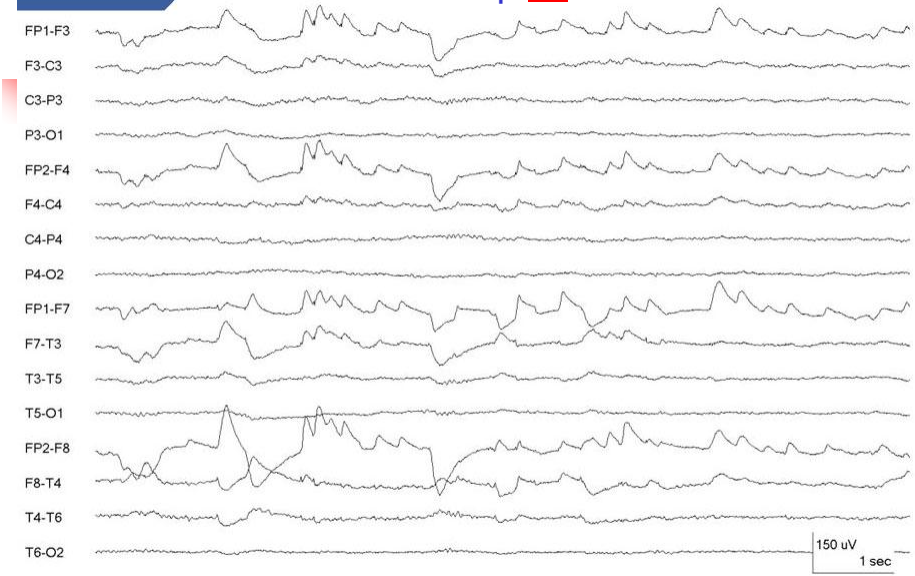
## Sleep stage II : K-complex and sleep spindle ☹



# Sleep stage III-IV



# REM sleep



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