**Neurophysiology & EEG**

PG4 Core Curriculum

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**EEG Signals**

- The brain is an electrochemical organ
- Post-synaptic potentials arise in neurotransmission; voltage gradients give rise to current flows, which generates a magnetic field as well as a voltage waveform at the scalp
- Most of the signal measured at the scalp comes from the apical dendrites of the cortex, near the recording electrode
- Summation in space and time, reflecting some degree of coordinated volleys of activity

[http://www.mrc-cbu.cam.ac.uk/EEG/doc/eeg_intro.shtml](http://www.mrc-cbu.cam.ac.uk/EEG/doc/eeg_intro.shtml)

**EEG Waveforms**

- Classic interpretation involves inspection and description of the waveforms and their frequency and morphology (shape)
- Scalp EEG signals can range from around 0.5 Hz to 100s of Hz; pen-and-paper polygraphs were challenged to record that fast
- Reflect neural events on the millisecond timescale; closer to the primary actions of the brain than metabolic or perfusion measures

**Frequency Bands**

- Alpha 8-13 Hz
- Beta >13 Hz
- Theta 4-8 Hz
- Delta <4 Hz
**Background Rhythms**

- Normal waking EEG
  - Posterior alpha
  - Anterior beta
- Excess slowing
  - Theta & Delta
  - Focal or diffuse (generalized)

**Paroxysmal Discharges**

- Spike & wave epileptiform discharges
- More common in children but can be seen at all ages
- Occur synchronously & bilaterally in generalized epilepsies; focally in partial epilepsies
- Absence / Petit mal - think of 3/sec spike-and-wave
- Slower rate - think brain injury
- Polyspike & wave - faster (3.5-4.5/sec)
- Think myoclonus or myoclonic seizures

**PLEDS**

- Periodic Lateralizing Epileptiform Discharges
- Often herald acute, localized brain injury or damage
- Especially likely if metabolic derangement as well
- Seen with cerebrovascular dis.

**TRIPHASIC WAVES**

- Triphasic waves (down-up-down)
- Classically associated with encephalopathy, esp. hepatic

**Vertex waves (V-Waves)**

- Sharp or even spike discharge that occurs symmetrically around the midline / vertex
- Often seen in stage II sleep

**K Complex - vertex wave plus sleep spindle**

- Common in stage II sleep
- Sleep spindles
  - Fast activity (12-14Hz) with envelope
  - Present over both hemispheres

- Slow Wave Sleep
  - Stages III and IV

**EEG Report or Interpretation**

- Description of technique
  - Conditions observed (waking, drowsy, sleep stage)
  - Was patient sleep deprived? Sedated?
  - Activation procedures? (hyperventilation, photic)
- Overall: normal or abnormal?
- Description of background rhythms
  - Posterior dominant rhythm - in alpha range?
  - Low voltage fast activity - normal variant
  - Intermixed slow wave (theta delta) activity
    - Focal or Generalized (diffuse)
  - State-specific findings? (K complexes, spindles)

**EEG Report or Interpretation**

- Description of Paroxysmal Discharges
  - Morphology (spike, sharp wave, spike & wave)
  - Topography (generalized, focal, multifocal, lateralized, synchronous)
  - Frequency (3/sec, 14-and-6)
  - In which states of arousal are they present?
  - Correlation with simultaneous clinical observations (movements, changes in LOC)
Sleep Pattern of Patients With Major Depression

**Event-Related Potentials (ERPs)**

- Event-related potentials or evoked potentials (EPs) are small voltage signals from a stimulus
- Computer averages epochs, synchronized to repetitions of the same event (sensory, cognitive, motor action)
- Spontaneous brain activity is averaged out.
- Characteristic shapes and delays to waveforms

**Fourier Transform: The inner product**

- Original signal
- Fourier transform
Quantitative EEG

Computer processing converts time-varying signals to power spectrum measures: how much energy in which band in which region?

Prefrontal Decreases in M-R

Cook et al., Neuropsychopharmacology 2002

Source Localization & LORETA

- Low resolution brain electromagnetic tomography
- Solve the “inverse problem” of where are the “generators” of the surface EEG signals

Pretreatment Features

- Pizzagalli built on the PET work from Mayberg (1997) and Wu (1999), by using LORETA - low resolution electromagnetic tomography, with 18 adults treated with nortriptyline for MDD.
- Theta activity in the rostral-most anterior cingulate (Brodmann 32, 24, some of 10) was related to outcome - better response accompanied higher pretreatment values (but only 2 NR)

Pizzagalli et al., Am J Psychiatry 2001