electroencephalogram(EEG)

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EEG~ Nature

- Non-invasive* method
- Record electrical activity of the brain along the scalp
- Voltage fluctuations resulting from ionic current within the neurons of the brain
- Clinical def. ~ recording brain's spontaneous electrical activity over a period of time

* Invasive in case of deep brain stimulation signal captures

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EEG~ Nature

- Most often used in epilepsy abnormalities in EEG readings
- Sleep disorder, Coma, encephalopathies or Brain death
- Two types of potentials that are used studies
  - Evoked Potentials
  - Event Related Potentials

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Evoked potentials

- ✓ Electrical potential recorded after a stimulus is presented
- ✓ Distinct from spontaneous potentials
- ✓ Amplitude tend to be low
- ✓ Ranging from les than a μV to several μV
- ✓ Signal is time-locked to the stimulus

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Event related potentials

- ✓ Electrical potential recorded when specific event occurs
- ✓ Events include – Sensory, Cognitive or Motor
- ✓ A.k.a. electrophysiological response to stimulus
- ✓ Volume conduction of neurons
- ✓ Reflects the summation of synchronous activity
- ✓ Deep brain activity difficult to detect.

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EEG Signal ~ Processing

- Electrical activity can be detected, but does not completely describe the action and interaction of the neurotransmitter

- Neurotransmitters
  - Action potential results in the release of neurotransmitters
  - That then affect the electrical activity of adjacent cells.

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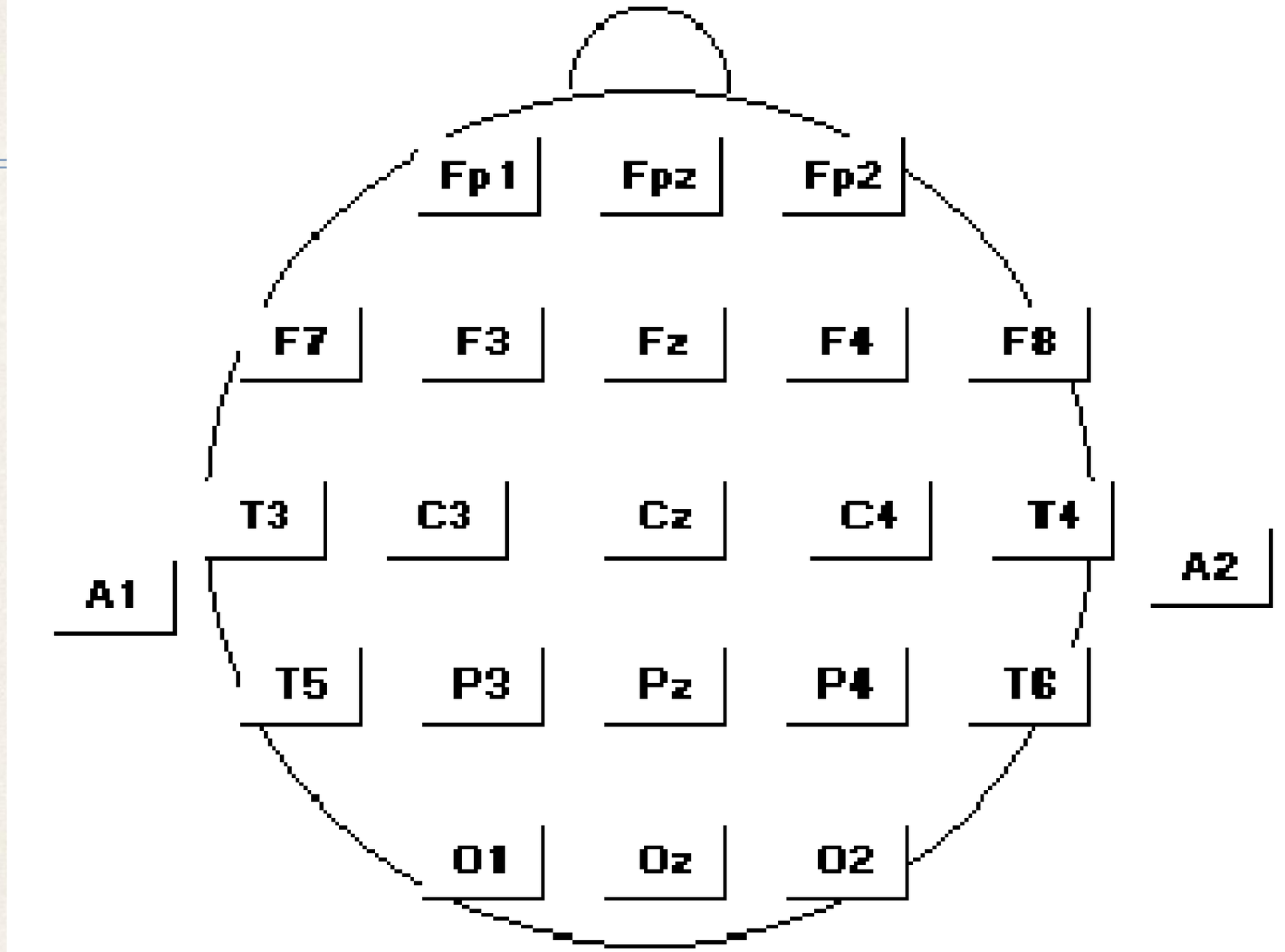
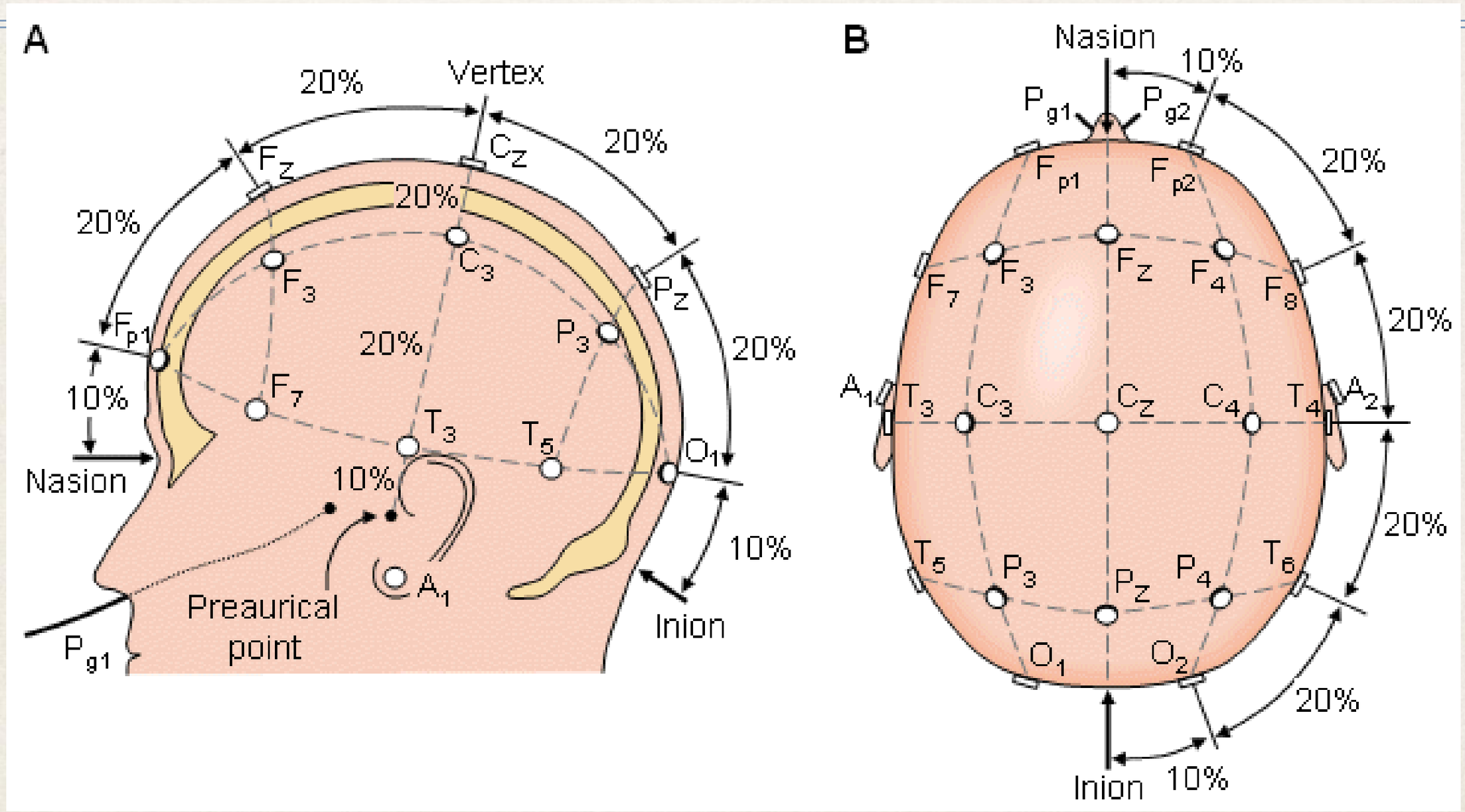

Fp1
Fpz
Fp2
F7
F3
Fz
F4
F8
T3
C3
Cz
C4
T4
A1
A2
T5
P3
Pz
P4
T6
O1
Oz
O2

EEG records differences in voltage: the way in which the signal is viewed can be set up in a variety of ways called *montages*

Bipolar montage: Each waveform in the EEG represents the difference in voltage between two adjacent electrodes, e.g. ‘F3-C3’ represents the difference in voltage between channel F3 and neighbouring channel C3. This is repeated across the whole scalp through the entire array of electrodes.

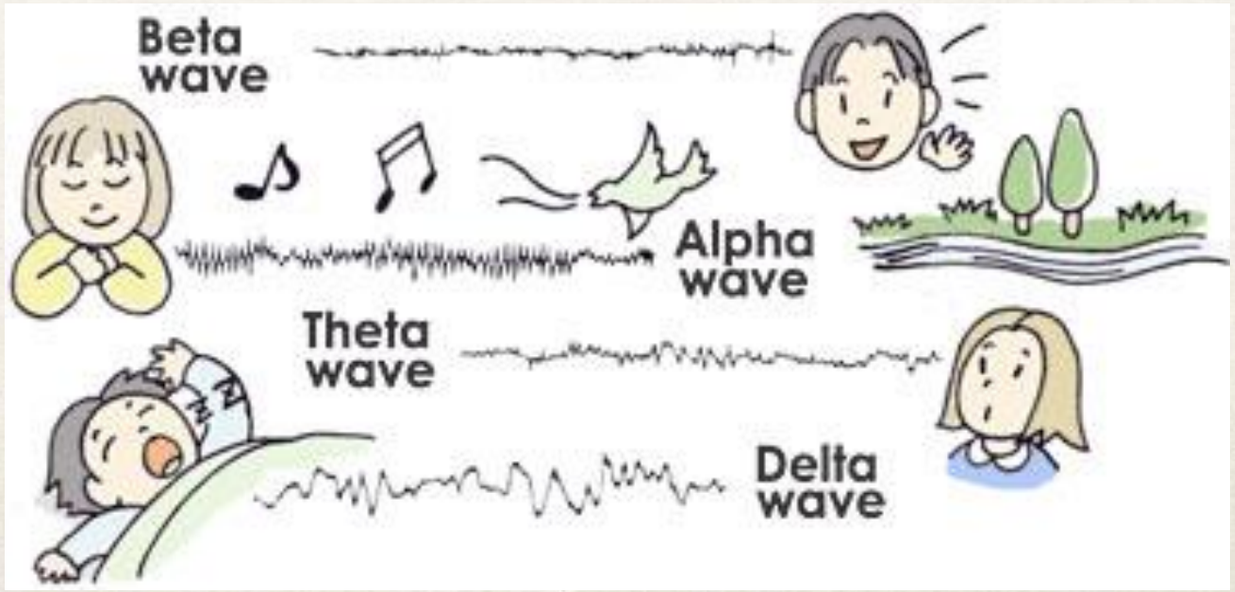
Reference montage: Each waveform in the EEG represents the difference in voltage between a specific active electrode and a designated reference electrode. There is no standard position for the reference, but usually a midline electrode is chosen so as not to bias the signal in any one hemisphere. Other popular reference signals include an average signal from electrodes placed on each ear lobe or mastoid.

10 /20 % system of EEG electrode placement



Neurological Signal Processing

- Amplitude ranging from 10 to 100 μV
- Frequency range from 0.5 to 40 Hz
- Manifests itself in the form of rhythms ~ δ, Θ, α and β
  - δ 0.5 – 3.5 Hz
  - Θ 3.5 – 7.5 Hz
  - α 7.5 – 12.5 Hz
  - β above 12.5 Hz



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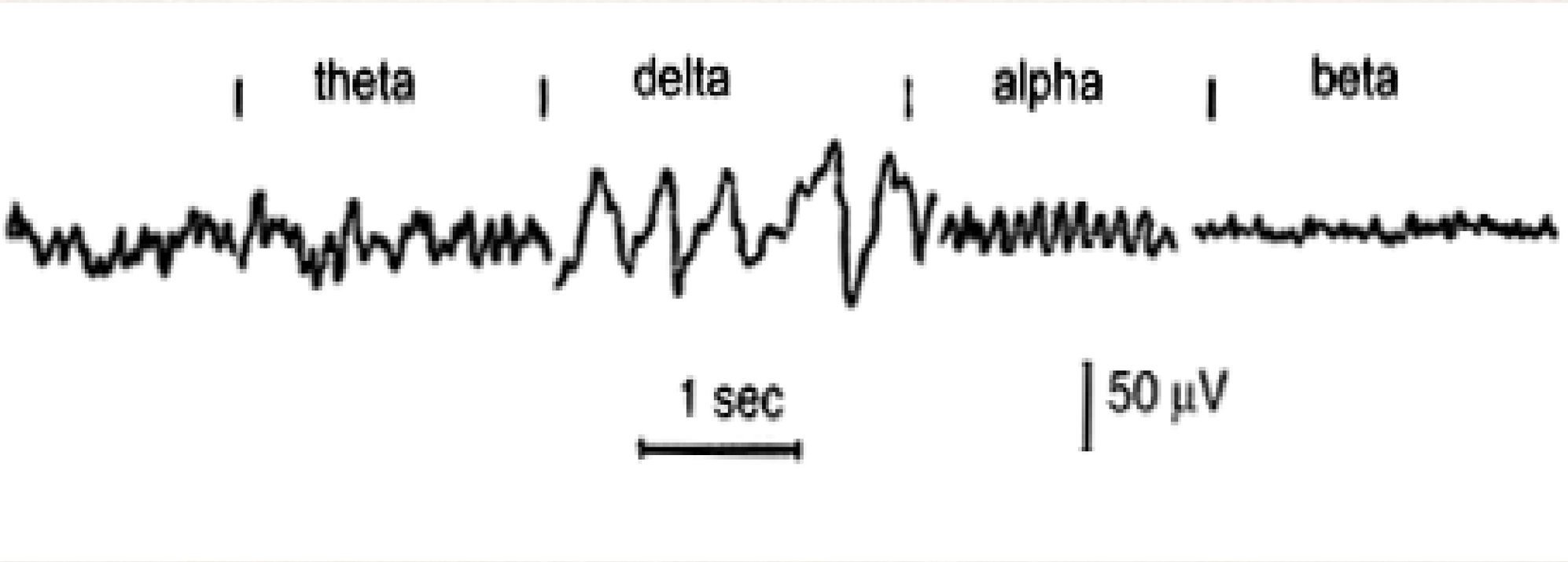
theta
delta
alpha
beta
1 sec
50 µV

Neurological Signal Processing

- Basic chain of operations in EEG signal analysis are
  - Acquisition of data including quality control of data in order to remove or avoid artifacts
  - Central processing
  - Presentation of results, graphs – numerical analysis.

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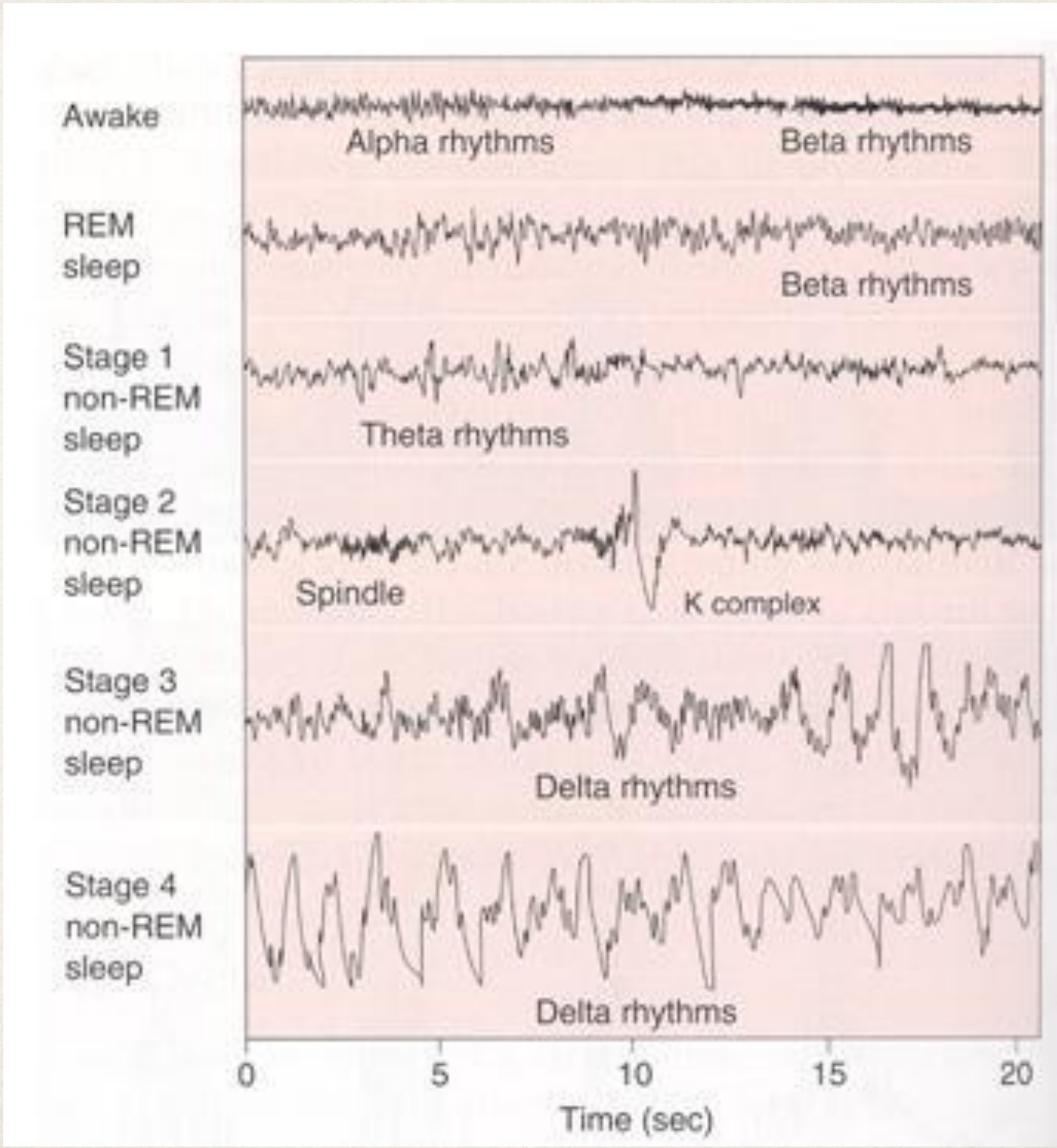
Neurological Signal Processing



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Neurological Signal Processing

- Brain Deterministic or Stochastic
  - Neither fully deterministic nor fully stochastic
  - Complex nonlinear system
  - Showing complicated emergent properties
    Ex. Consciousness
  - FFT may work for short time intervals for linear analysis
  - Linear systems may have small range of applicability
  - Inappropriate to use a linear system to deal with highly nonlinear complexity of the brain.
    - Perfect linear system ≈ ideal gas

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Applications: Brain Fingerprinting

The fundamental difference between the perpetrator of a crime and an innocent person is that the perpetrator, having committed the crime, has the details of the crime stored in his memory, and the innocent suspect does not.

This is what Brain Fingerprinting testing detects scientifically, the presence or absence of specific information.

Current Methods: Lie Detection

Modern polygraphy: uses physiological changes in the peripheral nervous system (PNS) measure deception

1. Skin conductance changes (sweating)
2. Blood pressure
3. Respiration
4. Heart rate

“Neurotechnological Lie Detection” (NTLD):

Measurements of blood flow or electrical impulses in the brain to identify distinct indicators of deceptive communication.

Measure lying more directly by measuring brain activity rather than second-order indicators like pulse or respiration.

Defining Brain Fingerprinting

- Scientific technique to determine whether or not specific information is stored in an individual's brain
- Relevant words, pictures or sounds are presented to a subject by a computer in a series with stimuli
- The brainwave responses measured using a patented headband equipped with EEG sensors
- P300- Specific, measurable brain response
  - emitted by the brain of a subject who has the relevant information stored in his brain

How Does it Work?

- measurements are recorded in fractions of a second after the stimulus is presented, before the subject is able to formulate or control a response

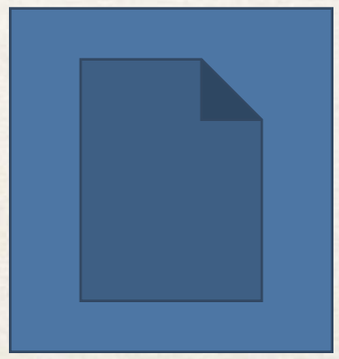
- Dr. Farwell discovered that the P300 was one aspect of a larger brain-wave response that he named and patented, a MERMER (memory and encoding related multifaceted electroencephalographic response)

- Brain responses were recorded from the midline frontal, central, and parietal scalp locations, referenced to linked mastoids (behind the ear), and from a location on the forehead to track eye movements

- At the end of each test, subjects were given a written list of all stimulus items and asked to mark each item as noteworthy, somewhat noteworthy, or irrelevant – those marked were thrown out

Applications

- National security
- Medical diagnosis
  - Alzheimer’s Disease
- Advertising
- Crimial justice system



Thank you

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