EEG History

Hans Berger 1873 - 1941

- Edgar Douglas Adrian, an English physician, was one of the first scientists to record a single nerve fiber potential
- Although Adrian is credited with the discovery of cortical electrical potentials, it was Hans Berger using Adrian's recording techniques who discovered EEG potentials
- On May 12 1934 the first public demonstration of the "Berger Rhythm" (now known as the Alpha rhythm) was made using a single channel EKG amplifier, verifying Berger's work of five years earlier
- Hans Berger is therefore known as the father of EEG.

Where and why is EEG used?

EEG is performed predominantly in Neurology/Neurophysiology, but as it provides a measure of cerebral function, it is also used in other specialities;

Neurology

- Epilepsy
- Creuzfeld Jacob Disease
- Head Injury
- Brain Tumor/Lesions
- Cerebrovascular disorders
- Neurosurgery

Pediatrics

- Pediatric Epilepsy
- Down's Syndrome
- Other diseases/syndromes

Internal Medicine

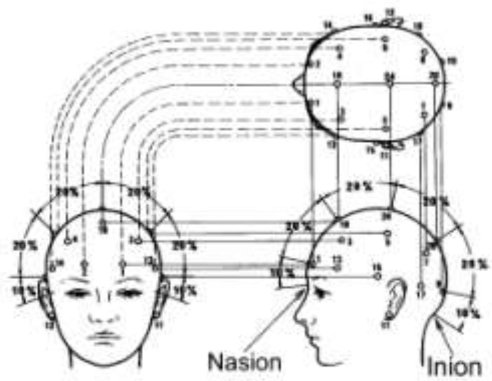
- Endocrine/Metabolic Diseases
- Hepatic Diseases
- Toxemia

Psychiatry

- Epilepsy & Related Disorders
- Organic brain diseases
- Developmental Disability
- Head Injury

EEG Electrode Positioning

Although there are various systems for electrode positioning, the **International Ten-Twenty** system is the most commonly used



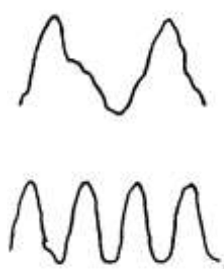
EEG Electrode Types

- In the United States and in the UK and Ireland, disk electrodes (Ag/AgCl or Gold) are most commonly used and affixed to the head using conductive paste or collodion glue and gel

- In continental Europe and other areas of the world, electrode caps and "bridge" electrodes with a rubber "head-net" are more common.

Basic EEG Rhythm Identification

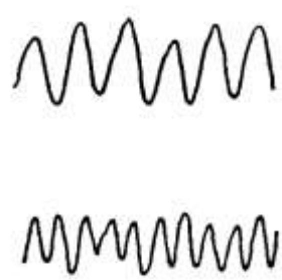
The EEG waveform is generated by the cerebral cortex and is indicative of the brain's activity. EEG therefore provides important data in determining normal or abnormal brain function



Rhythm >	Delta
Frequency Component	Up to 4 Hz
Amplitude	100μV
Main Scalp Area	Frontal
Patient Condition	Deep Sleep (Adult)

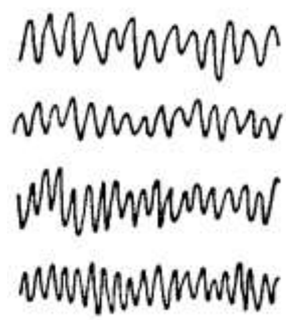
Basic EEG Rhythm Identification

Rhythm >	Theta
Frequency Component	4.1 to 8 Hz
Amplitude	Child: 50μV Adult: 10μV
Main Scalp Area	Temporal
Patient Condition	Drowsiness



Basic EEG Rhythm Identification

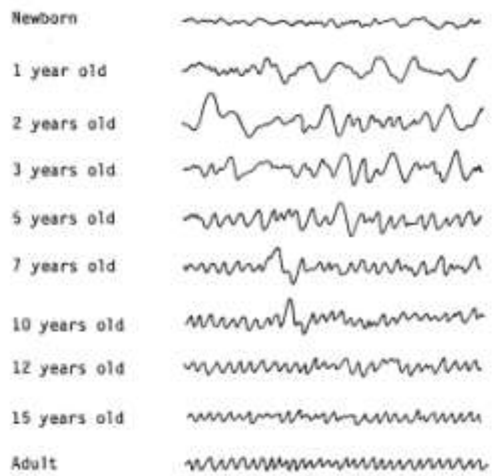
Rhythm >	Alpha
Frequency Component	8.1 to 13 Hz
Amplitude	Infant: 20μV Child: 50μV Adult: 10μV
Main Scalp Area	Occipital - Parietal
Patient Condition	Resting, Eyes Closed



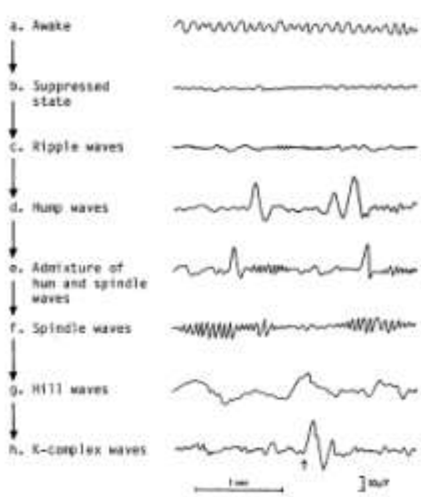
Basic EEG Rhythm Identification

Rhythm >	Beta
Frequency Component	Over 13 Hz
Amplitude	10 to 20 μV
Main Scalp Area	Frontal
Patient Condition	Resting, Eyes Open

EEG Waveforms and Age



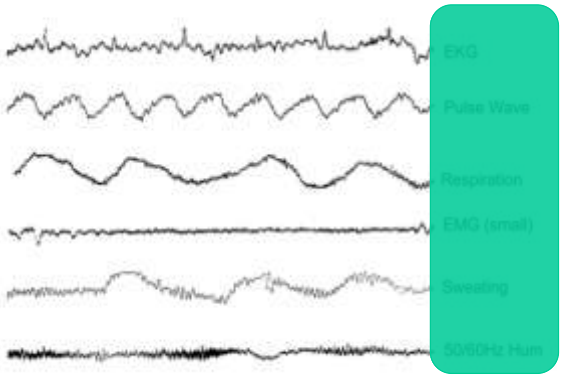
EEG Waveforms and Sleep



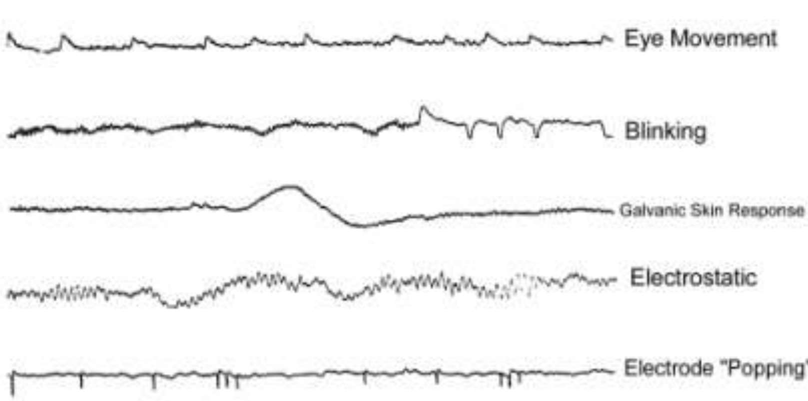
The EEG waveform in a normal subject changes according to the level of consciousness.

Artefacts in EEG Recordings

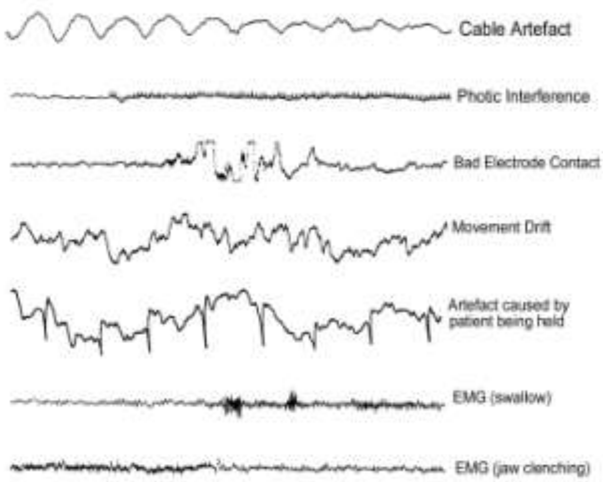
EEG activity is very small in voltage terms – it is therefore very easy to record artefacts in the EEG. It is important to be able to determine real EEG from many kinds of interference.



Artefacts in EEG Recordings



Artefacts in EEG Recordings



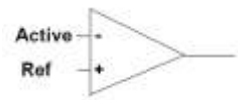
Photoelectric artefacts

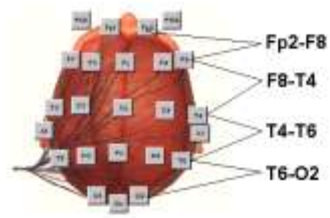
Recording the EEG

In clinical EEG recording, the waveforms are recorded in a series of ***Montages***.

What is a montage?

Each EEG trace is generated from an active and a reference electrode. Different patterns of electrodes are selected and the traces grouped to provide data from different areas of the scalp.





Types of Montage

Common Reference

All active electrodes are referred to a single point, e.g. Linked Ears (LE), or Cz.

Note: The linked ear reference is how Nicolet Digital systems record the raw (original) EEG signals, allowing calculation of other montages post-acquisition

Types of Montage

Average Reference

Here, all active electrodes are referred to a calculated average of other electrodes.

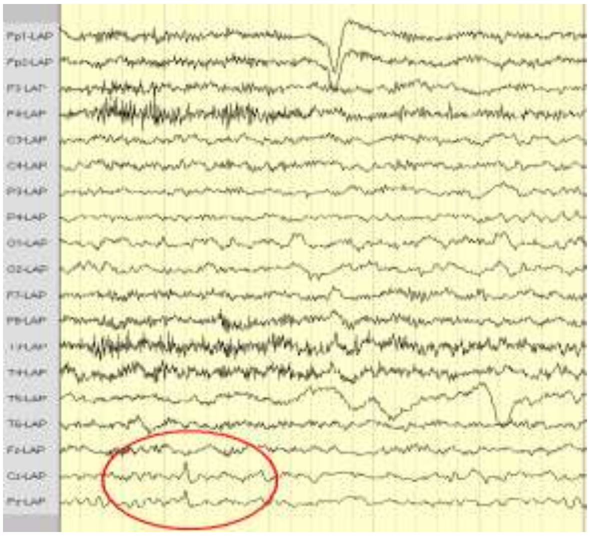
Electrodes which are likely to show artefacts are generally not included in this average calculation

Types of Montage

Bipolar

Each trace is made up of an electrode referred to a neighboring electrode. Traces are typically grouped in patterns such as anterior-posterior (front to back of head) or transverse (side to side)

Types of Montage



Laplacian

Also known as *Source Derivation*, the Laplacian montage shows each active electrode referred to a weighted average of all of its neighbors.

Laplacian montages are very good for localising the focus of abnormal activity

Stimulation

During the EEG recording, various techniques may be employed in an effort to illicit an epileptic response. The most commonly used are Photic Stimulation and Hyperventilation

Photic stimulation is presented at varying frequencies, typically with a stimulation time of around 10 seconds (of which, 5s will be recorded with the patient's eyes open and 5s with eyes closed) and an "off" time (no stim) of at least 5 seconds.

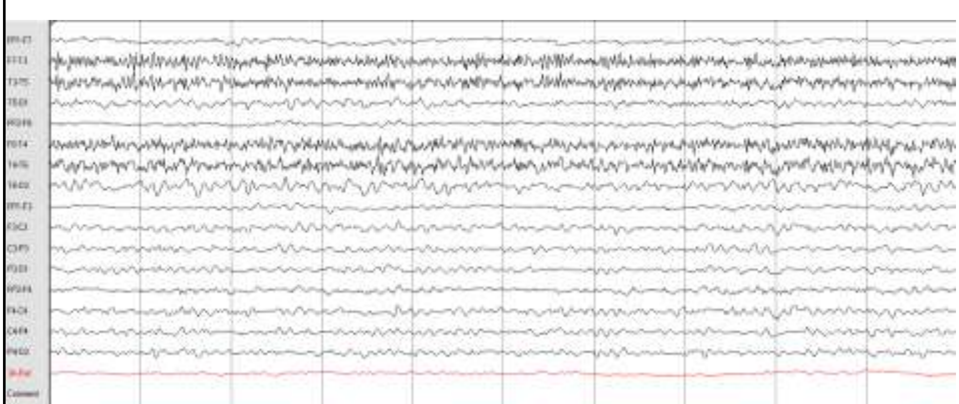
There is currently no standard for photic stimulation, either in terms of the stimulator itself, or the procedure to be followed and so this varies from lab to lab

Stimulation

In **<u>Hyperventilation</u>** (HV) the patient is asked to breathe in very deeply through the nose and gently out through the mouth. This will be continued for around three minutes and the EEG will be marked accordingly. The Post Hyperventilation condition is then recorded for a further three minutes, or more.

HV can cause the patient to feel dizzy or nauseous and annotation of the EEG should reflect those feelings.

HV slow



From Paper to Digital EEG

EEG machines were originally paper based chart recorders, which used galvanometers with pens and ink to plot the EEG signals.
Since around 1990, the vast majority of EEG systems installed have been Digital -- generally PC based system which record the EEG to disk.

The advantages of Digital EEG are as follows;

- EEG can be re-analysed after recording; montages can be changed, sensitivities and filters altered etc.
- Quantitative Analysis is readily available with Digital EEG – e.g. frequency analysis or Topographic Brain Mapping
- Synchronised Digital Video recording with the EEG enhances diagnostic capability of the test
- Digital EEG saves time – no pen calibration, ink or paper loading – little preparation is required
- Much more cost effective; paper costs with an analog system were significantly higher than current digital archive media
- Storage costs with paper were also significant – a lot of (expensive) space was required to store paper EEGs

Routine Clinical EEG

- The routine clinical recording is generally the first step in any testing requiring EEG investigation.
- The test is usually performed in the EEG lab on a system with 24 to 32 channels, most often on an outpatient basis. Simultaneous recording of patient video is becoming increasingly popular in clinical EEG, as valuable additional clinical information can be obtained.
- The recording typically lasts 20 to 30 minutes, but sometimes may be longer (for example if an EEG is required in the ICU, in the Operating Room, or the patient has been sleep deprived prior to the recording)
- For epilepsy patients, if the clinical EEG does not reveal any abnormality, the patient may be referred for ambulatory EEG or Long Term Monitoring

Ambulatory EEG

- An ambulatory EEG system allows the patient to go about their normal daily routine, while their EEG is recorded, typically over a 24 - 48hr period.
- This enhances the possibility of recording the EEG when the patient experiences an epileptic event (e.g. absences)
- The downside of ambulatory EEG is that the physician cannot see the patient’s behavior when an event is recorded and so discrimination from artifact becomes harder.
- Long Term Monitoring provides more information and may therefore be needed or preferred.

Long Term Monitoring

Long Term Monitoring makes three basic demands;

- Ability to record for extended periods, e.g 7 to 10 days continuously
- Absolute synchronisation of EEG and Video
- More EEG channels – upto 128 (to allow recording from intra-cranial electrodes)

There are three phases identified in Long Term Monitoring

- Phase I – Differential Diagnosis
- Phase II – Pre-surgical evaluation
- Phase III – Intraoperative and Post-surgical monitoring