UNIT - II

Epilepsy (seizure)

Epilepsy is symptom of brain damage.

This may be due to defect in the birth of head injury during accident. It may also due to brain tumour

 ---- Epilepsy.

Generally divided into two major groups

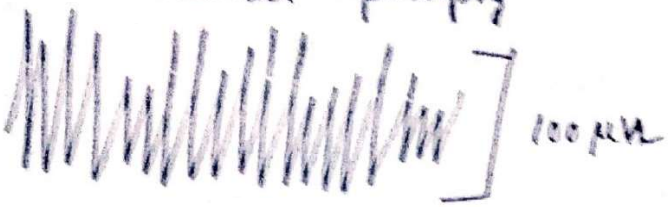
* Generalized → Seizures produced by widespread abnormal electrical impulses present throughout the entire brain
* Partial (focal/localized) → Seizures produced by electrical impulses that generate from a relatively small or "localized" part of the brain.

Generalized epilepsy classification

i) Generalized tonic - clonic (Grand mal)

* Symptoms :- The patient loses consciousness and usually collapses. The loss of consciousness is followed by generalized body stiffening ("tonic" phase), then by violent jerking ("clonic" phase), after which the patient goes into a deep sleep. During grandmal injuries and accidents may occur such as tongue biting and urinary incontinence.

Grandmal epilepsy



* This response can be recorded from almost any region of cortex
* The recorded potential is of high magnitude & the response is synchronous with same periodicity as normal alpha waves.

Petitmal epilepsy

Petitmal epilepsy is closely allied to grandmal epilepsy. It occurs in two forms

(i) myoclonic form
(ii) absence form

Myoclonic form

Symptoms :- Sporadic & brief jerking movements, usually on both sides of the body.

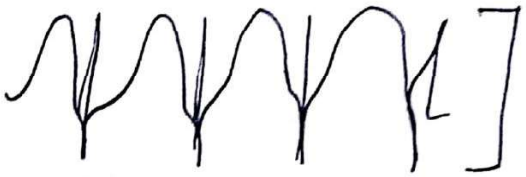
* In myoclonic form, a burst of neuronal discharges, lasting a fraction of second, occurs throughout the nervous system. These discharges are similar to those that occur at the begining of a grandmal attack
* The person exhibits a single violent muscular jerk involving arms or head. The entire process stops immediately, however the attack is over before the subject loses consciousness or stops what he or she is doing

* This type of attack often becomes progressively more severe until the subject experience to a grandmal attack.

Absence type :-

Symptoms : Brief loss of consciousness (just a few seconds) with few or no symptoms. It beings and end abruptly and might occur several times a day.

* It is characterised by 5 - 20 s of unconsciousness, during which the subject has several twitchlike contractions of the muscles, usually in the head region.
* There is a pronounced blinking of the eyes, followed by a return to consciousness & continuation of previous activities
* In rare cases, it can initate a grandmal attack.



Petitmal.

* It is a typical spike & dome pattern is recorded during the absence type of petitmal epilepsy.
* The spike portion of the record is almost identical to the spike occuring in grandmal epilepsy, but the dome portion is distinctly different.

* The spike & dome pattern can be recorded over the entire cortex, illustrating again that the seizure originates in the RAS [Reticular activating system]

Partial epilepsy

* Partial epilepsy can involve almost any part of the brain, either localized regions of the cerebral cortex or deeper structures of both the cerebrum and brain stem.

* partial epilepsy almost always results from some organic lesion of the brain, such as a scar that pulls on the neuronal tissue, a tumor that compresses an area of the brain or a destroyed region of the brain tissue.

* Lesion such as these can cause local neurons to fire very rapid discharges. when the rate exceeds approximately 1000 per second, synchronous waves begin spreading over adjacent cortical regions

* This will spreads to adjacent areas at rate as slow as a few millimeters per minute to as fast as several centimetres per minute.

* When such a wave of excitation spreads over the motor cortex, it causes progressive 'march' of muscular contractions throughout the opposite side of the body. This is called "Jacksonian epilepsy or Jacksonian march". [tingling or twitching begins in a small area & then "marches" or spreads to the larger area of the body.

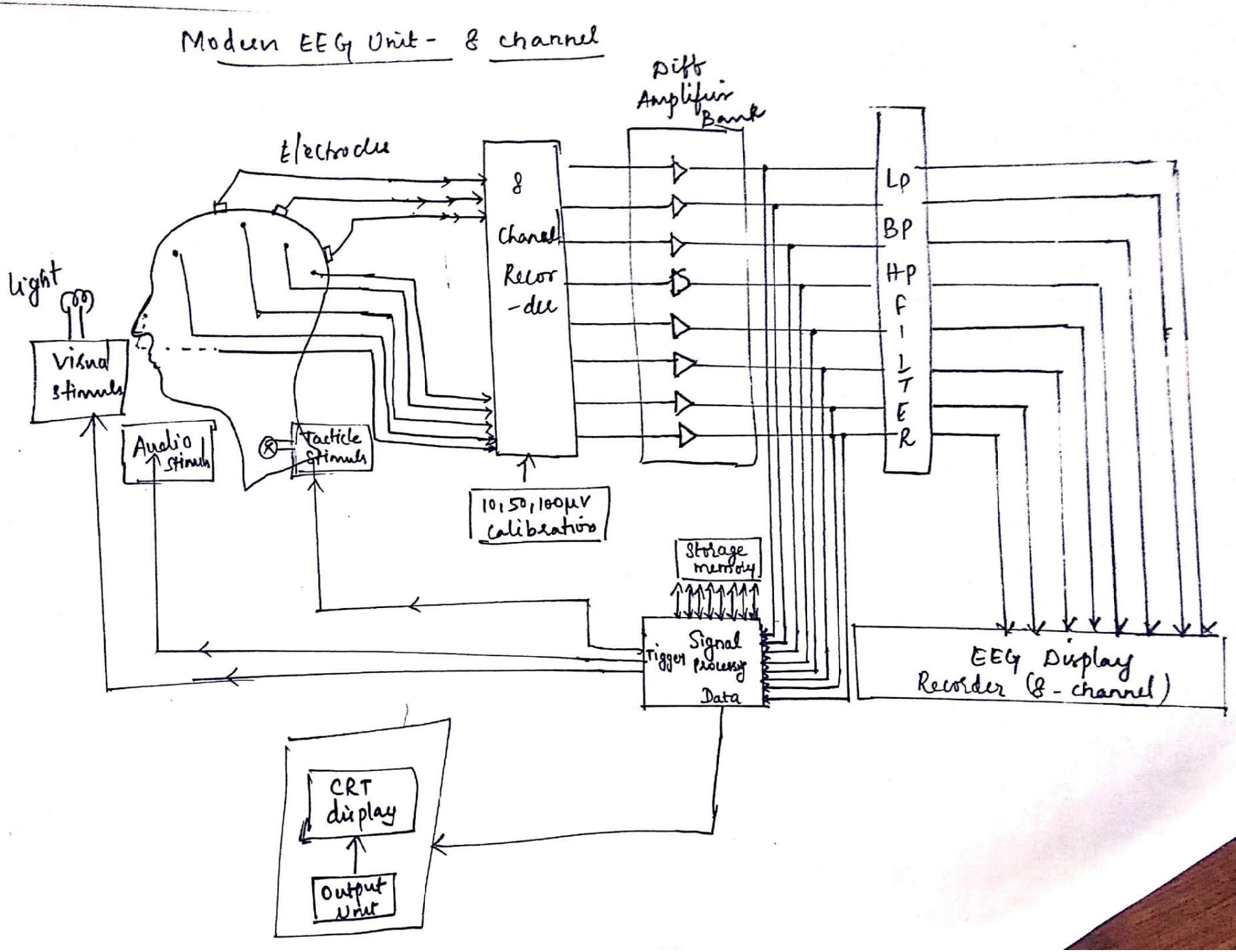
Another Type of Partial epilepsy is so called Psychomotor seizure which may cause

(i) a short period of amnesia
(ii) an attack of abnormal range
(iii) Sudden anxiety or fear
(iv) a moment of incoherent speech or mumbling or
(v) a motor act of rubbing the face with the hand, attacking Someone & soforth.

* Some times the person does not remember his or her activities during the attack, at other times the person is completely aware of but unable to control his (or) her behaviour.

Psychomotor

Psychomotor seizure shows a low frequency rectangular wave response with a frequency between 2 & 4 Hz with superimposed 14 Hz waves



Description:

↳ The modern 8 channel EEG recorder consist of 21 electrodes and is connected to the eight channel selector.

↳ The electrodes are attached to the channel selector in the group of eight called a montage of electrodes. The 50Hz interference is reduced by employing differential amplifiers as preamplifiers with more than 80 db CMRR and by use of 50Hz notch filters.

↳ The effect of notch filter on signal distortion is not so much important because EEG signals have frequencies below 30Hz. Further if the room, in which EEG unit is placed is covered with ferrous metal screen to reduce 50Hz interference

↳ The source of brain has high internal impedance, the input impedance of the preamplifier should be more than 10MΩ to prevent reduction of signal amplitude

↳ By cascading, the gain of the amplifier is increased to 10^6 so as to drive the recorder or imaging CRT without any difficulty.

↳ The output voltage from the amplifier may either be applied directly to the 8 channel display through the filter bank or it may be stored as data on a tape recorder or is a computer memory for further processing.

↳ The filter bank consist of appropriate filters to select different types of brain waves. There are other facilities are available to record evoked

potentials from sensory parts of the brain that there are external stimuli like visual stimulus, audio stimulus & tactile (touch) stimulus.

↳ The time delay between the stimulus & response can also be measured in the signal processing unit. In the eight channel per recorder there are 8 pens such that a pen for each channel. The normal paper chart speed is 30mm/sec.

↳ There are also 60mm/sec for high frequency recording & 10mm/sec to conserve paper during setup time.

Evoked potentials

↳ If an external stimulus is applied to a sensory area of the brain, it responds by producing an electrical potential known as "evoked potential".

↳ Most frequently used evoked potentials for clinical testing include brainstem auditory evoked responses, visual evoked responses & somatosensory evoked potentials.

↳ Evoked potentials, recorded at the surface of the brain, is the integrated response of the action of many cells.

↳ The amplitude of the evoked potential is the order of 10 microvolts.

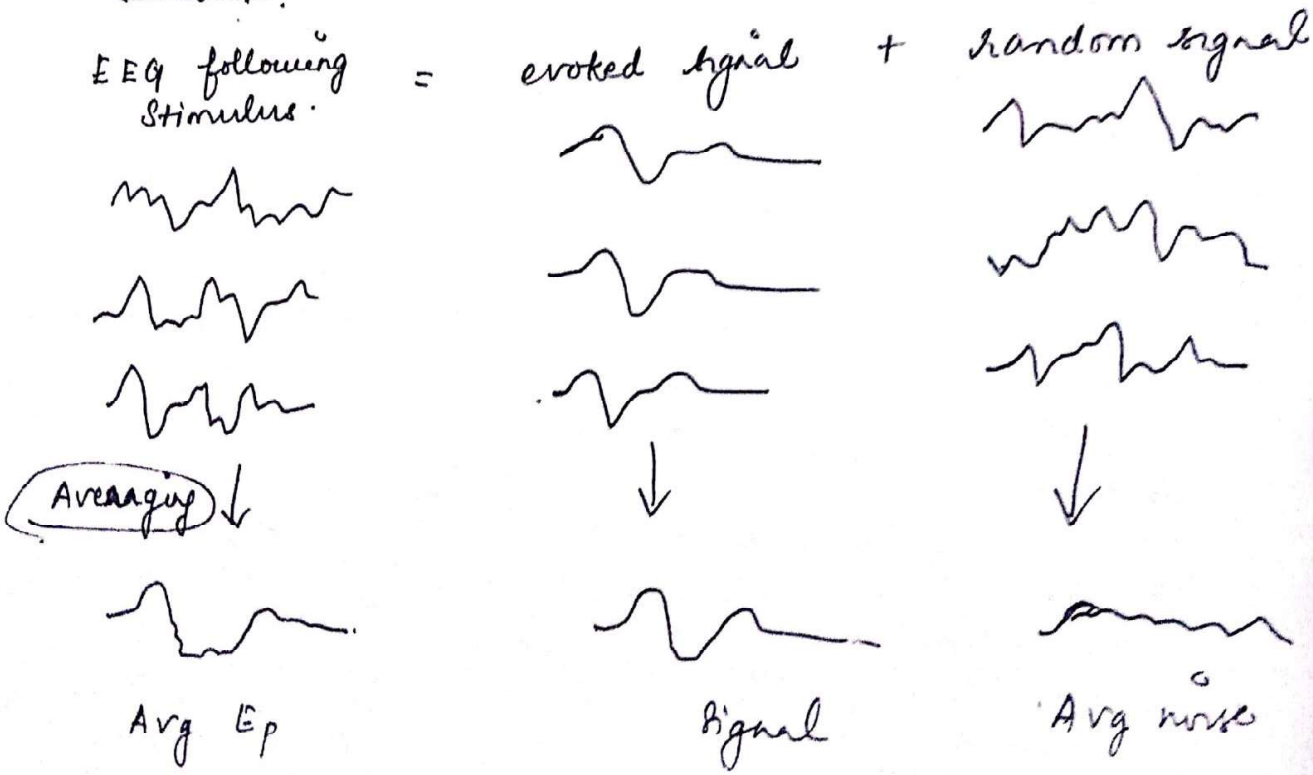
↳ The evoked potentials are generally superimposed with electroencephalograms.

↳ Therefore it is necessary to remove the EEG by an averging technique while making evoked Potential measurements.

↳ Since the background EEG & other unwanted signals often appear irregular, or do not synchronize to stimuli, they are markedly reduced by averaging across multiple trials. Most of the improvements in Signal to noise ratio occur within 40 to 100 trials.

↳ since many evoked potential components are of short duration, about 2ms to 1 sec, rapid sampling rates are needed to digitally record such low level potentials. Usually, sampling rate is 1000/sec.

Averaging.

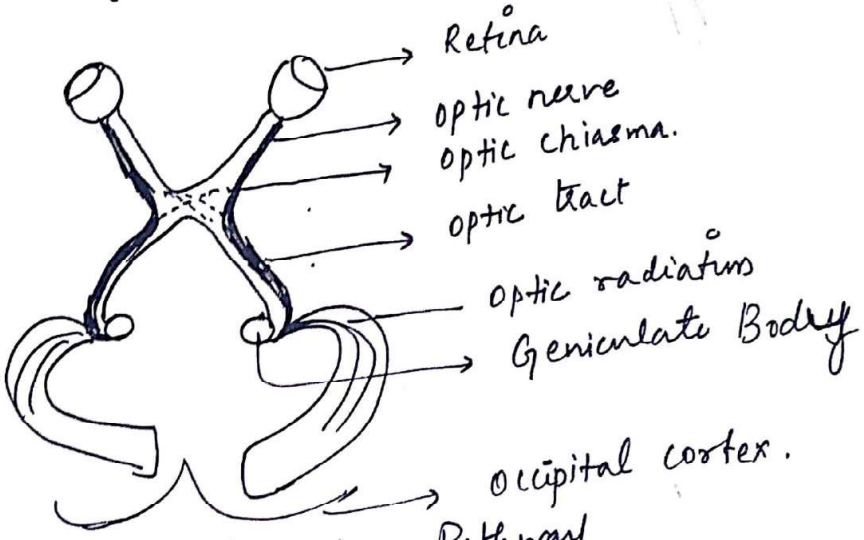


Visualy Evoked potential [VEP]

↳ It is record of gross electrical signal generated at visual (occipital) cortex in response to visual stimulation.

↳ The amplitude of VEP 3 to 25 microvolt is considerably smaller than that of EEG, which can be as large as 100 microvolt.

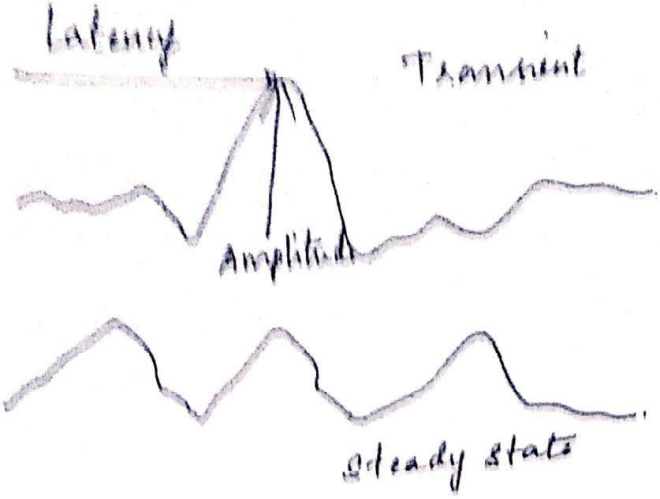
↳ VEP is the only objective technique available to assess clinically the functional state of the visual system beyond the retrial ganglion cells.



Visual system Pathway

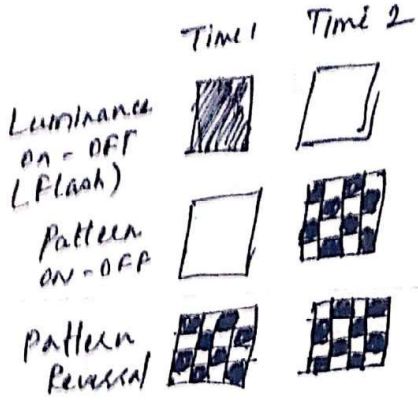
* At rapid rate of stimulation the waveform becomes sinusoidal → Steady state VEP

* At low rate of stimulation — discrete deflections are formed known as Transient VEP → This commonly employed.



Types of VEP

1) Flash VEP
2) Pattern ON/OFF VEP
3) Pattern - Reversal VEP



Flash VEP

* Response to diffusely flashing light stimulus that subtends a visual field of 20 degrees.
* Cruder response than pattern VEP
* Merely indicates that light has been perceived by cortex.
* Indications - Primary used when there is media haze, is fast, poor patients co-operations.
* Greater variability of response with multiple positive & negative peaks

Pattern reversal VEP

* Response to a patterned stimulus - Checkerboard or square & sine wave gratings

* frequency of gratings is described in cycles per degree [CPD].
* for check pattern visual angle subtended by a single check is used
* preferred technique for most clinical purposes, gives an estimate of form sense & thus visual acuity.

Pattern ON/OFF VEP

* A pattern is abruptly exchanged with an equiluminant diffuse background.
* More intersubject variability than pattern reversal VEP
* Useful in detection of patients with malingering & patients with nystagmus.

Prerequisites

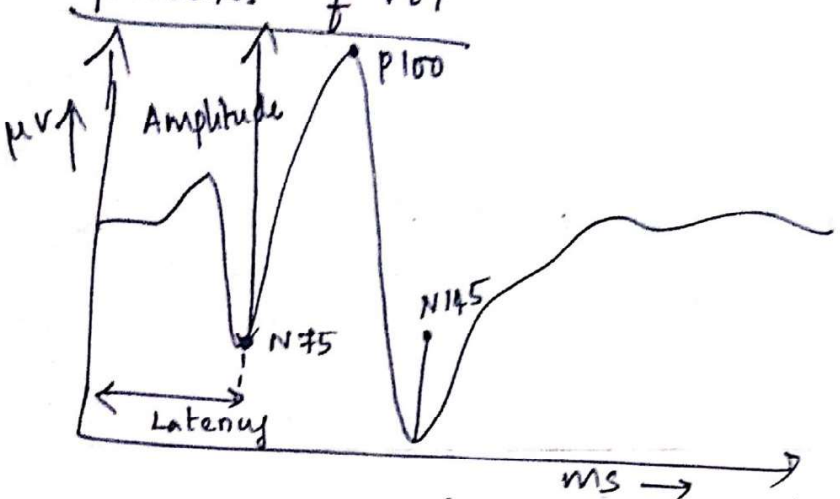
* NO distracting sound or light waves
* pattern & flash must both be done in all patients, as pattern cannot be detected in pts with media opacities.
* pattern VEP followed by flash VEP → significantly affected by eccentric fixation, excessive blinking of eyes & partial closure of eyes.

Technique of Recording

* Undilated pupil
* Refractive correction
* Relaxed position
* 1m distance from monitor.

Electrode placement → International 10/20 system. The active electrode at O_2 with reference electrode at F_z. Ground at the forehead, vertex (C_z), mastoid, earlobe (A_1 or A_2).

Components of VEP.



A normal pattern reversal VEP.

→ The first response of the full-field pattern-reversal VEP recorded mid-occipitally is a negative deflection termed N75

→ By convention full-field VEPs usually are assessed by evaluating the first positive major deflection that occurs at around 100 msec and therefore designated P100 component

→ Following the P100, the next negative deflection is referred to as N145.

N75 (N1) → reflects i/p from the dorsal LGN to the striate cortex (via optic radiations)

early phase P1 component (P100) → generated in dorsal extrastriate occipital cortex of the middle gyrus

→ P100 → reflect a Secondary inhibitory response at V1 or excitatory outflow to the accessory visual cortex of the brain (cortical)

→ later component (N145) N_2 → ~~reflects input from~~ generated from several areas including a deep source in parietal lobe

Two primary features to each deflection

(i) the time elapsed since the stimulus (latency)

(ii) The magnitude of deflection from the baseline (amplitude)

Note:- Latency delay is often interpreted as evidence of demyelinating injury to the visual pathway

optimal cut-off for inter-ocular latency ranges from 6 to 10 msecs

Normal ranges

P100 Latency (msec) = 102 +/- 5

R-L difference (msec) = 1.3 +/- 2.0

Amplitude (μV) = 10 +/- 4.2

Duration = 63 +/- 8.7.

Application of VEP

(1) ~~Craniofacial~~ procedure & pituitary surgery

(ii) Multiple Sclerosis
(iii) Demyelinating disorders
(iv) Axonal loss disorders
(v) Migraine Headaches

Limitations of VEP

↳ Don't not measure the pathways & useful clinical vision
↳ The large bulky "googles" usually used for stimulation pose technical problems.
↳ Anaesthetic sensitivity makes recording difficult.

Somato Sensory Evoked potentials

↳ Evoked potentials of Sensory nerves in the Peripheral & Central nervous system
↳ used to diagnose nerve damage or degeneration in the spinal cord.
↳ It can distinguish central Vs phriperal nerve lesion.

Anatomical & physiological basis of SSEP

Sense Organ – Pacinian & golgi complexes in joints muscles & tendons
(Type of fibres) ↓
Dorsal Root Ganglia
↓
Gracile & Cuneate Nucleus in Medulla
(Medial Lemniscus) ↓
Nucleus Posterolateralis of thalamus
(Thalamocortical Radiation) ↓
Sensory cortex

Methodology

Stimulus:

Electrical square wave pulse by surface or needle electrode.

Duration:

100 - 200msec at a rate of 3-7 sec

Intensity

2·5 - 3 time the threshold.

Upper extremity SSEP

Sites

* ERB's point
* Cervical spine - C_2 or C_5
* contralateral scalp overlying the area of the primary sensory cortex - C_3 or C_4.

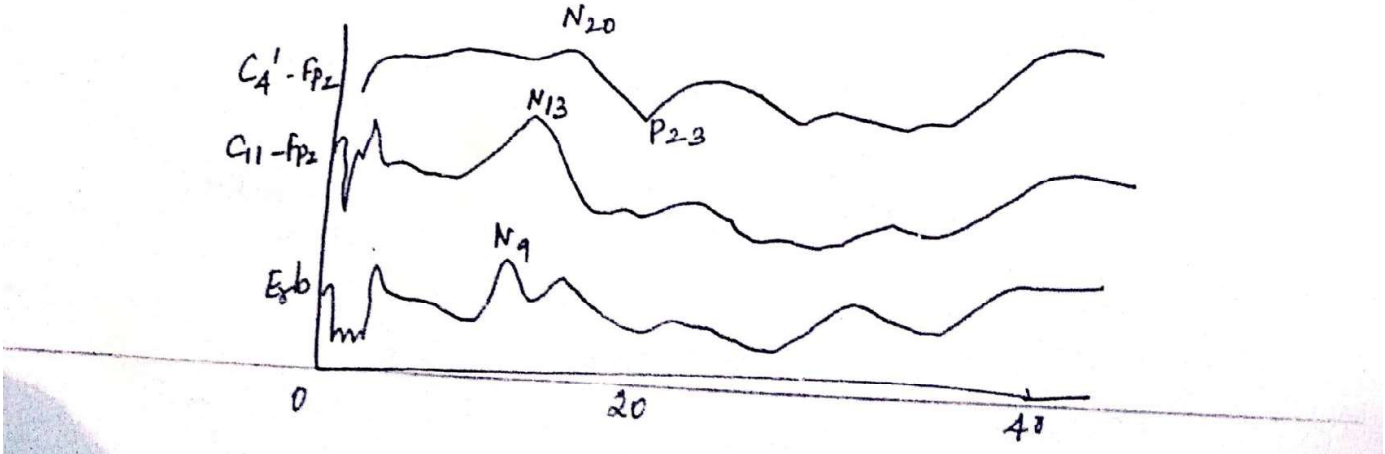
Reference - Forehead F_z

Ground - proximal to stimulation site

Median nerve SSEP

* ERB's point - N_9 - Branchial plexus
* Cervical spine: N_{13} - Dorsal column nuclei
* Scalp: N_{20} - P_{23} - thalamocortical radiation & Primary sensory cortex

Median nerve SSEP



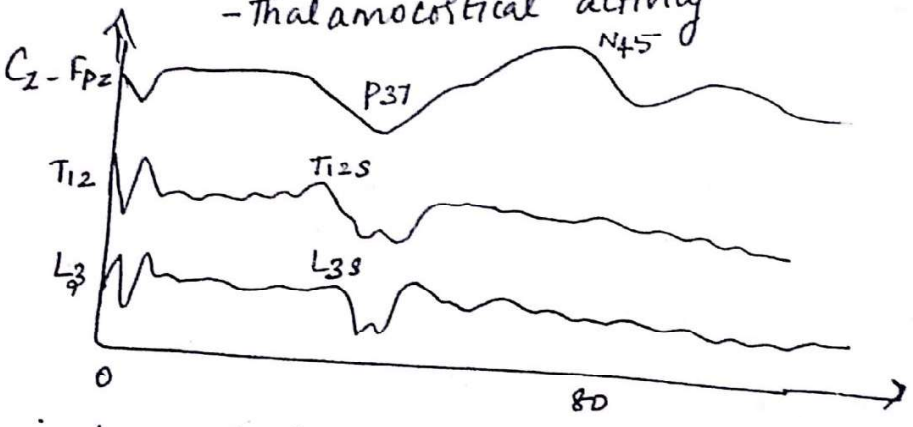
Lower limb SSEP

* Lumbar spine – L_3
* Thoracic spine – T_{12}
* Primary sensory cortex.

Tibial

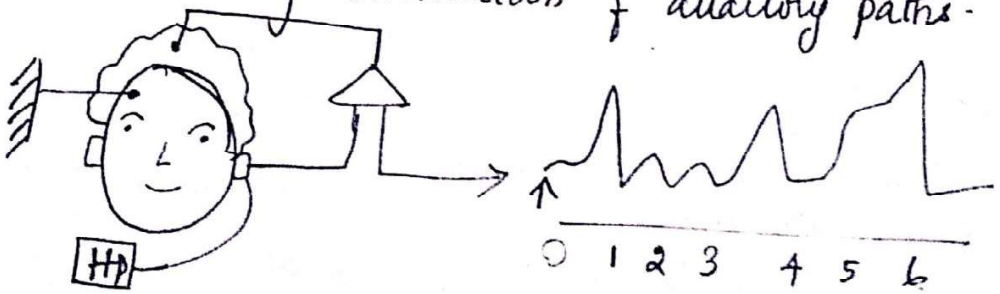
Tibial nerve SSEP Response

* L_3 - Negative peak with latency 19ms
  nerve root of cauda equina
* T_{12} - Negative peak with latency 21ms
  Dorsal fibres of spinal cord.
* Scalp - positive peak - P37
  Negative peak - N45
  - Thalamocortical activity



Brainstem Auditory Evoked potential

* BAEP are electric field potentials generated with repetive auditory stimulation of auditory paths.

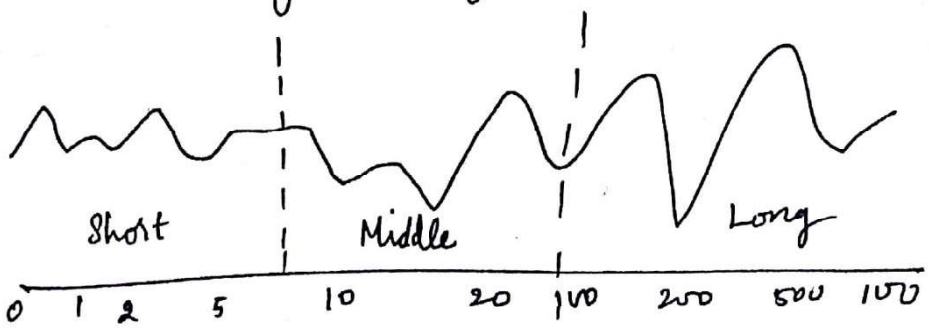


* BAEP reflect neuronal activity in the auditory nerve, cochlear nucleus, Superior olive & inferior calliculus of the brain stem

* These are recorded from ear & vertex in response to brief auditory stimulation

* BAEP comprise 5 or more waves within 10 ms stimulus

↳ Short latency response < 10ms
↳ Middle Latency response — 10–100ms
↳ long latency response > 100ms.

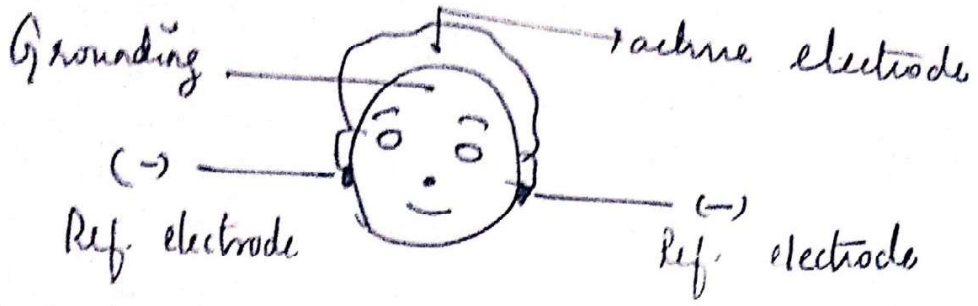


Ascending pathway

Primary Auditory cortex
Medial Geniculate body
Inferior Colliculus
Lateral leminscus
Superior olivary complex
cochlear Nucleus
VIII th Nerve

Electrode placement

1) Recording electrode — C_2 placed at vertex
2) Reference electrode — A_1 placed at Mastoid process
3) Ground Electrode — A_2 placed at Contralateral



Method of Recording

→ To elicit & record BAEPS an auditory stimulus is delivered to patient via headphones.

→ Auditory stimulus is a square wave pulse of 0.1ms duration

→ Pulse can move earphone diaphragm either towards or away from the ear

→ Earphone movement towards the ear is called condensation phase stimulus.

→ Stimulus away from patient ear is called rarefaction stimulus

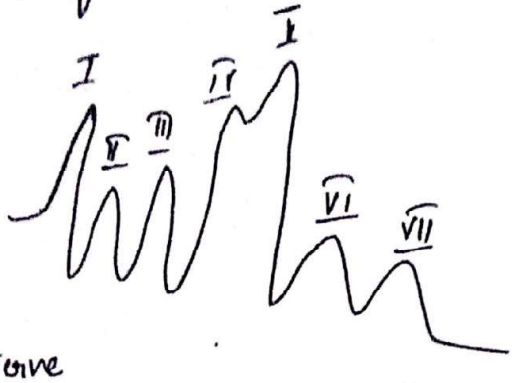
→ Intensity of stimulus in stimulating ear ranges from 70 to 100 db.

→ As one ear is stimulated with clicks, the other is marked with white nose, typically 30 to 50 db.

→ This method helps to prevent the undesired co-activation of contralateral ear caused by bony conduction from :

→ Atleast 2000 trials are averaged to get a good quality recording. 2 to 3 repetitions are done and superimposed to check for reproducibility

BAEP waveforms



I → VIII Nerve
II → Superior olivary Complex
III → Lateral lemeniscus
IV → Inferior Colliculi
V → ~~MGB~~ Inferior calliculus (Median geniculate body)
VI → Auditory cortex

Magneto Encephalography (MEG).

- MEG is a functional neuroimaging technique for mapping brain activity by recording Magnetic fields produced by electrical currents occurring naturally in the brain using very sensitive Magnetometers
- Records the magnetic flux that arises from source current.
- Current is always associated with magnetic field ⊥ to its direction.

Dipole

- Dipole generates a magnetic field.
- Dentritic current flows from apical Pyramidal neuron
- ~~Atleast 10,000 neuron firing simultaneous~~ for MEG to detect

Recording of Magnetic flux

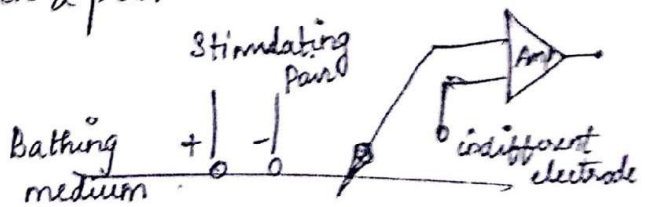
- Recorded by special sensors called Magnetometers
- Magnetometer is a loop of wires placed parallel to the head surface
- The strength of magnetic flux at a certain point determines the strength of ~~an~~ current Produced in magnetometer
- Current produced in magnetometers are extremely weak & must be amplified.
- Super-conductive Quantum Interference devices (SQUIDS)
- It is filled with liquid helium to keep them at extremely low temperature.
- Different types of sensors

Magnetometer - Magnetic flux through single coil

Gradiometers - Difference in magnetic flux between 2 points

Uses

↳ Epilepsy
↳ Seizure location
↳ Lesion
↳ Tumor



Advantage

i) The brain & overlying tissues can be characterised as a single medium having a constant magnetic permeability μ. The magnetic field therefore does not get affected/influenced by shell like inhomogeneities

surrounding the brain (skull, scalp, fluid layers, meninges)

2) The measurement is indirect in that electrodes are not necessary to record the MEG. The SQUID detector does not need to touch the scalp, because the magnetic field does not disappear in air.

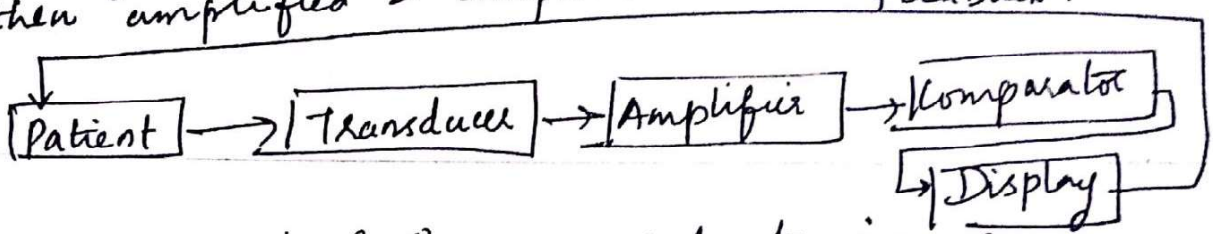
EEG Biofeedback Instrumentation

* In general Engineering terms, feedback is used to control a process is applied to biological process with in the body, then it is known as biofeedback of biological feedback.
* Many different physiological process have been evaluated for possible control by biofeedback methods, including EEG. (eg) certain brain wave patterns like α wave is influenced by biofeedback methods.
* ~~EEGs~~. Biofeedback instrumentation includes a transducer and amplifier to measure the body variable that is to be controlled by the biofeedback process.
* The magnitude of the measured variable is converted to suitable visual, auditory and output and is presented to the subject.
* The success of biofeedback depends on interpretation of data & the training of the subjects so that they can use the results effectively.

* The control for biofeedback may be direct or telemetric. In biofeedback the subject himself is doing the control by seeing or hearing the activity.

* Biofeedback is also called self control which directly controls the activity which involves autonomic nervous system through feedback.

* In the below figure, the patient bodily functions / Activity like heart rate, EEG, muscle activity is measured by a transducer which is then amplified & compared.



* This error signal is converted to visual & auditory signal, By seeing or hearing the signals a patient can control his/her signals (physiological activity).

* Epilepsy patients observe the EEG patterns & control the seizure. Active research is going on with this field to get valuable results which are tested and proven from self control (or) biofeedback setup.