

Recommendations for Minimum Standards for the Education and Training of Neurophysiological Technologists

Evoked Potential Unit:

Sections:

- 1. Electrodes**
- 2. Stimulus Delivery Characteristics**
- 3. Data Processing**
- 4. Additional Equipment Characteristics**
- 5. Procedures for Obtaining Evoked Potentials - General**
- 6. Procedures and Strategies – Obtaining Visual Evoked Potentials (VEP’s)**
- 7. Procedures and Strategies – Obtaining Auditory Evoked Potentials (AEP’s)**
- 8. Procedures and Strategies – Obtaining Somatosensory Evoked Potentials (SSEP’s)**
- 9. Evoked Potential Characteristics**
- 10. Patient Care**
- 11. Patient Experience (Range)**
- 12. Other Neurological Procedures**
- 13. Factual Reports (Descriptive)**
- 14. Structure, Function and Pathology of the Central Nervous System**

The following assumes a secondary school education or an equivalent background, with proven competence in mathematics, physics, biology and chemistry.

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RECOMMENDATIONS

1. ELECTRODES

The trainee should:

Competently apply electrodes using a standard electrode placement system and exercise correct care and maintenance of the electrodes:

1. Name the electrodes routinely used in the department and describe their construction
2. Discuss a range of electrodes and transducers used for EP recordings
3. Explain care, maintenance and sterilisation procedures for the electrodes in 2.above
4. Accurately measure the head using a standard system of electrode placement
5. Explain the consequences of incorrect measurement/placement of electrodes when recording EP data
6. Accurately apply electrodes to the scalp using the measured system of placement
7. Clean and, where appropriate, sterilise electrodes according to Health and Safety requirements (OSET Ref)
8. Prepare electrodes and equipment for re use
9. Explain the characteristics of EP electrodes with respect to:
 - a. Electrode Potential
 - b. Polarisation
 - c. Electrode Impedance and effect on recorded data
 - d. Chlorided and unchlorided silver electrodes

10. Describe the construction care and maintenance of electrodes and leads in EP recording :
 - a. Surface Electrodes
 - b. Stimulators
 - c. Needle Electrodes
11. Discuss recommended cleaning and sterilising procedures used in Peripheral Neurophysiology (OSET Ref)

2. STIMULUS DELIVERY CHARACTERISTICS

The trainee should be able to:

Demonstrate an understanding of the characteristics of stimulators and stimulation delivery with regard to visual, auditory, and somatosensory EP's.

1. Identify and describe the properties of visual stimulation with respect to:

- a) Stimulus Generation.
- b) Speed of pattern change.
- c) Type of pattern presented.
- d) Size and location of stimulus field.
- e) Size of pattern elements.
- f) Visual field being stimulated.
- g) Luminance and contrast of patterned stimulus.
- h) Ambient Light
- i) Mode of stimulus.
- j) Rate of presentation.

2. Identify and describe the properties of auditory stimulation with respect to:

- a) Stimulus generation.
- b) Stimulus bandwidth.
- c) Stimulus waveform, electrical and acoustical.
- d) Stimulus duration.
- e) Stimulus polarity.
- f) Stimulus rate.
- g) Stimulus intensity.
- h) Stimulus location.
- i) Stimulus presentation.

3 Identify and describes the properties of electrical stimulation for somatosensory EP's with respect to:

- a) Electrode type: transcutaneous, subcutaneous, or direct nerve stimulation.
- b) Applied electrode impedance.
- c) Constant current versus constant voltage stimulators.
- d) Stimulus waveform.
- e) Stimulus duration.
- f) Stimulus intensity.
- g) Stimulus rate.
- h) Stimulus presentation.
- i) Anode/cathode orientation.

3. DATA PROCESSING

The trainee should be able to:

Describe and understand the process of analogue to digital conversion and signal averaging, as well as the capabilities manifested by computer processing of data.

1 Describe analogue to digital conversion as it applies to horizontal (temporal) resolution of signals:

- a) Analysis time (epoch).
- b) Number of data points.
- c) Dwell time.
- d) Bin width.
- e) Sampling rate.
- f) Nyquist frequency.
- g) Aliasing.

2 Describe analogue to digital conversion as it applies to vertical (voltage) resolution of signals:

- a) Resolution of analogue to digital converters in bits.
- b) Converter range as it relates to amplifier gain.
- c) Principles of artefact rejection.

3 Understand principles of signal averaging as it relates to:

- a) Signal to noise ratio.
- b) Number of repetitions as relates to signal/noise.
- c) Effect of good recording techniques and the proper use of filtering on the signal to noise ratio.
- d) Triggering of recording epochs.
- e) Cursors for measurement purposes.

4 Demonstrate and explain aspects of data storage and retrieval.

5 Demonstrate and understand various types of data manipulation.

- a) Display gain increase/decrease.
- b) Waveform position on screen.
- c) Waveform(s) selection for manipulation.
- d) Waveform on/off or erase.
- e) Waveform grand averaging.
- f) Subtraction between waveforms.

- g) Waveform display polarity reverse
- h) Digital filtering(smoothing or FFT).

4. EQUIPMENT CHARACTERISTICS

The Trainee practitioner should be able to set up and calibrate the recording system in accordance with the required standard of performance.

1 Identify the component parts of the EP recording system

- a) Input board.
- b) Number of channels.
- c) Input selector switches.
- d) Differential amplifiers and polarity convention.
- e) Differential amplifiers and CMRR.
- f) Acceptable amplifier noise levels.
- g) Amplifier gain versus sensitivity.
- h) Low frequency filters including time constant, turnover frequency (hertz), roll-off characteristics, and the effects of phase shift (phase lead).
- i) High frequency filter turnover frequency (hertz), roll off characteristics, and the effects of phase shift (phase lag).
- j) Notch filters and their characteristics.
- k) Digital filters and their incorporation
- l) CRT oscilloscope, or computer monitors.
- m) Single or dual/multiple split screen displays.
- n) Raw input display.
- o) Individual averager sweep display.
- p) Ongoing averaged data display.
- q) Stop screen display.
- r) Printers

- 2 Describe the main function of the component parts in 1. above
- 3 Draw a schematic diagram of the signal pathway
- 4 Assess and document machine performance
- 5 Identify, document and rectify where possible equipment faults

5. PROCEDURES FOR OBTAINING EVOKED POTENTIALS---GENERAL

The Trainee should be able to:

Demonstrate electrode connections, apparatus calibration, and basic testing procedures.

- 1 Accurately apply electrodes to the patient using the measured system of placement
- 2 Connect electrodes correctly to the headbox
- 3 Record electrode impedance and rectify if required ($<5K\Omega$)
- 4 Connect stimulating electrodes/apparatus properly to patient, and ensure adequate stimulation.
- 5 Ensure that ambient conditions are conducive to optimal EP recording.
- 6 Correctly program individual test protocols and appropriately use evoked potential system controls.
- 7 Understand the numerous non-pathologic factors influencing evoked potentials.
- 8 Modify stimulation and recording parameters where appropriate, while maintaining parameters. These should remain constant in each procedure.
- 9 Compare and contrast amplifier input connections:

- a) Near field recording.
 - b) Far field recording.
 - c) Combined near and far field recording.
 - d) Central nervous system recording.
 - e) Peripheral nervous system recording.
 - f) Midline/lateralized derivations.
- 10 Compare and contrast a range of montages whether pre-set or independently switched.
- 11 Identify, eliminate and minimise instrumental artefacts:
- a) Artefacts from electrodes and leads.
 - b) Electrical interference.
 - c) High electrode impedance/resistance.
 - d) Faults limited to one channel.
 - e) Faults due to poor contact on switches.
 - f) Interference from CRT.
 - g) Excessive artefact from stimulation devices
- 12 Identify, eliminate and minimise physiological artefacts affecting the recording process.
- a) Excessive eye movements.
 - b) Excessive muscle potentials.
 - c) Pulse artefact (if time-locked).
 - d) Excessive perspiration.
 - e) Voluntary movement
 - f) Tremors, jerks, twitches or other involuntary movements
- 13 Identify, eliminate and minimise extraneous interference affecting the recording.
- a) Mains supply frequency fields (50, 60 Hz).
 - b) Electrostatic.
 - c) Electromagnetic.
- 14 Measure and annotate evoked potential recordings performed during the clinical

procedure.

- 15 Use cursors to perform and label absolute and inter- peak latency, amplitude and amplitude ratio measurements pertinent to the modality being performed.
 - a) Ensure that the patient information is correct.
 - b) Document any relevant information regarding the state or condition of the patient.
 - c) Label derivations used, and the polarity convention
 - d) Document all relevant recording and stimulation parameters, and machine controls used.
 - e) Identify and annotate waveforms correctly and relate to normative data

6. PROCEDURES AND STRATEGIES---OBTAINING VISUAL EVOKED POTENTIALS (VEP)

The Trainee will understand and be able to discuss optimal techniques for the obtaining of VEP's:

- 1 Understand additional factors necessary to obtain high quality pattern reversal VEP's (PRVEP's):
 - a) Alertness of patient.
 - b) Adequate visual acuity of the patient.
 - c) Proper fixation on the stimulus by the patient according to the visual field being stimulated.
 - d) The correct position of the patient in relationship to the stimulus field and pattern elements.
 - e) Perform monocular stimulation unless otherwise indicated.
 - f) Perform hemi-field stimulation when indicated.
 - g) Affect of ambient light
- 2 Describe methods of obtaining other types of VEP's:

- a) Flash VEP's.
 - b) Electroretinograms.
- 2 Understand the anatomy and physiological of the visual pathway and is able to discuss localization of visual pathway dysfunction:
- a) Prechiasmal.
 - b) Chiasmal
 - c) Retrochiasmal
 - d) Common ophthalmological conditions

7. PROCEDURES AND STRATEGIES---OBTAINING AUDITORY EVOKED POTENTIALS (AEP's)

The Trainee will understand and be able to discuss optimal techniques for the obtaining of AEP's:

- 1 Understand additional factors necessary to obtaining high quality brainstem AEP's (BAEP's):
 - a) Monaural stimulation at established intensity levels, converted to decibel hearing level (dB HL), or decibel sensation level (dB SL).
 - b) Accepted click stimulus characteristics for optimal BAEP recordings.
 - c) Utilizing contra lateral noise masking at proper levels, where possible.
 - d) Effect of extraneous noise
- 2 Describe and understand recording and stimulating criteria for other AEP types:
 - a) Latency-intensity series using BAEP's.
 - b) Electrocochleogram.

- c) Slow vertex response.
 - d) Frequency following potential.
 - e) Middle latency AEP's.
 - f) Long latency AEP's.
 - g) 40 Hz AEP.
- 3 Understand the anatomy and physiological of the auditory pathway and is able to discuss localization of lower auditory pathway dysfunction:
- a) Evidence of lower brainstem conduction deficits.
 - b) Evidence of upper brainstem conduction deficits.
 - c) Evidence of deficits between acoustic nerve and upper brainstem.
- 4 Describe and understand the effects of the various types of hearing loss on AEP's, and particularly BAEP's.

8. PROCEDURES AND STRATEGIES---OBTAINING SOMATOSENSORY EVOKED POTENTIALS (SEPs)

The Trainee will understand and be able to discuss optimal techniques for the obtaining of SSEP's.

- 1 Understand additional factors necessary to obtaining high quality pattern SSEP's in upper and lower extremities
- a) Median.
 - b) Ulnar.
 - c) Posterior tibial.
 - d) Common peroneal.
- 2 Understand additional factors when performing SSEP testing:
- a) Patient safety and comfort in regard to electrical stimulation parameters,

- e.g., stimulus intensity, duration, rates.
 - b) Appropriate stimulus intensities relating to motor/sensory thresholds.
 - c) Unilateral stimulation
 - d) Effects of limb temperature and patient's height
- 3 Understand the anatomy and physiological peripheral and central nerve pathway and detection and localization of conduction delays along somatosensory pathways
- a) Conduction delays along peripheral nerves.
 - b) Conduction delays between brachial plexus and cervical cord
 - c) Conduction delays between cervical cord and primary sensory cortex.
 - d) Conduction delays between lumbar spine and primary sensory cortex.

9. EVOKED POTENTIAL CHARACTERISTICS

The trainee should be able to:

Recognise and describe features of various evoked potentials.

- 1 Identify EP waveform as defined in the following ways:
 - a) Stimulus modality and type.
 - b) EP origin.
 - c) Recording sites.
 - d) Stimulus rate
- 2 Identify and measure the EP waveforms important for clinical identification and interpretation:
 - a) Electrical polarity.
 - b) EP sequence.
 - c) EP peak identification.

- d) EP latency from stimulus onset or from a preceding peak (interpeak latency).
- e) EP amplitude, measured from baseline or from the preceding or subsequent peak of opposite polarity.
- f) EP morphology.
- g) EP spatial distribution.
- h) EP variability's.

3 State references for Recommended Terminology for EP's.(IFCN)

10. PATIENT CARE

The Trainee must conform to the Principles of good practice

The beliefs and rights of the patient must be acknowledged, and the Trainee must take into account the patient's communication needs when discussing, explaining and conducting the investigation. The Trainee must also seek to maintain the patient's sense of dignity and self esteem during the investigation. These principles are presumed to apply throughout every part of this document

1. Understand and observe the policies relating to confidentiality of patient information
2. Understand and observe the policies and procedures for dealing with Medical and Nursing Staff, Parents, Relatives and/or Carers
3. Explain the procedure and put patients at ease
4. Describe how the patients condition may affect the recording
 - a. Anxiety, fever, pain
5. Evaluate the information given on the request form and obtain additional information from the patient
 - a. Medication
 - b. Visual Acuity/ Hearing Threshold/ Limb Temperature
 - c. Relevant medical history/recent surgical intervention

6. Recognise situations in which the planned investigation may be contraindicated by the physical or clinical state of the patient
 - a. Skin disorders
 - b. Severe oedema or swelling of extremities (for SEPs).
 - c. Limb hypothermia (for SEPs).
 - d. Severe otitis (for AEP's).
 - e. Open wounds or dressing on wounds

7. Describe the departmental arrangements for a cardiac emergency.

8. Locate the resuscitation equipment in the department.

11. PATIENT EXPERIENCE

The Trainee will be expected to gain experience of EP recording over a range of conditions and circumstances

1. Competently perform EPs in the following
 - a. Awake
 - b. Asleep
 - c. Altered state of consciousness
 - d. Poor compliance

2. Competently perform EEGs over a range of patient conditions
 - a. Adults
 - b. Children over 5 years
 - c. Ambulant and non-ambulant
 - d. Patients who are off-site (ward, ITU, other site)
 - e. Patients with psychiatric conditions

12. OTHER NEUROPHYSIOLOGICAL PROCEDURES

Where possible, the Trainee should have observed the following procedures and be able to

1. Describe the procedures for recording and discuss the main clinical uses of the following
 - a. EEG Recordings
 - b. Recording Nerve conductions
 - c. Recording Electromyography

13. TECHNICAL (DESCRIPTIVE) REPORTS

The Trainee is expected to prepare a concise factual report covering the procedure employed, neurophysiological findings and clinical events but without clinical interpretation

1. Describe normal values for latency, amplitude and interpeak differences (if appropriate) and amount in relation to age using standard terms to describe data
2. Describe the correlation of normal latencies and amplitude and interpeak differences with changing physical state of the patient if appropriate
3. Describe and identify abnormal waveforms

14. STRUCTURES, FUNCTION AND PATHOLOGY OF THE NERVOUS SYSTEM

The Trainee will understand and be able to discuss in detail the structure and function of the CNS and PNS

1.
 - a. Development and maturation of the CNS and PNS
 - b. Cerebral hemispheres and lobes
 - c. Parts of brainstem.
 - d. Cranial nerves.
 - e. Thalamus and midbrain structures.
 - f. Visual pathways.
 - g. Auditory pathways.
 - h. Spinal cord.
 - i. Somatosensory pathways.
 - j. Upper and lower extremity peripheral nerves.
2. Describe the mechanisms of cell and nerve conduction.
3. Discuss interactions and interconnections between organs of special sense and nervous system structures.
4. Identify specific clinical conditions in relation to EP findings, describe the main clinical features of those conditions and the pathological change, which may affect EPs.
 - a. Demylinating processes.
 - b. Structural lesions (e.g., tumours, infarcts, haematomas).
 - c. Degenerative changes.
 - d. Traumatic lesions.
 - e. Infectious processes.
 - f. Systemic diseases affecting the nervous system.
 - g. Other pathological changes occurring along visual pathways (e.g., ischemia, inflammatory processes).
 - h. Other pathological changes occurring along auditory pathways (e.g., ischemia, inflammatory processes).
 - i. Other pathological changes occurring along somatosensory pathways (e.g., peripheral nerve, plexus, or root lesions, posterior spinal cord compression).

- 5 Lists the techniques used to demonstrate the pathology of the nervous system, and have observed those techniques where possible:
- a. Neurological examination.
 - b. Magnetic resonance imaging.
 - c. Computerized axial tomography.
 - d. Angiography.
 - e. Biopsy and dissection
 - f. Other.