

# **ELECTROPHYSIOLOGICAL TESTING I**

**ASLP 617 (3.0 credits)**

**David L. McPherson, Ph.D. - 129 TLRB**

**378-6458 (office) - 375-9166 (home)**



**ELECTROPHYSIOLOGICAL TESTING I**  
**Educational Psychology 617 (3.0 credits) - Fall 2000**  
Monday - 1:00pm - 3:50pm - 295 TLRB  
**David L. McPherson, Ph.D.<sup>1</sup> - 129 TLRB**  
**378-6458 (office) - 375-9166 (home)**

**Course Description:** This course is required of all graduate students in Audiology and is the first in a two series course on electrophysiological assessments of the auditory and vestibular systems. The knowledge and skills presented in this course are necessary in order to be competitive in the job market and are basic to the practice of audiology in a non-school environment, and for those in school environments represent the standard of practice in the community. The material presented in this course is required for passing the national examination and certification by the American Speech-Language-Hearing Association (ASHA).

This course presents both basic and applied neurophysiology and electrophysiology of the auditory, vestibular and related systems. As the first of a two series course the student will be required to gain a theoretical knowledge of the normal and pathophysiology of the auditory system and how the nervous system responds to acoustic stimuli, including its ontogeny. The student will develop applied skills in the use of biophysical measurements for hearing assessment and auditory evoked potentials across all age ranges.

**Prerequisites:** The following courses are required prerequisites: An undergraduate degree in Audiology or consent of the instructor. Students that have not completed these prerequisites are required to discontinue this course until such time the prerequisite courses have been completed.

**Honor Code:** The student is expected to be familiar with the Honor Code. The Honor Code is enforced in this class and student's will be required to conform to its principles and practices. Cheating and plagiarism may result in a class failure, at the discretion of the instructor.

**Course Objectives**

- A. To develop a theoretical and practical knowledge of the neurophysiology of the auditory system, and its response to acoustic stimuli.
- B. To become proficient in the administration of electrophysiological measures of hearing.
- C. To understand the normal and pathophysiology of the auditory system and its relation to auditory function and medical management.
- D. To understand the importance of continued reading of professional journals and develop critical thinking in the area of auditory electrophysiology.

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<sup>1</sup>Office hours by appointment only.

### **Textbooks**

1. Jacobson, J.T. (ed). Principles and Applications in Auditory Evoked Potentials. Boston: Allyn and Bacon, 1994.
2. Katz, J. (ed). Handbook of Clinical Audiology (Fourth edition). Baltimore: William & Wilkins, 1994. (Although not required, assignments will be made from this book. This is an excellent resource book and should be part of the professional's library.)

### **Supplies**

1. Each student will be required to purchase a HIGH DENSITY 3.5 floppy disk. These are available at the BYU bookstore and should be available by the first laboratory demonstration.

### **COURSE REQUIREMENTS<sup>2</sup>**

**Examinations:** There will be two major examinations. Additional points on each question may be awarded for exceptional answers without penalizing other students. Students are encouraged to meet with the instructor following the midterm examination to discuss each question/answer.

The mid term examination will be taken during a regular class period.

The final examination has both a written and a practical portion. The practical portion of the final examination will be distributed the first week in December.

Two quizzes will be given that are to help the student prepare for the midterm and final examination. It is recommended that the student meet with the instructor to review the quizzes.

Student name, date, course identification and assignment (including assignment number) must be included on all materials (see appendices for examples and preferred style). Assignments not correctly identified will not be accepted.

**Laboratory Demonstrations:** There will be thirteen laboratory demonstrations. The class following the laboratory session the handouts from that session are due. This assignment may be done using handwriting.

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<sup>2</sup>All assignments must be typewritten unless otherwise noted. If computer generated an easily readable font must be used. Originals and copies must be clear with dark print.

| Demo. No. | Demonstration  |
|-----------|--|
| 1         | Instrumentation for Auditory Evoked Potentials                               |
| 2         | Stimulus Specifications and Averaging  |
| 3         | Recording of Cochlear Potentials and the 8th nerve Action Potential          |
| 4         | Recording of the Auditory Brainstem Evoked Potential                         |
| 5         | Recording of the Auditory Brainstem Evoked Potential for hearing assessment. |
| 6         | Patient Recording of the Auditory Brainstem Evoked Potential                 |
| 7         | Recording of the Middle -and Long Latency Auditory Evoked Potentials         |
| 8         | Recording of Cognitive Evoked Potentials (P300 and MMN)                      |

**Laboratory Assignments:** There will be five laboratory assignments each worth 2 points each.. These will be practical experiences in electrophysiological recordings and will be assigned by the instructor. The assignments for Ed Psych 617 are as follows:

| Lab Assignment no. | Topic  |
|--------------------|--|
| 1                  | Cochlear potentials and AP recordings (one ear, two separate recordings)       |
| 2                  | Brainstem Auditory evoked potentials (two separate recordings).                |
| 3                  | Middle- and long latency auditory evoked potentials (two separate recordings). |
| 4                  | Cognitive evoked potentials (two separate recordings).                         |
| 5                  | Complete set of EVP and ERPs on one subject.                                   |

**Abstracts:** The reading of journal articles and critical thinking is expected of professionals throughout their entire career. There will be ten abstracts due throughout the term. One point will be given for each abstract. The abstracts consist of the assigned articles. Be sure to refer to the Course Schedule and Outline for due dates.

1. Brazier, M.A.B. Pioneers in the discovery of evoked potentials. Electroencephalography and Clinical Neurophysiology, 59, 2-8.
2. Jewett, D.L., & Williston, J.S. (1971). Auditory-evoked far fields averaged from scalp of humans. Brain, 94, 681-696.
3. Stockard, J.S., Stockard, J.J., Westmoreland, B.F., & Corfits, J.L. (1979). Brainstem auditory evoked response. Normal variations as a function of stimulus and subject characteristics. Archives of Neurology, 36, 823-831.
4. Eggermont, J.J. (1988). On the rate of maturation of sensory evoked potentials. Electroencephalography and Clinical Neurophysiology, 70(4), 293-305.
5. Buchwald, J.S., Erwin, R., Van, L.D., Guthrie, d., Schwafel, J., & Tanguay, P. (1992). Middle Latency auditory evoked responses: P1 abnormalities in adult autistic subjects. Electroencephalography and Clinical Neurophysiology, 84(2), 164-171.
6. Picton, T.W., Woods, S.L., & Proulx, G.B. (1978). Human auditory sustained potentials. I. the name of the nature of the response. Electroencephalography and Clinical Neurophysiology, 45, 186-187.
7. Polich, J. (1989). P300 from a passive auditory paradigm. Electroencephalography and Clinical Neurophysiology, 74(4), 312-320.
8. Hillyard, S.A., & Kutas, M. (1983). Electrophysiology of cognitive processing. Annual Review of Psychology, 34, 33-61.
9. Jirsa, R.E., & Clontz, K.B. (1990). Long latency auditory event-related potentials from children with auditory processing disorders. Ear and Hearing, 11(3), 222-232.
10. Starr, A., McPherson, D., Patterson, J., Don, M., Luxford, W., Shannon, R., Sininger, Y., Tonakawa, L., & Waring, M. (1991). Absence of both auditory evoked potentials and auditory percepts dependent on timing cues. Brain, 1157-1180.

**Grading Standard:** Each of the above areas will be weighted for a total of 100 points. Assignments are due at the end of the class period. A late penalty of 50% of the earned points will be assessed for any assignments received after 4:00 p.m. of the due date, unless otherwise specified. The distribution is accordingly:

|  |         |
|--|---------|
| Final examination                        | 50 pts  |
| Written (20 pts)                         |         |
| Practical (30 pts)                       |         |
| Midterm examination                      | 25 pts  |
| Five laboratory assignments (2 pts each) | 10 pts  |
| Two unit quizzes (5 pts each)            | 5 pts   |
| Ten Abstracts (1 pt each)                | 10 pts  |
| TOTAL <sup>3</sup>                       | 100 pts |

### Grade Point Distribution

|    |            |    |            |
|----|------------|----|------------|
| A  | 96-100 pts | C+ | 78-80 pts  |
| A- | 92-95 pts  | C  | 75-77 pts  |
| B+ | 88-91 pts  | C- | 70-74 pts  |
| B  | 84-87 pts  | D  | 65-69 pts  |
| B- | 81-83 pts  | E  | 64 & below |

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<sup>3</sup>Two additional points may be earned for attending Multi-Stake Firesides, Devotional and Forums (see section).

## COURSE SCHEDULE AND OUTLINE

### Auditory Evoked Potentials – ASLP 617

| Class Number | Date of Class | Lecture topic  | Assignments <sup>4</sup>   | Comments  |
|--------------|---------------|--|--|---|
| 1            | 28 Aug        | 1. Syllabus distributed.<br>2. Lecture: Neural generators.<br>3. Demonstration 1: Instrumentation for Auditory Evoked Potentials.  | 1. Jacobson Chpts 1&2  |   |
| 2            | 11 Sep        | 1. Lecture: Calibration and stimulus specification in auditory evoked potentials and averaging techniques.<br>2. Lecture: Instrumentation in Electrophysiological Measures.<br>3. Demonstration 2: Specification of auditory stimulus in evoked potential ting and averaging techniques. | 1. Jacobson Chpts 3 & 4.   | 1. Demo 1 due.<br>2. Abstract 1 due.  |
| 3            | 18 Sep        | 1. Lecture: Electrocochleography.<br>2. Lecture: Use of ECOG in clinical medicine.   | 1. Jacobson Chpt 5.  | 1. Demo 2 due.  |
| 4            | 25 Sep        | 1. Demonstration 3: Recording of Cochlear Potentials and the 8th nerve Action Potential  |  | 1. Quiz 1.<br>2. Abstract 2 due.  |
| 5            | 2 Oct         | 1. Lecture: The brainstem auditory evoked potential.<br>2. Lecture: Hearing assessment and the BAEP.<br>3. Lecture: BAEP in the infant and neonate.<br>4. Lecture: Neurodevelopment and auditory function in the neonate.  | 1. Jacobson Chpt 6.<br>2. Jacobson Chpt 10 & 11<br><br>3. Jacobson Chpts 13,14,15.<br>4. Jacobson Chpt 12. | 1. Demo 3 due.<br>2. Lab 1 due  |
| 6            | 9 Oct         | 1. Demonstration 4: Recording of the Auditory Brainstem Evoked Potential   |  | 1. Abstracts 3 due.   |
| 7            | 16 Oct        | 1. Demonstration 5: Recording of the Auditory Brainstem Evoked Potential for hearing assessment.   |  | 1. Demo 4 due   |
| 8            | 23 Oct        | 1. Demonstration 6: Patient Recording of the Auditory Brainstem Evoked Potential<br>2. Lecture: Neurologic disorders and the BAEP.   |  | 1. Demo 5 due.<br>2. MID TERM EXAMINATION (take home)<br>3. Abstract 4 due. |
| 9            | 20 Nov        | 1. Lecture: The Middle and long latency auditory evoked potential.<br>2. Lecture: Event Related Potentials in the auditory system.<br>3. Demonstration 7: Recording of the Middle -and Long Latency Auditory Evoked Potentials.  | 1. Jacobson Chpts 7,8 & 9.   | 1. Demo 6 due.<br>2. Lab 2 due.<br>3. Mid Term Examination Due.             |
| 10           | 27 Nov        | 1. Demonstration 8: Recording of Cognitive Evoked Potentials (P300 and MMN).   | 1. Jacobson Chpt 20 & 21.  | 1. Demo 7 due.<br>2. Lab 3 due.<br>3. Abstract 5 due.                       |
| 11           | 4 Dec         | 1. Lecture: Case studies in EPs  | 1. Jacobson Chpts 16, 17, 18, 19   | 1. Demo 8 due.<br>2. Quiz 2.<br>3. Lab 4 & 5 due.                           |
|              | 12 Dec        | <b>FINAL EXAMINATION</b>   | 3:00 pm – 6:00 pm  |   |

<sup>4</sup>Reading assignments are to be completed prior to the beginning of the class period.

## STANDARD RECORDING PARAMETERS OF AUDITORY EVOKED POTENTIALS

| Component                          | Electrode Placement                  | Filter Window   | Analysis Window                                    | Number of Averages | Stimuli Parameters  | Rate of Presentation                              |
|------------------------------------|--------------------------------------|-----------------|--|--------------------|---|---|
| CM (Cochlear microphonic)          | Ec-Cz                                | Same as stimuli | 10 msec pre-stimulus and 50 msec post-stimulus     | 2000               | Tone burst  | 5/sec   |
| SP (Summating potential)           | Ec-Cz                                | DC-1000         | 5 msec   | 2000               | Clicks  | 50/sec  |
| AP (Action potential)              | Ec-Cz                                | DC-1000         | 5 msec   | 2000               | Clicks 50/sec   |   |
| Auditory Brainstem                 | Cz-Mi; Cz-Mc; Cvii-Mi; Mi-Mc         | 30-3000         | 10 msec (adults)<br>20 msec (infants)              | 2000               | Clicks  | 11-33/sec (also 70/sec for adaptation evaluation) |
| Slow Negative                      | Cz-Cvii                              | 30-3000         | 1.0 sec  | 2000               | Tone burst  | 0.7/sec   |
| Middle Latency                     | Cz-Mi                                | 30-3000         | 50 msec (adults)<br>100 msec (infants)             | 1000               | Clicks Tone pips  | 11/sec 8/sec                                      |
| FFR (Frequency following response) | Cz-Mlnk                              | DC-3000         | 1000 msec  | 1000               | Tone Burst<br>3 msec rise/decay<br>20 msec plateau                | 0.9/sec   |
| 40 Hz Response                     | Clicks                               |                 |  | 1000               |   | 40/sec  |
| Long Latency                       | Mlnk-Cz; Mlnk-Fz<br>Mlnk-T2; Mlnk-T3 | 1-1500          | 50 msec pre-analysis;<br>500 msec post-stimulation | 500                | Tone Burst<br>3 msec rise/decay<br>20 msec plateau                | 0.9/sec   |
| P300                               | Cz-Mlnk; Pz-Mlnk                     | 0.1-100 Hz      | 50 msec pre-analysis;<br>500 msec poststimulation  | 300                | Tone Bursts <sup>5</sup><br>10 msec rise/decay<br>30 msec plateau | 0.9/sec   |
| MMN                                | Fz-Mi<br>Fpz (ground)                | 0.1-100 Hz      | 50 msec pre-analysis;<br>500 msec poststimulation  | 300                | Tone Bursts <sup>6</sup><br>10 msec rise/decay<br>30 msec plateau |   |

Electrode placements referenced to the International 10-20 system except as noted below

Ec=Ear canal on same side as stimulation

Mlnk = Linked mastoid electrodes

Mc=Mastoid process contralateral to the ear of stimulation

Mi=Mastoid process ipsilateral to the ear of stimulation

Cvii=Seventh cervical vertebrae (used as a non-cephalic recording site)

<sup>5</sup>The stimuli for the P300 may be a variety of sensory stimuli including speech material. The rare or 'oddball' stimuli normally has a probability of occurrence about 15-20%.

Laboratory Demonstration 1:  
**Instrumentation for Auditory Evoked Potentials**

**Purpose:** The purpose of this laboratory session is to acquaint the student with the instrumentation and technical considerations in the recording of event related potentials, specifically auditory evoked potentials.

**I. Demonstrations**

- A. Familiarization of equipment terminology and function. The manner in which equipment is connected together including precautions and safety requirements. Basic trouble shooting will be discussed.
- B. The use of a volt/ohm meter will be reviewed and demonstrated:
  1. Voltage measure.
  2. Amperage measure.
  3. Impedance measurement (a discussion between acoustic impedance, electrical impedance and impedance measures of electrodes).
  4. Continuity check.
- C. Oscilloscope measurements of :
  1. A sine wave, square wave and acoustic click for various frequencies (rates) will be completed.
  2. Synchronization (triggering vs. gating)
  3. Amplification (referential and differential), CMR
- D. The effects of filtering on sine waves, square waves and acoustic clicks will be demonstrated.
- E. A signal averager (Cadwell Quantum 84) dedicated to event related potential studies will replace the function generator. The student will learn the fundamentals of signal generation and signal averaging.
- F. Oscilloscopic display of the various acoustic stimuli used in event related potential recordings:
  1. Acoustic clicks (condensation, rarefaction, alternating)
  2. Tone pips
  3. Ramp
  4. Tone bursts (various rise, decay and plateau)
  5. P300 paradigm
  6. Variable repetition rates
- G. Signal averaging
  1. Signal-to-noise ratio
  2. Averaging signals in noise with various signal-to-noise ratios
  3. Synchronization (triggering vs. gating)
  4. Sweep replication
  5. Sweep delays and offset
- H. Formatting a floppy disk on the Quantum 84

**II. Review Questions**

- A. Explain the difference between triggering and gating.
- B. Explain the effects of signal averaging on signal-to-noise ratios.
- C. What is meant by rise time, plateau, and decay time?
- D. What is a time-locked response?
- E. What are the advantages of a variable repetition rate?

## Laboratory Demonstration 2

### **Calibration of Instrumentation for Auditory Evoked Potentials**

**Purpose:** The student will be familiar with the various methods of calibrating EVP equipment, completing continuity checks

#### **I. Demonstrations**

- A. Discussion of HL, nHL, SPL, SPL<sub>pe</sub>, and SPL<sub>peak</sub>.
- B. Biologic Calibration
- C. Introduction and Review of the Sound Level Meter
- D. Electronic Calibration of headphones
  1. Click
  2. Tones
- E. Electronic Calibration of Insert earphones
  1. Click
  2. Tones

#### **II. Review Questions**

- A. What is meant by nHL and how does it differ from HL?
- B. Why is a biologic calibration necessary and what are the advantages vs disadvantages?
- C. What is the correction factor when using electronic calibration for a click (i.e., dB<sub>SPL</sub><sub>pe</sub> vs dB<sub>nHL</sub>)?
- D. What is the frequency spectrum of a click?

Laboratory Demonstration 3  
**Recording of Cochlear Potentials and the 8th nerve Action Potential**

**Purpose:** The purpose of this laboratory session is to acquaint the student with the instrumentation and technical considerations in the recording of the cochlear microphonic, summing and the 8th nerve action potential.

**I. Demonstrations**

- A. Electrodes (all three will be used and each channel simultaneously recorded)
  - 1. Mastoid/earlobe electrode
  - 2. Wick tympanic membrane electrode
  - 3. Earrode ear canal electrode (gold foil)
- B. Recording of the CM, SP and AP to click stimulation
  - 1. Condensation
  - 2. Rarefaction
  - 3. Alternating
- C. Recording of the CM, SP and AP to tonal stimulation
  - 1. 500 Hz
  - 2. 2000 Hz
  - 3. 4000 Hz

**III. Technique**

- A. Prepare the examining room
  - Note: pre-soak the electrode in sterile saline
- B. Set the Quantum 84 up and adjust to the proper parameters :
  - a. Gain:
  - b. Filter window: 10Hz-1000Hz
  - c. Analysis time: 1-5msec preanalysis, 10msec sample window
  - d. Nol of Averages: 2000
  - e. Stimulus:
    - (1) clicks at 80dBnHL
    - (2) tone burst (3/10/1) at 1500Hz at 80dBnHL
    - (3) Use insert earphones (this actually takes care of the pre-analysis delay)
- C. Electrode Montage (TM, non -inverting; Mc, inverting; Fpz, ground).
- D. Patient preparation
  - 1. Irrigate ear with sterile saline and drain
  - 2. Place subject in lateral supine position with head properly and comfortably supported
  - 3. Attach the Mc and Fpz electrodes to the patient and to the amplifier
  - 4. Explain to the patient that you are going to insert the electrode. You will be tapping on the side of the electrode and the patient is to indicate to you when it gets LOUD
  - 5. Atatch the TM electrode to the amplifier and listen and watch as you insert the electrode.
  - 6. Once the electrode has been inserted properly then insert the ear insert for the sound tube.

7. Secure all wires and tubes and then check to be sure the patient is hearing the stimuli. Once everything is good the patient must be instructed NOT to move with first speaking to you.

E. Recordings

1. 2000 averages of condensation clicks (x2)
2. 2000 averages of rarefaction clicks (x2)
3. Store the waveforms
4. 2000 averages of a rarefaction 1500 Hz tone burst (x2)
5. 2000 averages of a condensation 1500 Hz tone burst (x2)
6. Store the waveforms

F. Disconnect the patient and secure the equipment (i.e., clean-up)

G. Recall the waveforms and perform the following analysis

1. Print the waveforms with all clicks one page and the tone bursts on the second page. Be sure to overlay the pairs.
2. For the following analysis choose the BEST of each pair.
3. For the **AP**: Subtract the Condensation from the Rarefaction waveform (Rare-Cond) and print the results.
4. For the **CM**: Invert the Condensation waveform and add the New Inverted Condensation waveform to the Rarefaction waveform and print the results
5. For the **SP**: Add the Condensation and the Rarefaction waveforms and print the results
6. Measure and mark the amplitude and latency for all three measures.

**III. Review Questions**

- A. Describe the effect that alternating polarity has on the CM and the AP.
- B. Why does reversing the polarity of the stimulus on one of two trials and then adding the two waveforms enhance the AP and diminish the CM ?
- C. What effect does recording two trials with the same stimulus polarity then shifting one recording 180° and adding the two waveforms have on the CM and the AP ?
- D. Which electrode gives the best recording and why?

## Laboratory Demonstrations 4a

### Recording of the Auditory Brainstem Evoked Potential I

**Purpose:** The purpose of this laboratory session is to acquaint the student with the instrumentation and technical considerations in the recording of the brainstem auditory evoked potentials.

#### I. Demonstrations

- A. Discussion of electrode types
  1. Tin
  2. Gold
  3. Silver
  4. Silver-Silver Chloride
- B. Electrode Montages
  1. Discussion of inverting, non-inverting, and non-cephalic electrodes
  2. Discussion of a ground electrode and its importance
  3. International 10-20 system
  4. Electrode Placements (handout)
    - a. Cz-Mi
    - b. Cz-Mc
    - c. Cz-Cvii
    - d. Mc-Mi
    - e. ground (Fpz)
    - f. Discussion of when we use Fz and why.
- C. Scalp Preparation
  1. Omniprep precautions etc.
  2. Electrode paste vs electrode gel
  3. Use of adhesive
- D. Electrode Impedance
  1. Measurement of impedance and its significance
  2. Demonstration of correct impedance
  3. Demonstration of high impedance
    - a. Normal number of averages
    - b. Large number of averages
  4. Demonstration of poor connection
  5. 60 Hertz noise
  6. RF noise
  - 7 Other noise
- E. Artifact Reject
  1. Ocular muscle effects
  2. Jaw movement effects
  3. Body movement effects

#### II. Review Questions

- A. Describe the four types of electrodes and briefly (one or two sentences) discuss their differences as to recording techniques.
- B. Why is a low impedance important and what occurs when the impedance is too high?
- C. Discuss the four different montages and how they are used.
- D. If adhesive tape is stuck in hair what method may be used to remove the tape while minimizing discomfort to the patient?

## Laboratory Demonstrations 4b

### Recording of the Auditory Brainstem Evoked Potential II

**Purpose:** The purpose of this laboratory demonstration is to show the use of the various recording montages, the effect of averaging, repetition rate, intensity, polarity, and filtering on the BAEP.

#### I. Demonstration

- A. Standard Recording: The effect of montage configuration of the BAEP.
  - 1. Headphone recordings
  - 2. Insert earphones
- B. The effective use of averaging and the minimal requirements to obtain good waveforms.
- C. The effect of repetition rate on the BAEP
- D. The effect of Polarity (click) on the BAEP
  - 1. Rarefaction
  - 2. Condensation
  - 3. Alternating
- E. The effect of filtering on the BAEP
  - 1. Clinical filtering (30-3000 Hz): Preferred
  - 2. Clinical filtering (150-3000Hz): Most used
  - 3. Wideband filtering (1-3000Hz)
  - 4. Narrow filtering I (150-1500Hz)
  - 5. Narrow filtering II (300-2000Hz)
- F. The use of tone pips on the BAEP
- G. Measurement of latency and amplitude.
  - 1. Absolute conduction times
  - 2. Central conduction times
  - 3. Amplitude measurements
    - a. Absolute amplitude of wave V
    - b. Ratio of I:V

#### II. Review Questions (due at the end of Laboratory Demonstration 4)

- A. What is the difference in the morphological features of waves I through V for Cz-Mi, Cz-Mc, Cz-Cvii and Mi-Mc?
- B. What effect does polarity have on waves I through V?
- C. What is the effect of rate increase on waves I through V and the I-V interpeak interval?
- D. For consistency how should the amplitude of wave V be measured?

## Laboratory Demonstrations 5

### Recording of Clinical Auditory Brainstem Evoked Potential

**Purpose:** To familiarize the student with the clinical procedures in making an assessment of hearing and neurological function.

#### I. Demonstration

- A. Preparing the testing area etc.
  1. Establishing the test area
  2. Preparing the electrodes. paste etc.
  3. Checking the equipment
    - a. Signal averager
      - (1). Sweep time (10, 20 msec. window)
    - b. Amplifier
      - (1) Gain
      - (2) Filter setting (30-3000Hz, 150-3000Hz)
    - c. Earphones (listening check)
      - (1) 70dBnHL, 75dBnHL
- B. Introducing the patient to the procedure and making the patient comfortable
  1. No food (i.e., chewing gum)
  2. Bathroom facilities
  3. Sitting in a comfortable modest position
- C. Preparing the patient
  1. Electrode placement (for this demonstration and all clinical recordings one of the following should be used):
    - a. Single Channel Recordings: Cz-Mi, Fpz (gnd)
    - b. Dual Channel Recordings: Cz-Mi, Cz-Mc, Fpz (gnd)
    - c. Four channel recordings: Cz-Mi, Cz-Mc, Cz-Cvii, Mc-Mi (deal recording)
    - d. Multi-channel recording: Cz-Mi, Cz-Mc, Cz-Cvii (my preference)
  2. Earphone placement.
    - a. Headphones
    - b. Insert phones (preference)
  3. Impedance and continuity check
- D. Recording of the BAEP (all recordings are replicated)
  1. Baseline (no sound stimulus)
  2. Neurological Evaluation
    - a. 70dBnHL at 11.1 clicks/sec (or 75 dBnHL)
  3. Hearing levels (all completed at a repetition rate of 33.3/sec).

Note: Since the 70 or 75 dBnHL was completed for the neurological evaluation, it is not necessary to repeat as part of this process IF it was clearly present and NORMAL.

    - a. 75, 60, 45, and 30 dBnHL (minimal acceptable procedure if NORMAL).
    - b. 70, 50, and 30 dBnHL (minimal acceptable procedure if NORMAL)
    - c. 70, 60, 50, 40, and 30 dBnHL (preferred procedure)
    - b. 35 dBnHL (screening only)
  4. High rate of stimulation (70 clicks/sec)
- E. Disconnecting the patient and cleaning the room
- F. Printing and measurements

1. Measurement of results
    - a. Waveform identification and measurements
  2. Storage of results
  3. Printing of results
- G. Recalling saved waveforms and off-line analysis  
H. Report Writing and presentations of the results

## **II. Review Questions**

- A. What is one of the most important activities in dealing with a patient that will place the patient at ease during the evaluation period.
- B. Why should one make latency notes prior to saving/printing results?
- C. On replicating trials, what should be done if poor agreement is found?
- D. What is the purpose of a ground electrode and why is it so important?

## Laboratory Demonstrations 6

### **Patient Recording of the Auditory Brainstem Evoked Potential**

**Purpose:** The purpose of this laboratory demonstration is to complete, from beginning to end a full BAEP evaluation on a patient. The parameters specified in this exercise are the instructor's preference. Please remember that there may be (read there is) considerable variation from facility to facility. However, the procedure used in the demonstration is most commonly used in facilities that are involved in both BAEP for hearing as well as neurological evaluations.

#### **I. Demonstration**

- A. Preparing the testing area etc.
  1. Establishing the test area
  2. Preparing the electrodes. paste etc.
  3. Checking the equipment
    - a. Signal averager
      - (1). Sweep time (10, 20 msec. window)
    - b. Amplifier
      - (1) Gain
      - (2) Filter setting (30-3000Hz, 150-3000Hz)
    - c. Earphones (listening check)
      - (1) 70dBnHL
- B. Introducing the patient to the procedure and making the patient comfortable
  1. No food (i.e., chewing gum)
  2. Bathroom facilities
  3. Sitting in a comfortable modest position
- C. Preparing the patient
  1. Electrode placement (for this demonstration and all clinical recordings)
    - a. Multi-channel recording: Cz-Mi, Cz-Mc, Cz-Cvii (my preference)
  2. Earphone placement.
    - a. Insert phones (preference)
  3. Impedance and continuity check
- D. Recording of the BAEP (all recordings are replicated)
  1. Baseline (no sound stimulus)
  2. Neurological Evaluation
    - a. 70dBnHL at 11.1 clicks/sec
  3. Hearing levels (all completed at a repetition rate of 33.3/sec).  
Note: Since the 70 dBnHL was completed for the neurological evaluation, it is not necessary to repeat as part of this process IF it was clearly present and NORMAL.
    - a. 70, 60, 50, 40, and 30 dBnHL (preferred procedure)
  4. High rate of stimulation (70 clicks/sec)
- E. Disconnecting the patient and cleaning the room
- F. Printing and measurements
  1. Measurement of results
  2. Storage of results
  3. Printing of results
- G. Recalling saved waveforms and off-line analysis
- H. Report Writing and presentations of the results

## II. Review Questions

- A. Why is it important to prepare the room and make sure everything is working BEFORE the patient arrives?
- B. Describe, not the exact technique, but the considerations in adjusting the artifact reject.
- C. If the patient needs to take a break during the exam what must be done prior to continuing the examination?
- D. If wave V is not seen at 30dBnHL in the hearing part of the examination what is done next and why?

## Laboratory Demonstration 7

### **Recording of the Middle- (including the 40Hz response) and Long Latency Auditory Evoked Potentials**

**Purpose:** The purpose of this laboratory session is to acquaint the student with the instrumentation and technical considerations in the recording of the middle- and long latency auditory evoked potentials.

#### **I. Demonstrations**

- A. Electrode montage: Cz-Mi (minimal) or Cz-Mi and Cz-Vii (preferred)
- B. Middle latency auditory evoked potentials
  - 1. Waveform identification and analysis of the MLR
  - 2. Effect of stimulus conditions on the MLR
    - a. Rate
    - b. Intensity
    - c. Frequency (Click, 500 Hz, 2000 Hz and 4000 Hz)
- C. 40 Hz response
- D. Long latency auditory evoked potentials
  - 1. Waveform identification and analysis of the LLR
  - 2. Effect of stimulus conditions on the LLR
    - a. Rate
    - b. Intensity
    - c. Frequency (Click, 500 Hz, 2000 Hz and 4000 Hz)

#### **II. Review Questions**

- A. How does rate effect the MLR ?
- B. How does intensity effect the MLR ?
- C. What is different about the 40 Hz response versus the MLR ?
- D. What is the effect of attention on the MLR vs. LLR ?

## Laboratory Demonstrations 8 Recording of Cognitive Evoked Potentials (P300 and MMN)

**Purpose:** The purpose of this laboratory session is to acquaint the student with the instrumentation and technical considerations in the recording of the P300 and mismatched negativity.

### I. Demonstrations

#### A. P300

1. Electrode montage (Cz, Pz and Fz to linked mastoids)
2. Effect of attention
  - a. Mentally alert (counting oddball)
  - b. Mentally non-alert (reading)

#### B. MMN

1. Electrode montage (Cz, Pz and Fz to linked mastoids)
2. Effect of attention
  - a. Mentally alert (counting oddball)
  - b. Mentally non-alert (reading)

### II. Review Questions

- A. What is the effect of attention on the P300 ?
- B. What is the effect of attention on the MMN ?
- C. What is the difference between the P300 and the MMN?
- D. Why is the MMN considered a derived waveform?

Laboratory Demonstration 9a  
**Recording of the Frequency Following Response and Binaural Function**

**Purpose:** The purpose of this laboratory session is to acquaint the student with the instrumentation and technical considerations in the recording of the Frequency Following Response (FFR).

**I. Demonstrations I: FFR**

- A. Electrode Montage (Cz-linked mastoids)
- B. Recording of the FFR
  - 1. 300 Hz
  - 2. 600 Hz
  - 3. 1000 Hz
  - 4. 2000 Hz
  - 5. 4000 Hz

**II. Demonstration II: Binaural Interaction**

- A. BAEP
- B. MLR
- C. LLR

**II. Review Questions**

- A. What are the effects of a 500 Hz vs a 4000 Hz tone stimuli on the FFR ?
- B. What is the procedure for recording the Binaural interaction in the AEPs?
- C. When might one perform a binarual interaction evaluation on a patient (what does it tell us)?
- D. When might one perform a FFR on a patient (what does it tell us)?

Laboratory Demonstrations 9b  
**Special Techniques in AEPs**

**Purpose:** The purpose of this laboratory demonstration is to give the student an exposure to some of the new techniques in AEPs.

**I. Demonstration**

- A. Brain mapping of the BAEP, MLR and LLR
- B. Brain mapping of the P300 to speech sounds
- C. Brain mapping of the N400 to sentences
- D. 3CLT
- E. Dipole Source Localization
- F. BAEP to notched noise.

**II Review Questions**

- A. What are the advantages of brain mapping?
- B. What does 3CLT analysis tell us about the generators?
- C. What does dipole source localization tell us about the generator
- D. What is the advantage of using notched noise in BAEP?

Laboratory Assignment 1  
**Recording of the Cochlear Potentials and the AP**

**Purpose:** The purpose of this assignment is to provide the student with the experience of making tympanic membrane recordings of the CM, the SP and the AP. The student must receive permission of the instructor PRIOR to beginning this laboratory assignment. Only one ear (the better ear) and one subject will be used for this assignment.

**I. Assignment**

A. Prepare the examining room

Note: pre-soak the electrode in sterile saline

B. Set the Quantum 84 up and adjust to the proper parameters :

- a. Gain:
- b. Filter window: 10Hz-1000Hz
- c. Analysis time: 1-5msec preanalysis, 10msec sample window
- d. Nol of Averages: 2000
- e. Stimulus:

(1) clicks at 80dBnHL

(2) tone burst (3/10/1) at 1500Hz at 80dBnHL

(3) Use insert earphones (this actually takes care of the pre-analysis delay)

C. Electrode Montage (TM, non -inverting; Mc, inverting; Fpz, ground).

D. Patient preparation

1. Irrigate ear with sterile saline and drain
2. Place subject in lateral supine position with head properly and comfortably supported
3. Attach the Mc and Fpz electrodes to the patient and to the amplifier
4. Explain to the patient that you are going to insert the electrode. You will be tapping on the side of the electrode and the patient is to indicate to you when it get LOUD
5. Attch the TM electrode to the amplifier and listen and watch as you insert the electrode.
6. Once the electrode has been inserted properly then insert the ear insert for the sound tube.
7. Secure all wires and tubes and then check to be sure the patient is hearing the stimuli. Once everything is good the patient must be instructed NOT to move with first speaking to you.

E. Recordings

1. 2000 averages of condensation clicks (x2)
2. 2000 averages of rarefaction clicks (x2)
3. Store the waveforms
4. 2000 averages of a rarefaction 1500 Hz tone burst (x2)
5. 2000 averages of a condensation 1500 Hz tone burst (x2)
6. Store the waveforms

F. Disconnect the patient and secure the equipment (i.e., clean-up)

G. Recall the waveforms and perform the following analysis

1. Print the waveforms with all clicks one page and the tone bursts on the second page. Be sure to overlay the pairs.
2. For the following analysis choose the BEST of each pair.
3. For the **AP**: Subtract the Condensation from the Rarefaction waveform (Rare-Cond) and print the results.

4. For the **CM**: Invert the Condensation waveform and add the New Inverted Condensation waveform to the Rarefaction waveform and print the results
5. For the **SP**: Add the Condensation and the Rarefaction waveforms and print the results
6. Measure and mark the amplitude and latency for all three measures.

## **II. Report**

- A. Paste-up the print outs and carefully label all points with their latency, amplitude and label (i.e., CM, SP or AP).
- B. Write a narrative about the experience and what difficulties you encountered (if any) and how they were solved. Be sure to indicate an assessment on the validity of your measures.

## Laboratory Assignment 2a

### Brainstem Auditory Evoked Potentials (BAEP)

**Purpose:** The purpose of this laboratory assignment is to gain practical experience in the diagnostic procedure used in BAEP. The procedure is the same whether one is testing an adult or an infant except the analysis window in infants would be 20 msec, minimum.

#### I. Assignment

- A. Subjects: Three adult subjects (they may be class members) will be used.
- B. Ears: The procedure will be completed for BOTH the left and right ears.
- C. Procedures:
  1. Sweep time (10, 20 msec. window)
  2. Amplifier
    - a. Gain
    - b. Filter setting (30-3000Hz, 150-3000Hz)
  3. Earphones: Insert earphones
  4. Electrode placement: Cz-Mi, Cz-Mc, Cz-Cvii
  5. Baseline (no sound stimulus)
  6. Neurological Evaluation
    - a. 70dBnHL at 11.1 clicks/sec
  7. Hearing levels (all completed at a repetition rate of 33.3/sec).  
Note: Since the 70 dBnHL was completed for the neurological evaluation, it is not necessary to repeat as part of this process IF it was clearly present and NORMAL.
    - a. 70, 60, 50, 40, and 30 dBnHL.
  9. High rate of stimulation (70 clicks/sec)

#### II. Reporting

- A. Printing and measurements
    1. Measurement of results
    2. Storage of results
    3. Printing of results
  - B. Recalling saved waveforms and off-line analysis
  - C. Report Writing and presentations of the results
  - D. Paste-up each ear and clearly label wave V along with its amplitude and latency (for each intensity).
  - E. Write a FORMAL report on your results including recommendations etc.
- Note: Remember you have three patients therefore three separate reports.

Laboratory Assignment 2b  
**Screening Procedure for BAEP**

**Purpose:** The purpose of this laboratory assignment is to gain practical experience in the screening procedure used in BAEP. The procedure is the same whether one is screening an adult or an infant.

**I. Assignment**

- A. Subjects: Four adult subjects (they may be class members) will be used.
- B Ears: The procedure will be completed for BOTH the left and right ears.
- C. Stimulus Parameters.
  - 1. Stimuli: Acoustic clicks
  - 2. Transducer: Inset earphones
  - 3. Repetition rate: Recordings at 22.1clicks/sec
  - 4. Intensity: 75 dBnHL and 35 dBnHL (replicate each level)
- D. Recordig Parameters
  - 1. Analysis time: 10 msec.
  - 2. Filter window: 150-3000 Hz
  - 3. Gain: 10uV/div
  - 4. No. averages: 2000
  - 5: No. replications: 2
  - 6 Pre-analysis time: Default of tube (i.e., 1msec).
- E. Archive Procedure
  - 1. Print: Overlap waveforms of equal intensity with one ear per page (adjust scale accordingly).
  - 2. Store to disk

**II. Report**

- A. Paste-up each ear and clearly label wave V along with its amplitude and latency (for each intensity).
  - B. Write a FORMAL report on your results inclding recommendations etc.
- Note: Remember you have four patients therefore four separate reports.

### Laboratory Assignment 3

#### **Recording of the Middle- and Long Latency Auditory Evoked Potentials**

**Purpose:** The purpose of this laboratory assignment is to gain practical experience in the recording of the middle- and long latency auditory evoked potentials. The procedure is the same whether one is screening an adult or an infant.

#### **I. Assignment**

- A. Subjects: Three adult subjects (they may be class members) will be used.
- B Ears: The procedure will be completed for BOTH the left and right ears.
- C. Stimulus Parameters.
  - 1. Stimuli:
    - a. Middle Latency: 2000Hz tone pip
    - b. Long Latency 2000Hz tone burst
  - 2. Transducer: Inset earphones
  - 3. Repetition rate
    - a. Middle Latency: 11/sec.
    - b. Long Latency: 0.7/sec
  - 4. Intensity: 75 dBnHL (replicate each recording)
- D. Recordig Parameters
  - 1. Analysis time:
    - a. Middle Latency: 100 msec.
    - b. Long Latency: 500 msec.
  - 2. Filter window:
    - a. Middle Latency: 30-3000Hz
    - b. Long Latency: 1-1500Hz
  - 3. Gain: 20-50uV/div
  - 4. No. averages:
    - a. Middle Latency: 1000
    - b. Long Latency: 500
  - 5: No. replications: 2
  - 6 Pre-analysis time:
    - a. Middle Latency: 10 msec.
    - b. Long Latency: 50msec.
- E. Archive Procedure
  - 1. Print: Overlap waveforms with one ear per page (adjust scale accordingly).
  - 2. Store to disk

#### **II. Report**

- A. Paste-up each ear and clearly label waveform including the amplitude and latency.
  - B. Write a FORMAL report on your results inclding recommendations etc.
- Note: Remember you have three patients therefore three separate reports.

## Laboratory Assignment 4 Recording of the Cognitive Evoked Potentials

**Purpose:** The purpose of this laboratory assignment is to gain practical experience in the recording of the middle- and long latency auditory evoked potentials. The procedure is the same whether one is screening an adult or an infant.

### I. Assignment

- A. Subjects: Three adult subjects (they may be class members) will be used.
- B Ears: The procedure will be completed for BOTH the left and right ears.
- C. Stimulus Parameters.
  - 1. Stimuli:
    - a. Common: 1000Hz tone pip
    - b. "Oddball": 2000Hz tone burst
  - 2. Transducer: headphones
  - 3. Repetition rate: 0.7/sec
  - 4. Intensity: 75 dBnHL (replicate each recording)
- D. Recording Parameters
  - 1. Analysis time: 500msec. post stimulus
  - 2. Filter window: 0.1-100Hz
  - 3. Gain: ~50uV/div
  - 4. No. averages: 300
  - 5: No. replications: 2
  - 6 Pre-analysis time: 50msec.
- E. Archive Procedure
  - 1. Print: Overlap waveforms with one ear per page (adjust scale accordingly).
  - 2. Store to disk

### II. Report

- A. Paste-up each ear and clearly label waveform including the amplitude and latency.
  - B. Write a FORMAL report on your results including recommendations etc.
- Note: Remember you have three patients therefore three separate reports.

## SAMPLE JOURNAL ABSTRACT

### JOURNAL ABSTRACT #1

*Student name)*

*(Course)*

*(Date)*

Karzon, R.G. (1991). Validity and reliability of tympanometric measures for pediatric patients. Journal of Speech and Hearing Research, 43, 386-390.

Purpose: The purpose of this paper was to report on the validity and reliability of acoustic impedance measures in children.

Subjects: The author used 116 children (8 months to 20 years of age) and compared static admittance and the width of the tympanogram against an otologic exam.

Equipment: A Grason-Stadler model 27 Auto Tymp was used for the collection of acoustic admittance data, and a standard otoscope was used for inspection of the tympanic membrane.

Statistics: Descriptive statistics along with ANOVA (within-subjects design) and a simple sign test was used in this paper.

Results: No significant findings were noted for measures of .....

Pertinent findings:

1. Standard normative values are in widespread disagreement and may not be relevant to clinical practice with a varied population.
2. Although re-screening is cost effective it may unduly delay medical intervention and/or the patient may be lost to follow-up.
3. The use of visual inspection of the tympanic membrane.....

Comments:

This article contributes little new or unique information. Statistical assumptions were, at best, misused and poorly designed. The discussion was not tightly related to the results, but was more philosophical and did not need the data presented in the article.

Of particular interest was.....

**SAMPLE LABORATORY DEMONSTRATION  
DEMONSTRATION #1**

*(Student name)*

*(Course)*

*(Date)*

Laboratory Assignment: Auditory brainstem evoked potentials

Auditory brainstem evoked potentials were recorded in a 23 year old female with normal hearing. A Cadwell Quantum 84 evoked potential machine was used to collect the data. Electrodes were placed across the scalp: Cz-M1, Cz-M2, M1-M2 and Cz to Cvii. A ground electrode was placed at Fpz. Acoustic clicks were presented at 11.1/sec and the intensity varied from 80 dBnHL to 0 dBnHL in 10 dB steps. The patient was placed in the supine position. The recordings...

*Note: The student must also answer the questions accompanying each demonstration.*

## SAMPLE ESSAY EXAM QUESTION

**Blue books, using double spacing, are to be used in all examinations except for 'take home' examinations that are to be typewritten, double spaced.**

*(Student name)*

*(Course)*

*(Date)*

Exam question: Describe and characterize the measures used in the auditory brainstem evoked potential recording and their relationship to stimulus intensity.

Response: The auditory brainstem evoked potential may be described as a biphasic waveform with quantitative properties of amplitude and latency. In addition a qualitative feature may be described in terms of its morphology.

Amplitude may either be described in voltage, usually microvolts, from the baseline to corresponding peak, or from positive peak to corresponding negative peak. As stimulus intensity increase, the amplitude of the response increases. The converse is also true. The first amplitude changes from baseline, in ideal recording conditions, may be seen as early as 10 dB above behavioral threshold for the stimulus; especially sharply rising (i.e. clicks) stimuli.

Latency is defined as the time, in milliseconds, from the onset of the stimulus to a peak. For consistency, wave V, which may be broad, is defined as the breaking point, or departure point, from the linear descending slope. Latency decreases as stimulus intensity increases. The converse is also true.

It should be noted that there is a point where both amplitude and latency asymptote.

In formulating this question one point is awarded for each correct identification and discussion of the pertinent areas:

1. Description of amplitude
2. Description of latency
3. Description of morphology
4. Use of microvolts
5. Use of milliseconds
6. Relationship of amplitude to intensity
7. Relationship of latency to intensity
8. Statement of how amplitude is measured
9. Statement of how latency is measured
10. Relationship of amplitude and latency to morphological features

It should be noted that areas 1, 2, 4, 5, 6, 7 and 8 were covered providing 7 points for this answer. However additional discussions in some areas were significant enough that extra points were awarded:

1. Acknowledging that the response is biphasic.
2. Amplitude may be measured using one of two references.
3. Amplitude of a wave may first appear at about 10 dB SL.

Consequently, an additional three points are awarded for this question providing a total of 10 points. Such additional points are solely at the discretion of the instructor. Since a grading curve is not used, other students are not penalized.