Evoked Potentials – Part 2
Electrocochleography, MLR, P300 and Cortical Responses

Kathleen Hill, Au.D.
Director of Commercial & Education Development
Otometrics, a division of Natus

natus.   1   otometrics
                                               a division of natus.

Evoked Potentials

- Electrical signals generated by the nervous system in response to a stimulus
- Event related (evoked by onset of stimulus)
- Useful in diagnosing a variety of neurological disorders
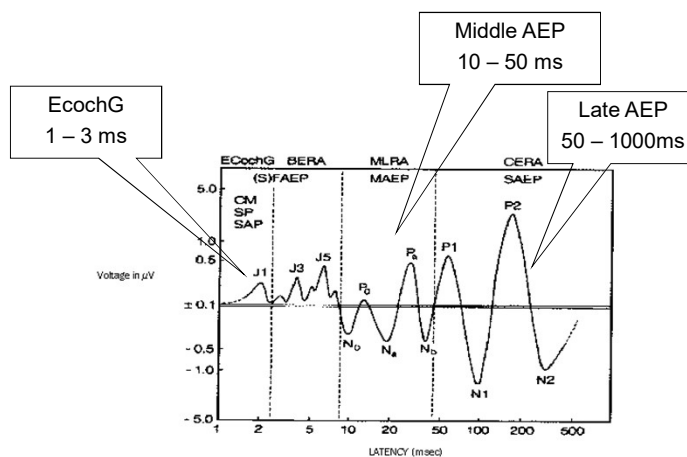
natus.   2   otometrics
                                               a division of natus.

Presented in Cooperation with

CONTINUED

Auditory Evoked Potentials

OVERVIEW of AEP in the Time Domain

EcochG
1 – 3 ms

Middle AEP
10 – 50 ms

Late AEP
50 – 1000ms

natus.

3

otometrics
a division of natus.

Recording Evoked Potentials

- Far Field recording-electrodes placed on the scalp
- Electrodes assigned as Active (+), Reference (-), and Ground
- Record from a pair of electrodes (i.e. Cz to A1)
- Recording from an non-inverting (+) and inverting (-) electrode
- Amplify the difference between the signals
- Proper care of the electrodes & impedance are important because this is the medium for collecting the EP data

natus.

4

otometrics
a division of natus.

Presented in Cooperation with

continueD

Recording EP Data

- Common mode rejection
  - The voltage is different between the active and reference electrodes
  - The voltage related to noise is similar at both electrodes and the response voltage has the greatest difference
  - The response at the reference electrode (inverting) is added to the response at the active (non-inverting) electrode
  - The components which are "common" to both electrodes are cancelled (i.e. noise - mains, biological or environmental)
- Inter-electrode impedance is the most important (common mode rejection does not work well if inter-electrode impedance varies)

natus.

5
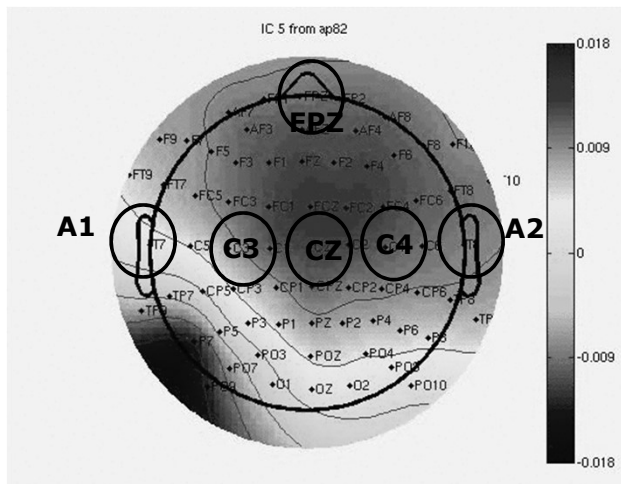
otometrics
a division of natus.

Preparation

natus.

6

otometrics
a division of natus.

Presented in Cooperation with

CONTINUED

10-20 System of Electrode Placement

True Cz = larger amplitude response

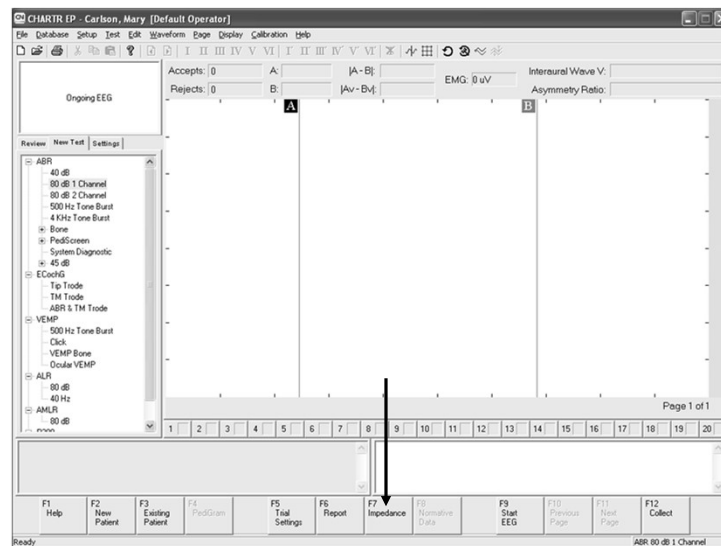~15% reduction in amplitude using high forehead

natus.

7

otometrics
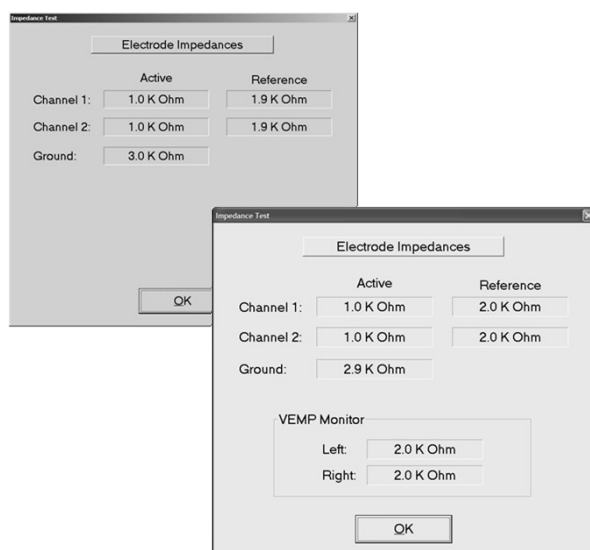a division of natus.

Impedance

natus.

8

otometrics
a division of natus.

Presented in Cooperation with

continueD

Checking Electrode Impedance

Impedance Test

Electrode Impedances

	Active	Reference
Channel 1:	1.0 K Ohm	1.9 K Ohm
Channel 2:	1.0 K Ohm	1.9 K Ohm
Ground:	3.0 K Ohm	

OK

Impedance Test

Electrode Impedances

	Active	Reference
Channel 1:	1.0 K Ohm	2.0 K Ohm
Channel 2:	1.0 K Ohm	2.0 K Ohm
Ground:	2.9 K Ohm	

VEMP Monitor

Left:	2.0 K Ohm
Right:	2.0 K Ohm

OK

Goal: Low electrode readings of **<5K** Ohms each balanced with no more than **<2K** Ohms difference between electrodes
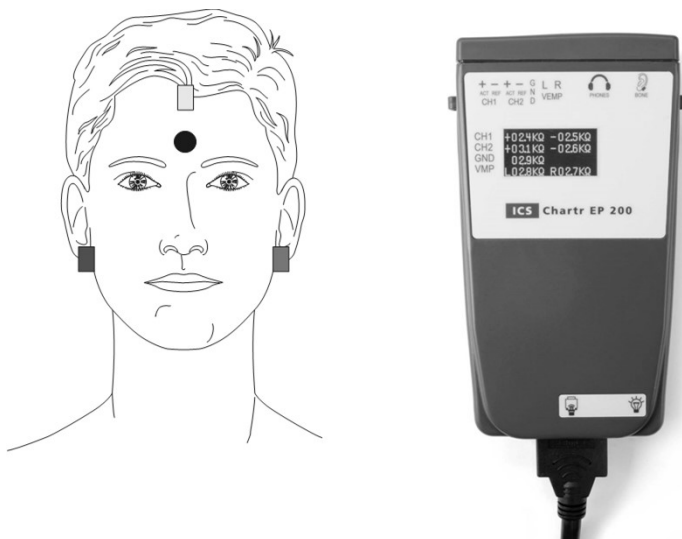
Inter-electrode impedance is the most important (common mode rejection does not work well if inter-electrode impedance varies

natus.

9

otometrics
a division of natus.

ICS Chartr EP 200 Preamp

CH1	+0.24KΩ	−0.25KΩ
CH2	+0.31KΩ	−0.26KΩ
GND	0.29KΩ	
VMP	L0.28KΩ	R0.27KΩ

ICS Chartr EP 200

natus.

10

otometrics
a division of natus.

Presented in Cooperation with

continuED

Selecting a Protocol

Procedure

Selected Protocol

Review | New Test | Settings

- ABR
  - 40 dB
  - 80 dB 1 Channel
  - 80 dB 2 Channel
  - 500 Hz Tone Burst
  - 4 KHz Tone Burst
  - Bone
  - PediScreen
  - System Diagnostic
- ECochG
  - Tip Trode
  - TM Trode
  - ABR & TM Trode
- VEMP
  - 500 Hz Tone Burst
  - Click
  - VEMP Bone
  - Ocular VEMP
- ALR
  - 80 dB
  - 40 Hz
- AMLR
  - 80 dB
- P300
  - Tone Burst

The CHARTR EP default procedures are:

- **ABR (Auditory Brainstem Response)**

- **ASSR (Auditory Steady State Response)** *(optional)*

- **ECochG (Electrocochleography)**

- **VEMP (Vestibular Evoked Myogenic Response)**
  - **EMG monitor** *(optional)*

- **ALR (Auditory Late Response)**

- **AMLR (Auditory Middle Latency Response)**

- **P300** *(optional)*

natus   11   otometrics
                                                                          a division of natus.
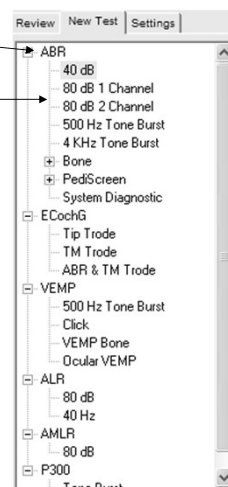
Listening Check

- Use subjects with hearing thresholds within normal limits
- Listen to the stimulus
- Should be able to barely hear it at 0-5 dB
- If the softest level anyone can hear the stimulus is 20 dB – there is a 20 dB correction factor
- Subtract the correction factor from the response obtained on the dial (i.e. patient's threshold is 60, 60-20=40; 40 is their true threshold)
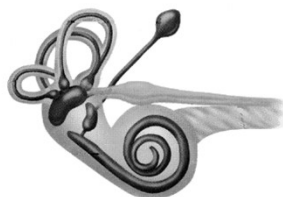- Call local representation or manufacturer to have system calibrated

natus   12   otometrics
                                                                          a division of natus.

Presented in Cooperation with

continueD

Electrocochleography

natus.   otometrics
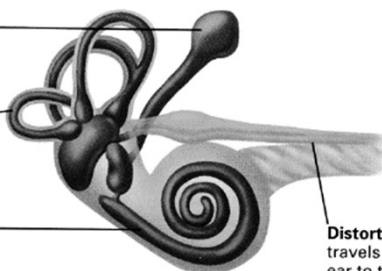   a division of natus.

Electrocochleography (ECochG)

Backed-up fluid in the sac and inner ear leads to swelling and pressure.

Swelling in the balance canals distorts balance information.

Swelling in the hearing canal distorts or blocks sound information.

Distorted information travels from the inner ear to the brain.

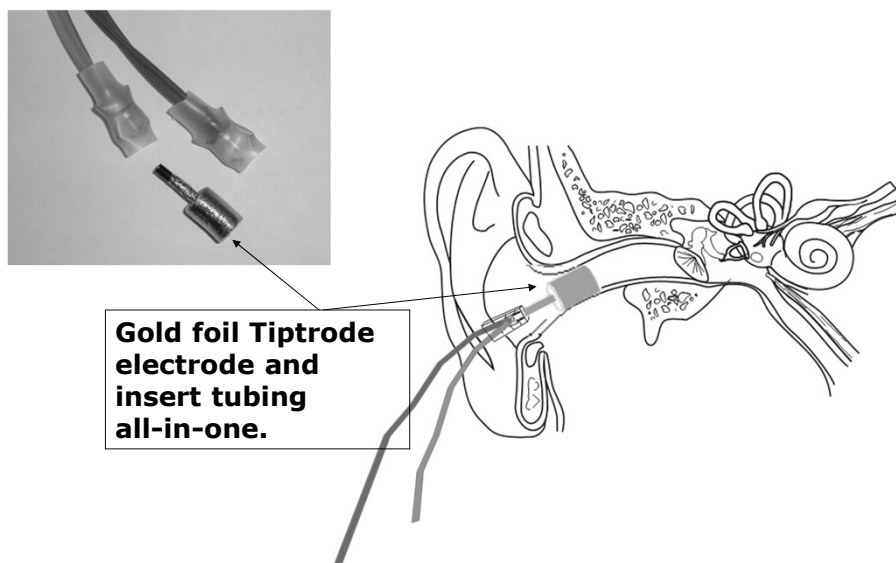natus.   otometrics
                                                                              a division of natus.

Presented in Cooperation with

CONTINUED

Types of Electrodes - Tiptrode

Gold foil Tiptrode electrode and insert tubing all-in-one.

natus 15 otometrics
a division of natus.

Application of Tiptrodes

- The ear canal must be scrubbed in order to obtain lower impedances. Be careful is using conductive paste on gold foil (may remove the gold).
- This electrode is further away from the generator site and results in less pronounced SP/AP ratio.
- Attach the metal clip making good contact with the gold foil near the base of the foam tip.
- Be careful when compressing the foam tip as not to remove the gold foil layer.
- Make sure to remove the red and blue tubing of the insert phones. Do not double the length of the tubing. Attach the tubing from the tiptrodes to the insert transducer boxes.
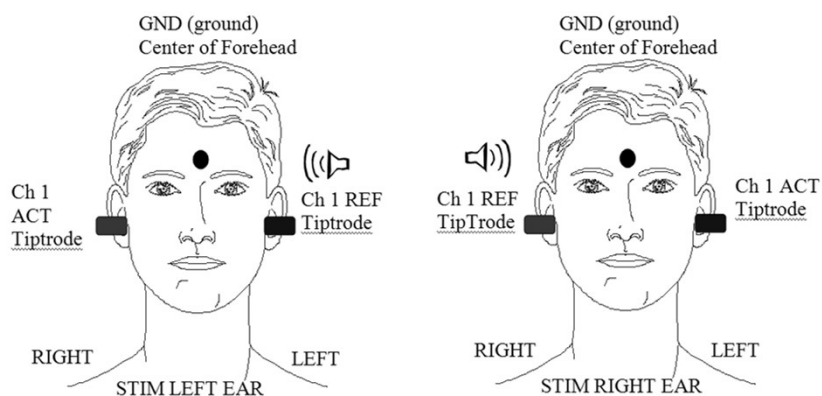- Attach leadwire to the patient cable.

natus 16 otometrics
a division of natus.

Presented in Cooperation with

continueD

ECochG with Tiptrode

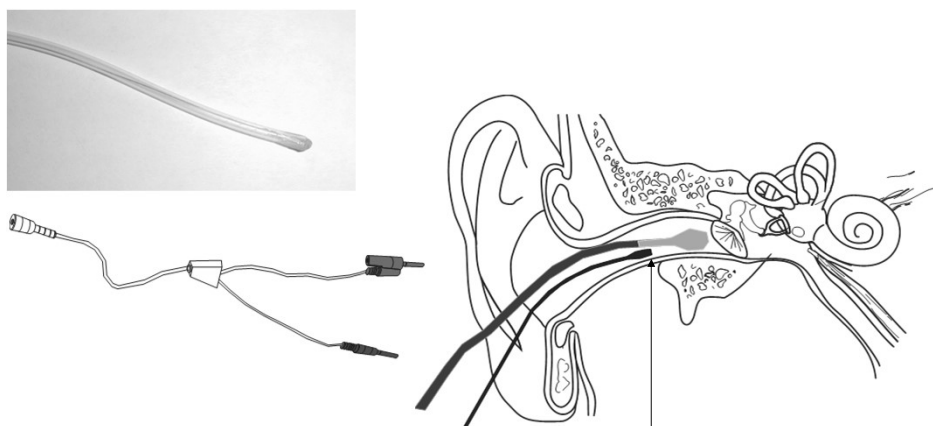
1-CHANNEL ECochG with Tiptrode (Horizontal Montage)

Extra tympanic electrode – TM ECochGtrode

Tymptrode and insert earphone in earcanal. Closer to the neural generator gives a more robust response.
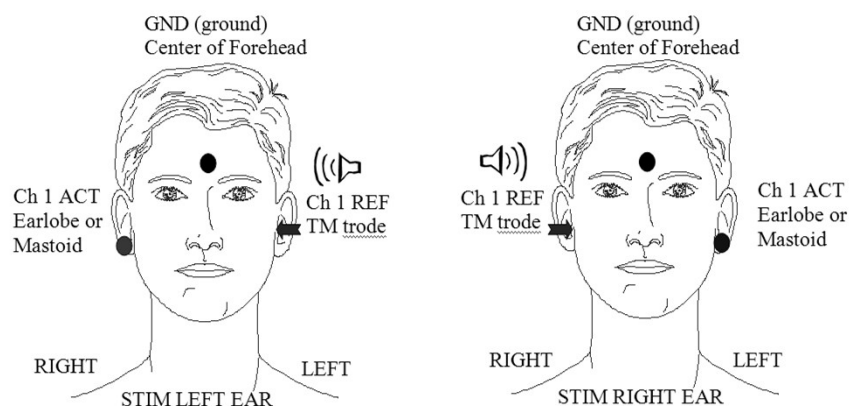
Presented in Cooperation with

Application of TM ECochGtrode

- Perform Otoscopic exam first. Remove any cerumen obstructing the ear canal before placing the TM ECochGtrode.
- Do not place if there is a TM perforation.
- Place 2 cc of saline into the ear canal and then drain the ear. Saline will help reduce impedance. Make sure saline is body temperature (37 degrees Celsius or 98 degrees Fahrenheit).
- Place a small amount of conductive gel on the cover of the hydrogel end of the electrode. Too much gel can occlude the insert earphone.
- Secure the electrode with tape to prevent the cable from moving.
- Electrode impedance may be high (>20K ohms). Therefore, you may have a large interelectrode impedance difference.
- Might need to disable artifact rejection to collect the response.
- After testing, carefully remove insert eartip and electrode. TM may be red but inflammation will go away within a few hours.

natus.   19   otometrics
a division of natus.

ECochG with Tymptrode

1-CHANNEL ECochG with TM ECochGtrode (Horizontal Montage)

GND (ground)
Center of Forehead

GND (ground)
Center of Forehead

Ch 1 ACT
Earlobe or
Mastoid

Ch 1 REF
TM trode

Ch 1 REF
TM trode

Ch 1 ACT
Earlobe or
Mastoid

RIGHT   LEFT
STIM LEFT EAR

RIGHT   LEFT
STIM RIGHT EAR

natus.   20   otometrics
a division of natus.

Presented in Cooperation with

CONTINUED

Clinical Applications

- Assist with Meniere's diagnosis (endolymphatic hydrops) but can't diagnose Meniere's with this test alone.
  - Characteristics of Meniere's disease
    - o Vertigo
    - o Hearing loss (typically fluctuating)
    - o Tinnitus
    - o Aural fullness
- Improve identification of Wave I
  - Not always visible with high frequency hearing loss
  - Used for determining interwave latencies I-III and I-V
- Identification of cochlear microphonic
  - Auditory neuropathy
  - Must use rarefaction and condensation polarity

natus.   21   otometrics
a division of natus.

ECochG Test Parameters
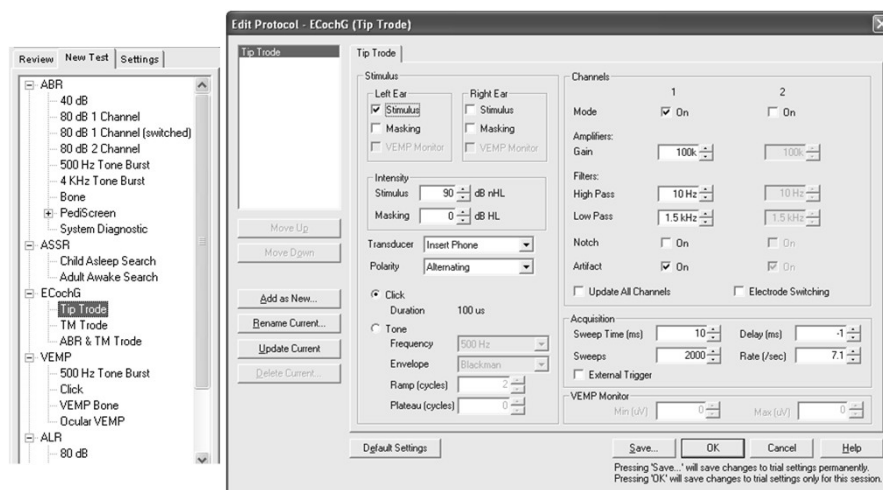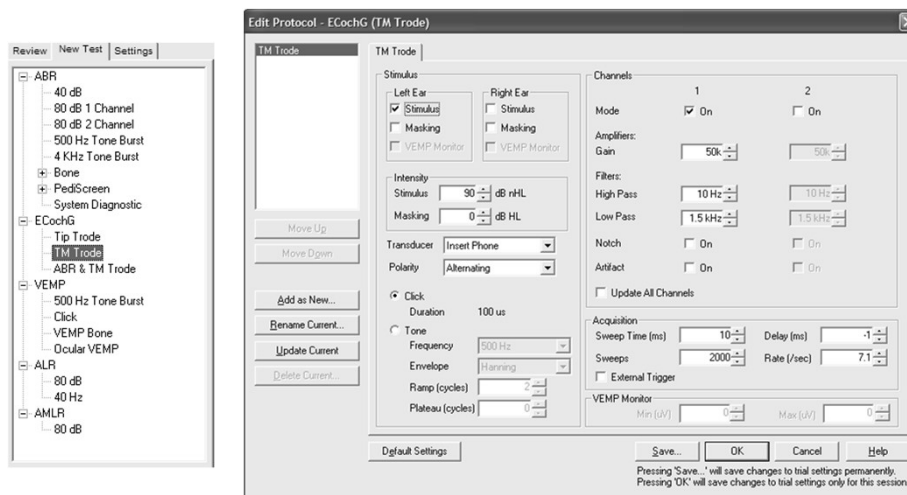

Why use 90 dB? Ecog can be detected as low as 60dB but increases amplitude with increase in intensity. Easier to discern SP and AP.

natus.   22   otometrics
a division of natus.

Presented in Cooperation with

continueD

ECochG Test Parameters

Why use a slow rate? Response amplitude decreases with faster rates. Easier to discern SP and AP. Why alternating? Easier to discern SP and AP when CM is canceled out.

natus.

23

otometrics
a division of natus.

ECochG Components

CM (cochlear microphonic)
a stimulus-dependent cochlear response, which changes direction with changing polarity. Hence, it is not detected when averaging is performed to alternating polarity **(running a rare and con run will cancel out the CM and help locate baseline)**

¨ **SP (summating potential)**
direct current response from the Organ of Corti hair cells. SP is often seen as a leading hump on the AP or wave I, although sometimes it can appear as a separate hump

¨ **AP (action potential)**
alternating current response generated by the cochlear end of the 8th nerve (wave I). The AP represents the summed response of thousands of firing auditory nerve fibers
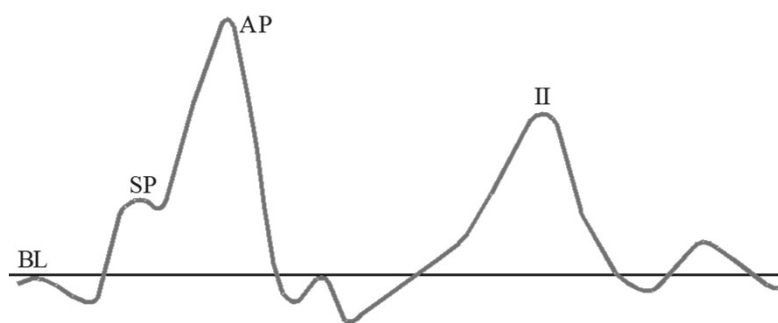
natus.

24

otometrics
a division of natus.

Presented in Cooperation with

continueD

ECochG Results and Interpretation

- **BL** – baseline
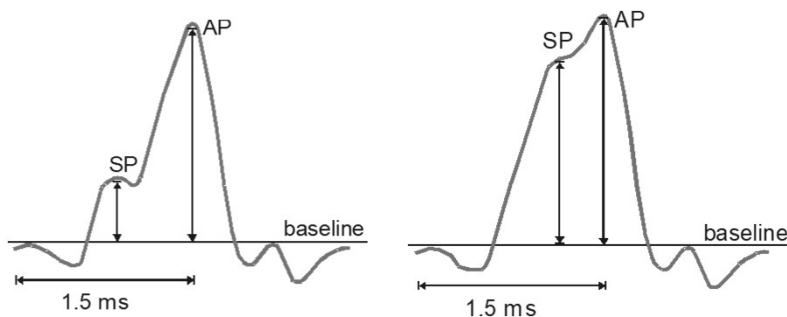- **SP** – summating potential
- **AP** – action potential

natus

otometrics
a division of natus.

Normal Range

- **< 50%** - Tiptrode
- **< 25%** - Tymptrode

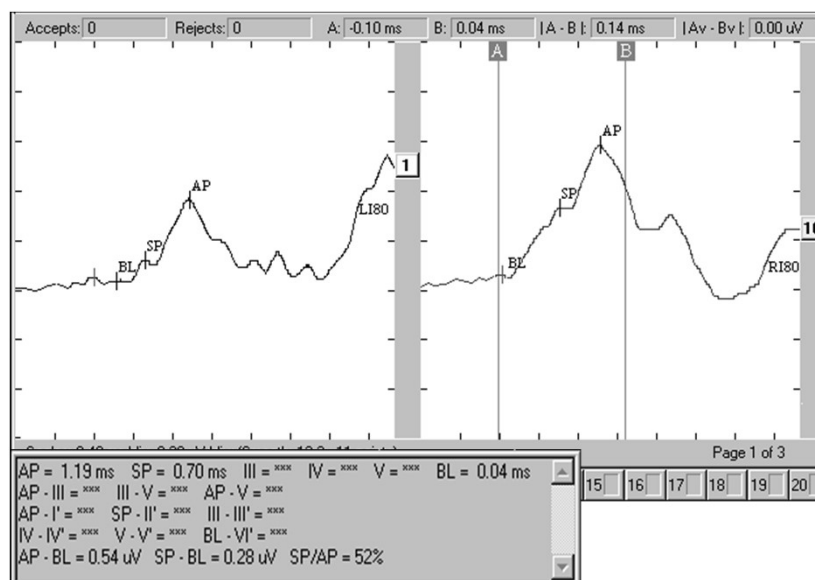
Normal SP/AP ratio

Abnormal SP/AP ratio

natus

otometrics
a division of natus.

Presented in Cooperation with

CONTINUED

Calculation of SP/AP ratio

MLR (AMLR)

Presented in Cooperation with

continuⓔD™

MLR

- Derived from the medial geniculate, inferior colliculus and primary auditory cortex
- Produces waveforms that are identifiable near threshold and may be useful in identifying low-frequency auditory sensitivity.
- ABR latencies are more consistent
- MLR has larger amplitude than ABR and less dependent on neural synchrony.
- Amplitude is smaller if patient is asleep. Latency is unchanged based on patient state.
- Anesthesia and light sedatives can eliminate MLR response.

- Montage – Cz/A1/A2/ground – Cz (vertex)gives best response.
- C3 and C4 are also recommended instead of Cz.

natus.   29   otometrics
                                                                                                              a division of natus.

Clinical Usage

- Determine auditory cortical function (presence/absence)
- If dysfunction is present determine side affected

natus.   30   otometrics
                                                                                                              a division of natus.

Presented in Cooperation with

CONTINUED

MLR Stimulus Factors

- Change in intensity does not effect latency
- Po, Pa and Pb are observed at higher intensities
- Pa will remain for lower intensities. With reduced intensity may see a slight increase in latency and decrease in amplitude.
- Not highly frequency dependent – increase stimulus frequency will result in slight reduction of latency and lower amplitude.
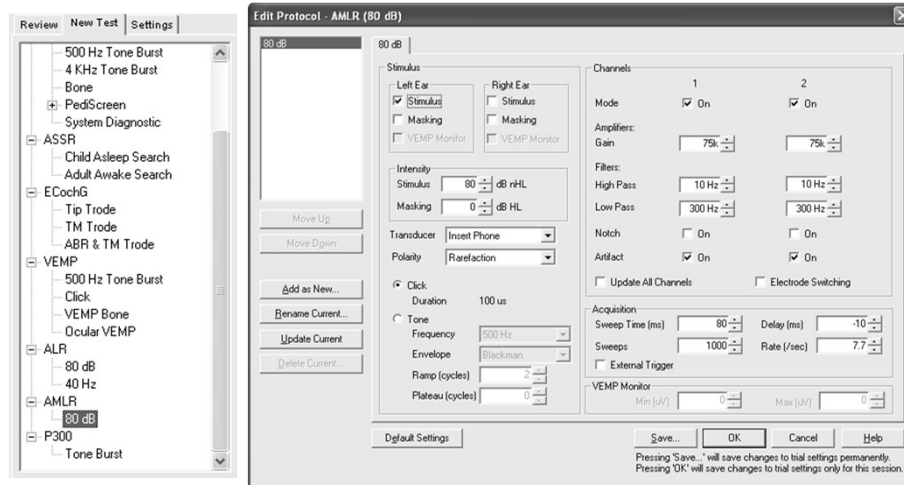- Stimulus Rate should be between 6 -10 stimuli/sec

natus.   31   otometrics
                                                a division of natus.

MLR Response

- MLR occurs at 10 to 80 msec
- Na – 12-18 msec
- Pa – 25-30 msec
- Pb - ~50 msec

natus.   32   otometrics
                                                a division of natus.

Presented in Cooperation with

CONTINUED
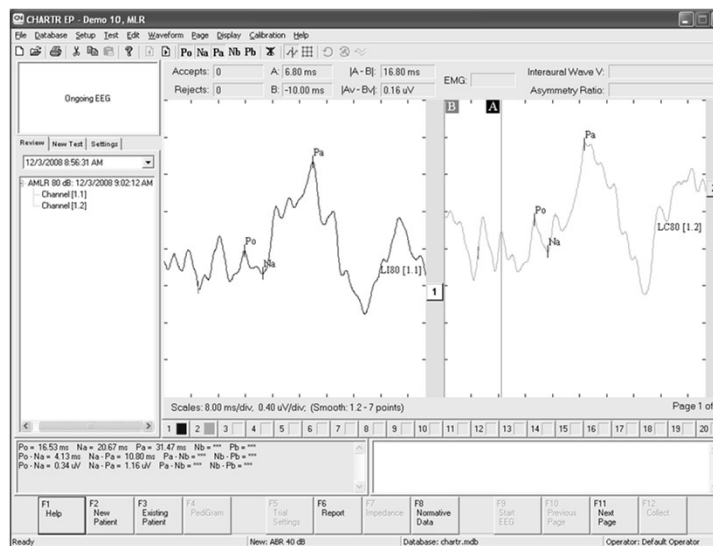
MLR Test Parameters

Why use a slow rate? Response amplitude decreases with faster rates.
Easier to the MLR.

natus.   33   otometrics
a division of natus.

MLR Response

natus.   34   otometrics
a division of natus.

Presented in Cooperation with

continueD

P300

P300

- Dependent on internal thought process – patient must be awake and alert to the stimuli
- Hippocampus generates the response (this is where short term memory functions)

- Montage – Cz/A1/A2/ground

Presented in Cooperation with

continueD

P300 Stimulus

- 2 stimuli (frequent and infrequent) (typically 1000 and 2000 Hz toneburst)
- Patient listens and counts the infrequent (rare) stimuli
- Ratio 5 frequent to 1 infrequent stimuli (~20 rare stimuli presented)
- Only the infrequent stimuli generate the P300
- More difficult the discrimination task the smaller the P300 response
- Can present stimuli binaurally

natus.   37   otometrics
                                                                                              a division of natus.
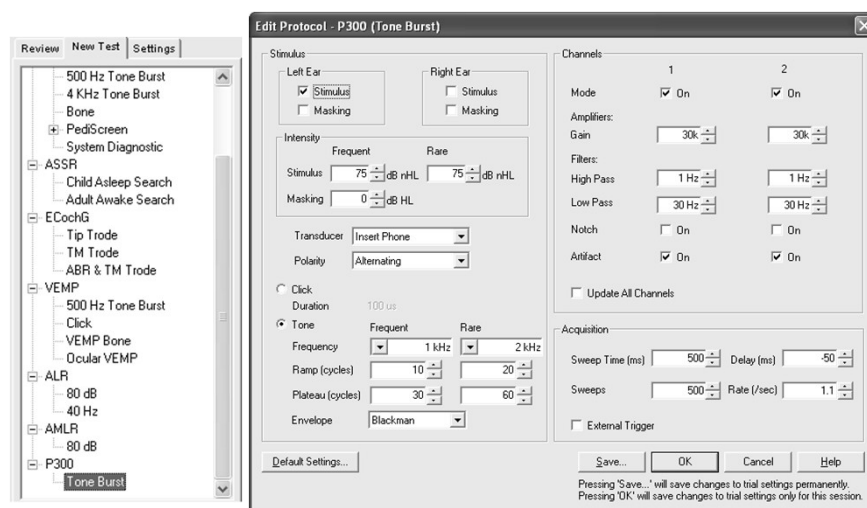
P300 Response

- Slow, Broad response with a peak at 250 to 300 msec
- Decrease in amplitude and increase in latency is indicative of dementia, Alzheimers, and various neurological and psychiatric diseases
- Diagnoses disorders of cognitive function

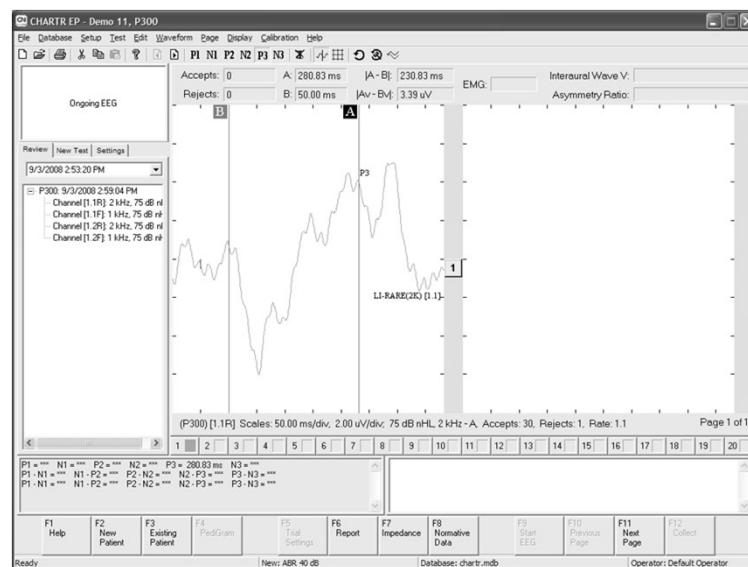natus.   38   otometrics
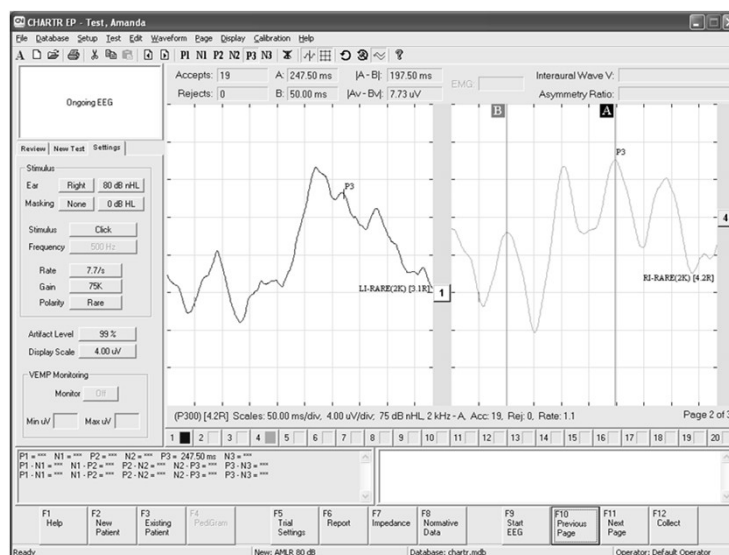   a division of natus.

Presented in Cooperation with

CONTINUED

P300 Test Parameters

P300 Response

Presented in Cooperation with

P300 Response

Cortical Response
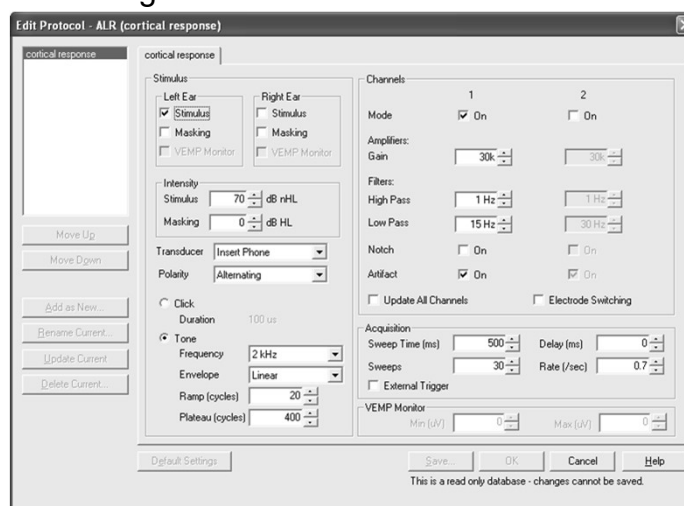
Presented in Cooperation with

Cortical Response

- Derived from a slow vertex response
- Produces waveforms that are identifiable near threshold and may be useful in identifying hearing status using toneburst stimuli
- Used for medical-legal cases or patients difficult to test with audiometry
- Response is not fully mature until late teens
- Montage – Cz/A1/A2/ground – Cz (vertex)gives best response.
- Patient should be awake (reading a book)

http://corticalera.com/ (for more info)

natus.   43   otometrics
a division of natus.

Cortical Response

- Trial Setting

natus.   44   otometrics
a division of natus.

Presented in Cooperation with

continuED

Cortical Response

- P1, N1, P2 are marked
- Decrease in Intensity
  - Amplitude decreases
  - Latency does not change much
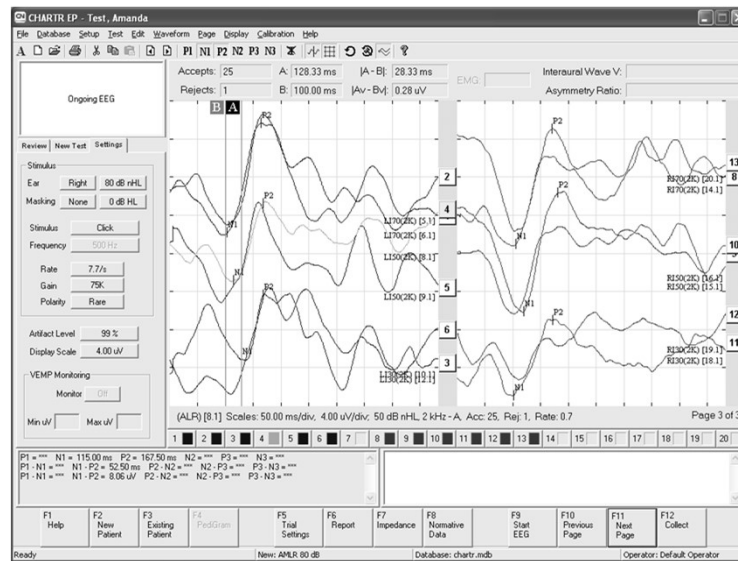- Response habituates so very few sweeps (10 to 20) are collected

natus   45   otometrics
                                                              a division of natus.

Cortical Response

- Cortical occurs at 50 to 300 msec
- N1 – ~100 msec
- P2 – ~200 msec
- Sum responses from 3 waveforms
- If response is >5uV = threshold is 5 dB lower
- If response is <5uV = threshold is same level

natus   46   otometrics
                                                              a division of natus.

Presented in Cooperation with

CONTINUED

Cortical Response

Thank You!

https://otometrics.natus.com/en-us

Presented in Cooperation with