# Audiology presentation

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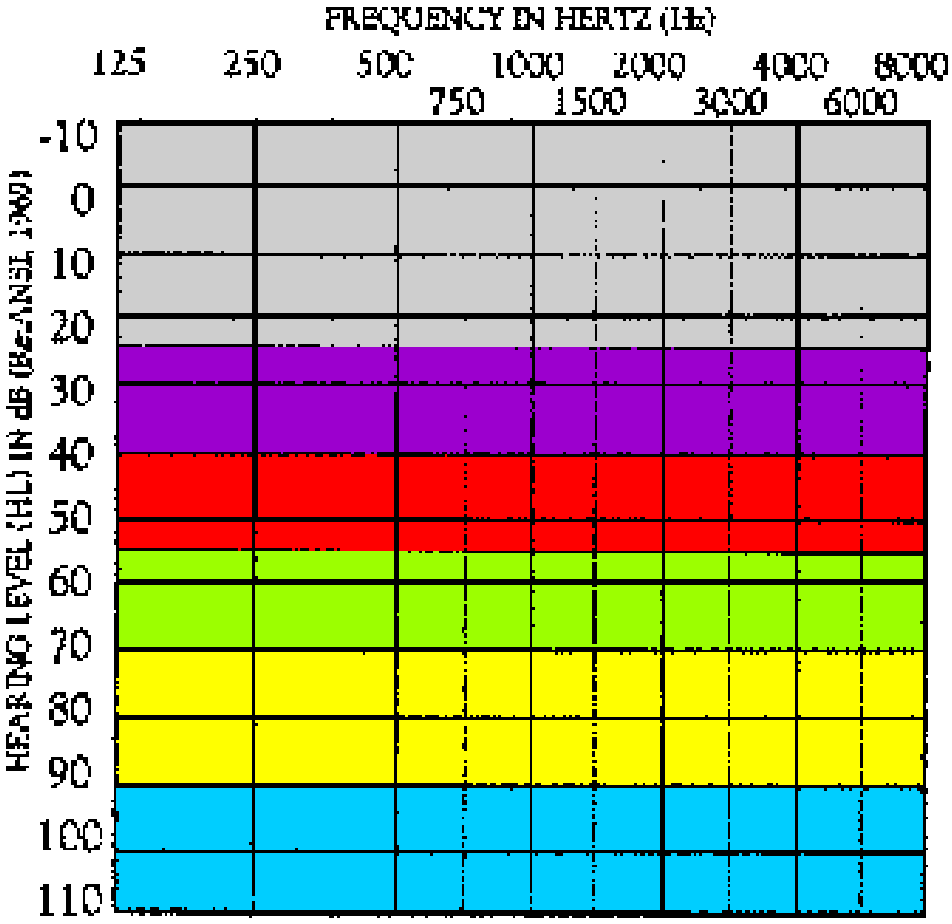
American Board of Audiology

# Outline

- Students will be able
  - Identify type, degree and configuration of hearing loss.
  - Identify possible site of lesion for each type of hearing loss.
  - Determine middle ear function from Tympanometry measurement.
  - Understand origin, indications and clinical applications of OAE, ABR and speech audiometry.
  - Briefly recognize vestibular assessment test battery and its clinical significance.

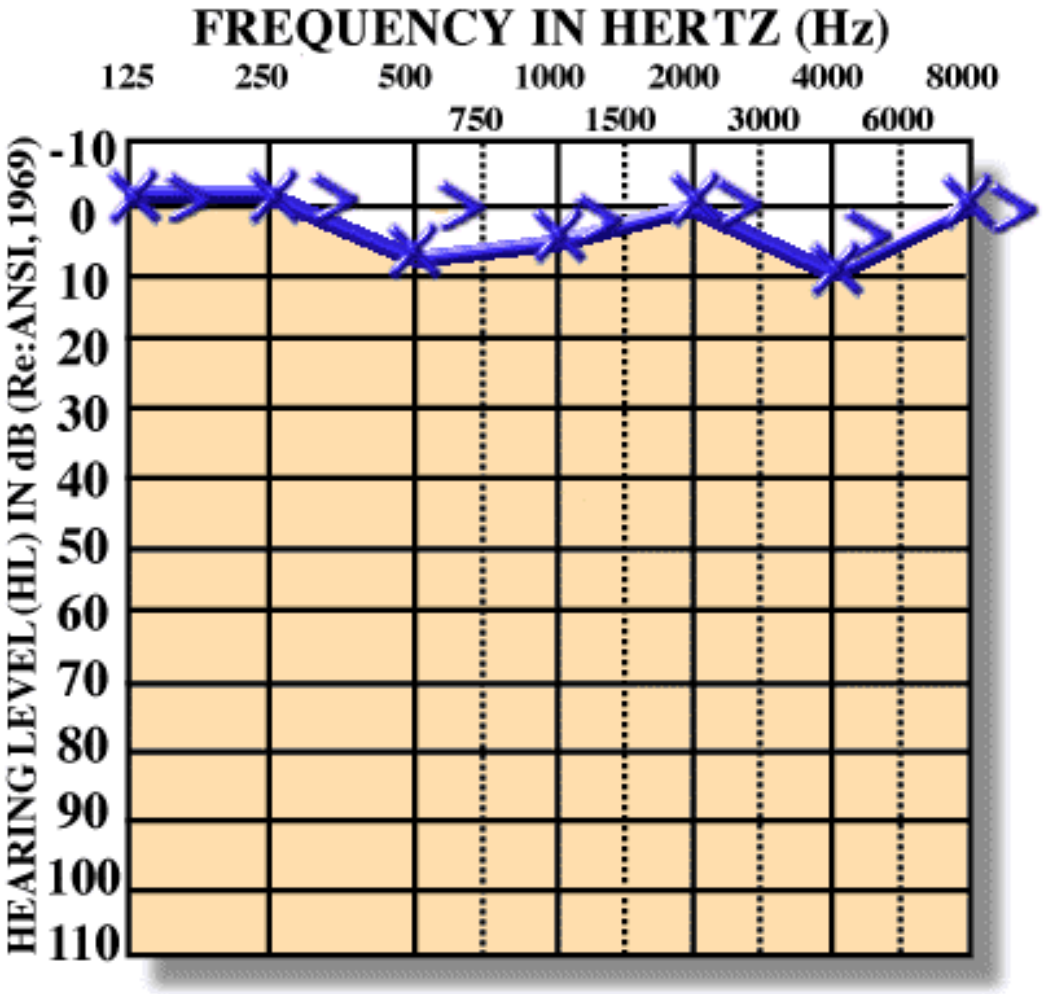
# Pure tone audiometry

# Ranges of Hearing Loss

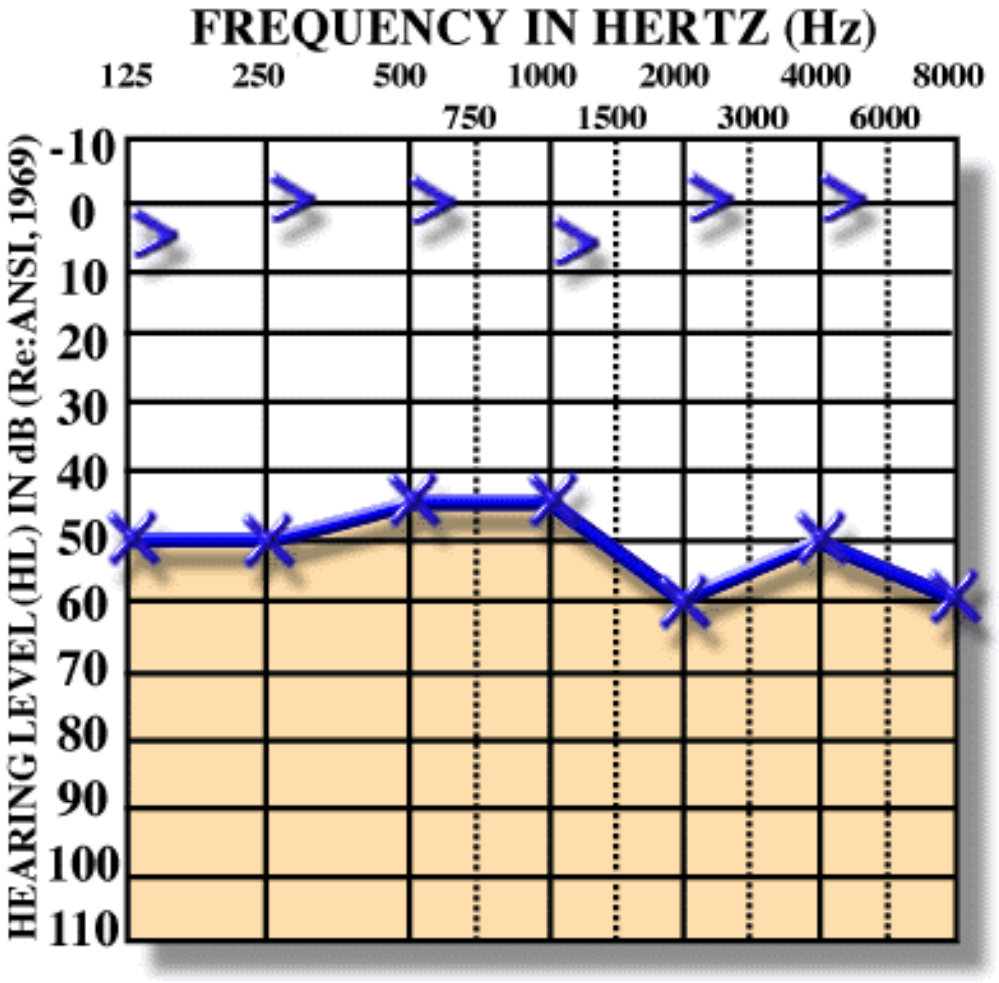



- -10 – 25 dB HL = Normal range
- 26 – 40 dB HL = Mild hearing loss
- 41 – 55 dB HL = Moderate
- 56 – 70 dB HL = Moderately Severe
- 71 – 90 dB HL= Severe
- Greater than 90 dB HL = Profound

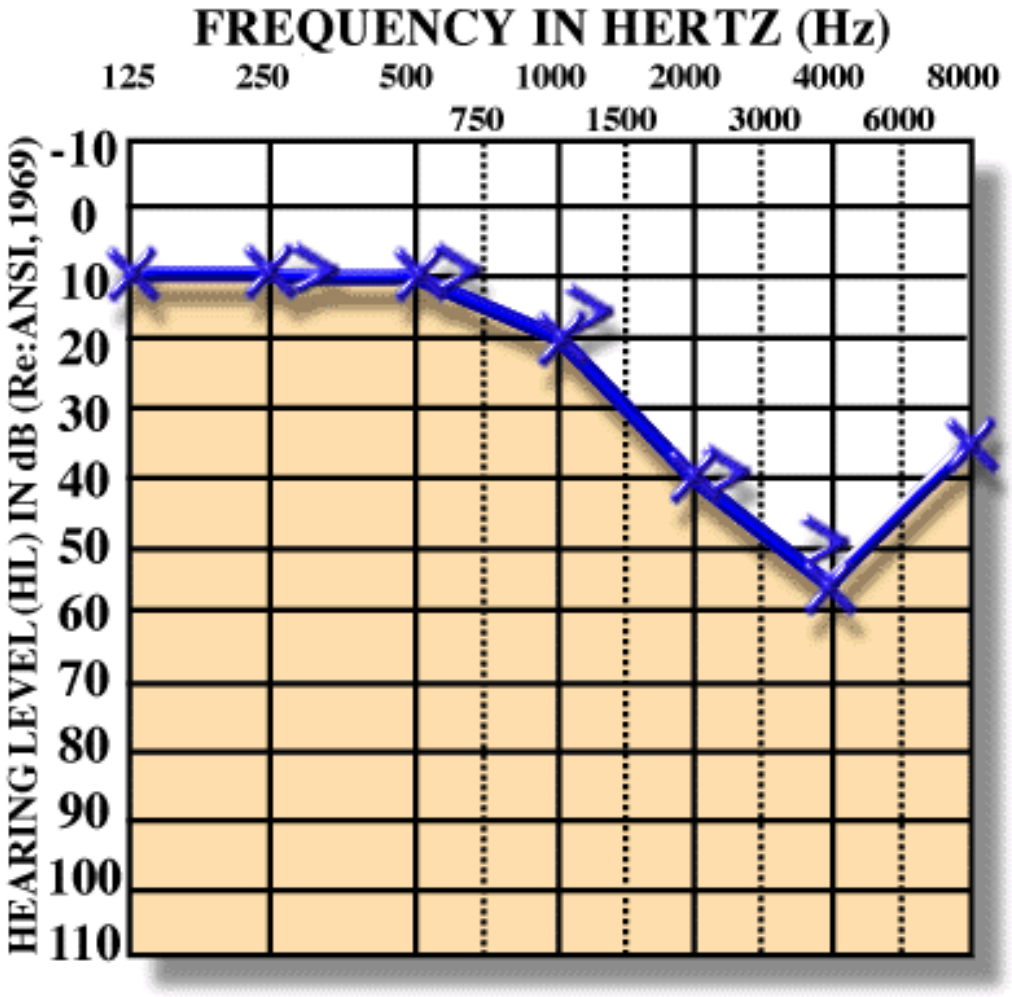
# Normal Hearing



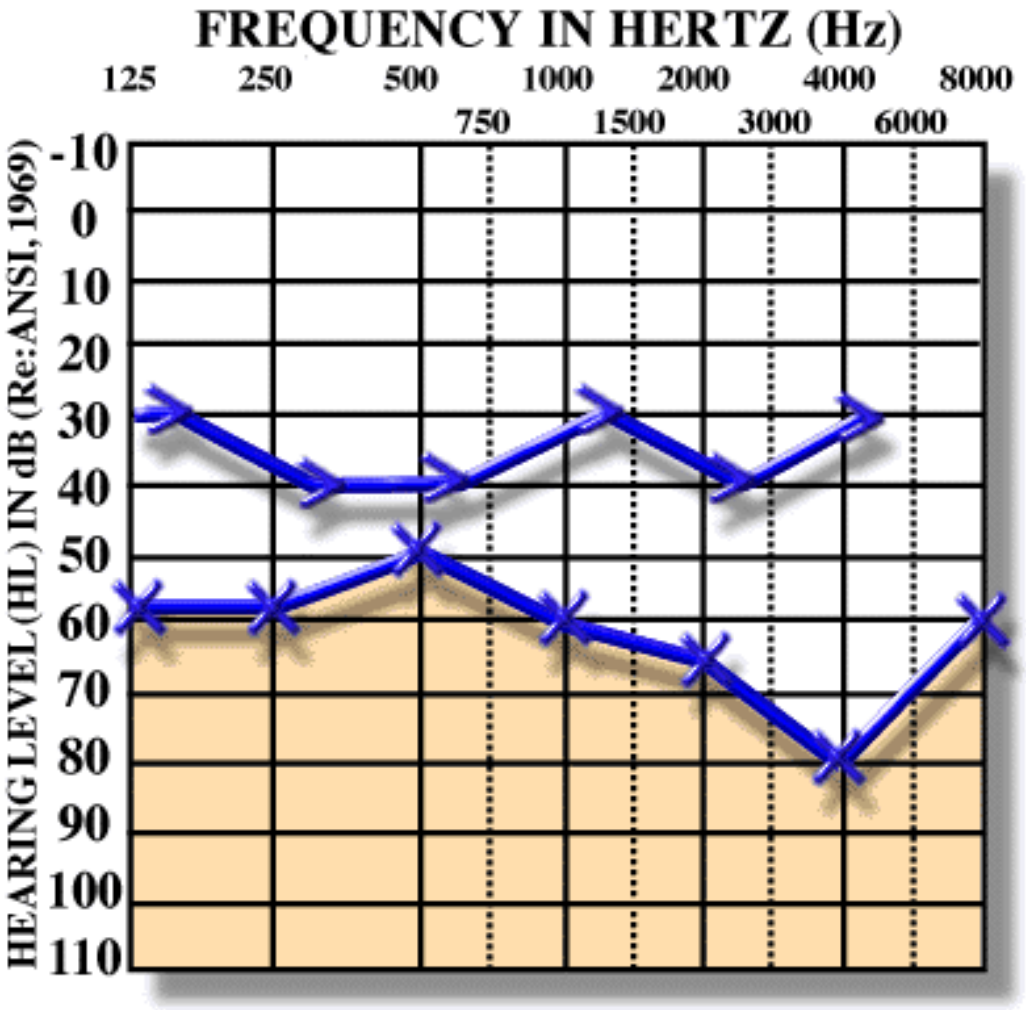
# Conductive Hearing Loss



# Sensorineural Hearing Loss



# Mixed Hearing Loss



# Procedures for conventional pure-tone audiometry

- After history taking and otoscopy we must choose how to test the hearing thresholds.
- Before we do pure tone audiometry (PTA), we usually perform middle ear immitance testing
- PTA will be almost done to all pts visiting us in the clinic because it is the basic test and give us a lot of information about the problem.

# PTA

- With PTA we can determine whether the pt has peripheral hearing loss (that is at the level of outer, middle, inner ear or the auditory nerve).

- PTA is administered both by air (air conduction PTA) or by bone (bone conduction PTA).

- Air conduction tests are administered by loudspeakers or ear phones.

# PTA

- After establishing threshold at 1 KHz, we move to the frequencies (2000, 4000, and 8000Hz).

- If the difference between any two adjacent frequencies is 20 dB or more, we must measure the threshold at the inter octave frequencies.

- After we are done from the high frequencies, we return back and check the 1 KHz again to check for test-retest reliability.
- Then we test (500, 250 and 125 Hz).

# PTA

- If we test in the sound field, we must use warble tones instead of pure tones to avoid the production of standing waves.

- When using ear phones make sure that there is no excessive wax in EAC and that the earphone is snugly inserted in the canal.

- All equipment (audiometer, earphones, and testing room should be calibrated according the standards (will teach you how to do that in the instrumentation course).

# PTA-BONE CONDUCTION

- The most commonly used procedure for bone-conduction testing is mastoid placement because it is more convenient.

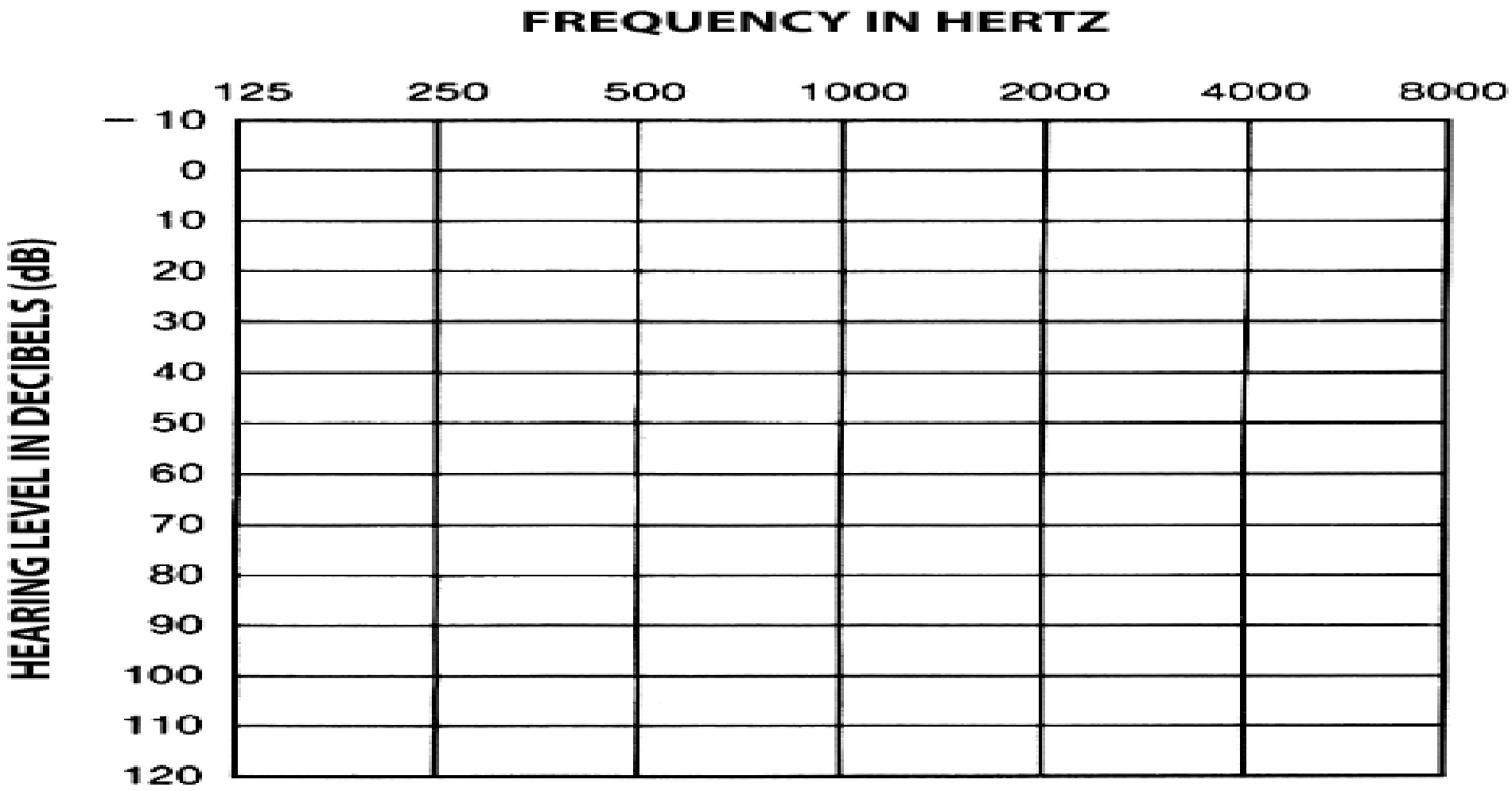
- Frontal bone can be used as the place for the bone vibrator.

# PTA.BONE CONDUCTION

- We should do bone conduction if the air conduction thresholds are above the normal range otherwise we do not need to do bone conduction testing.
- Some exceptions?

- We first do unmasked thresholds and then we should apply masking to the contralateral ear in order to get precise threshold measurement in this ear (will talk about masking next lecture).

# AUDIOGRAM


FREQUENCY IN HERTZ
125
250
500
1000
2000
4000
8000
HEARING LEVEL IN DECIBELS (dB)
— 10
0
10
20
30
40
50
60
70
80
90
100
110
120

# LEGEND / KEY

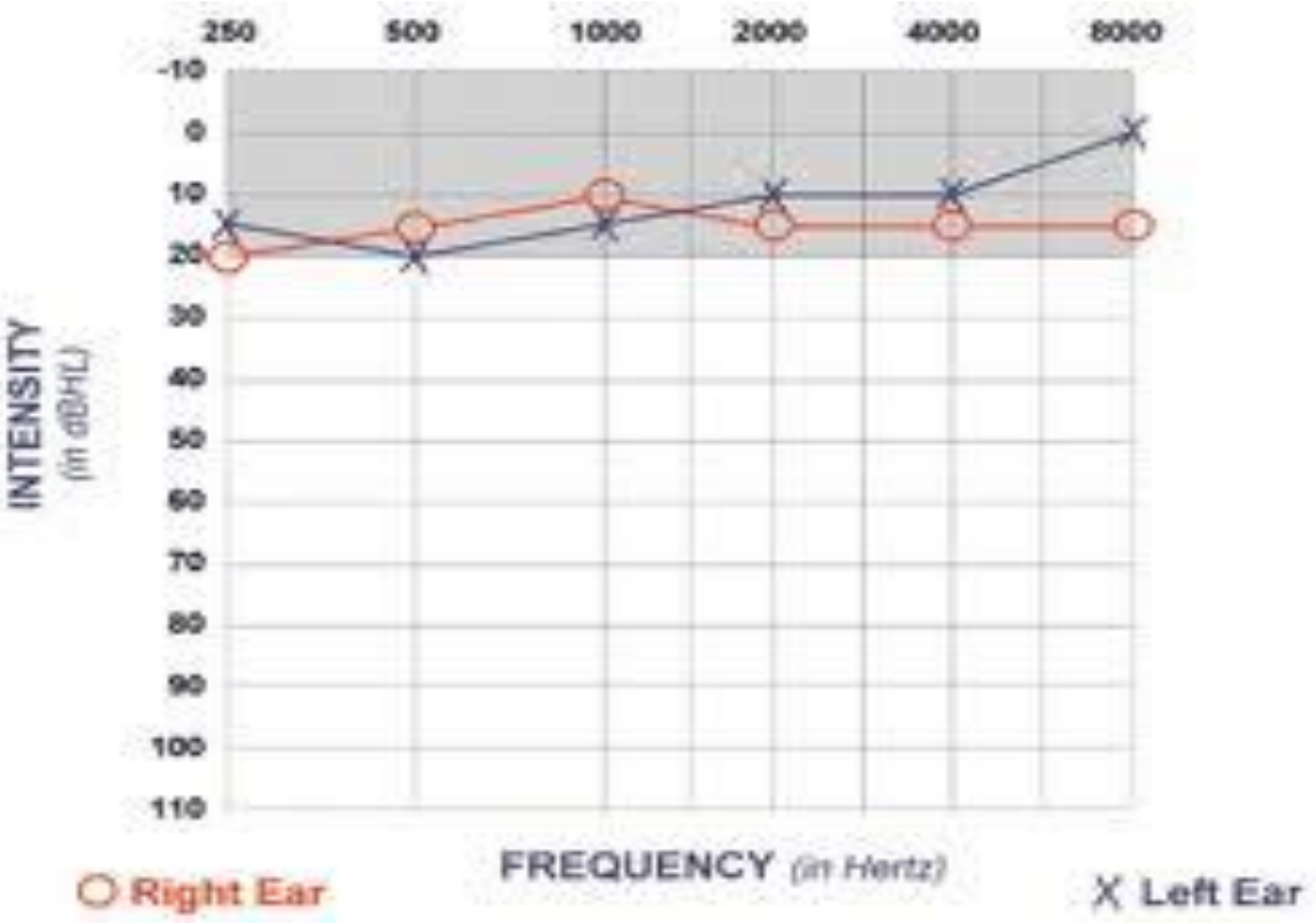
BLUE is the standard used to signify the LEFT.
RED is the standard used to signify the RIGHT.

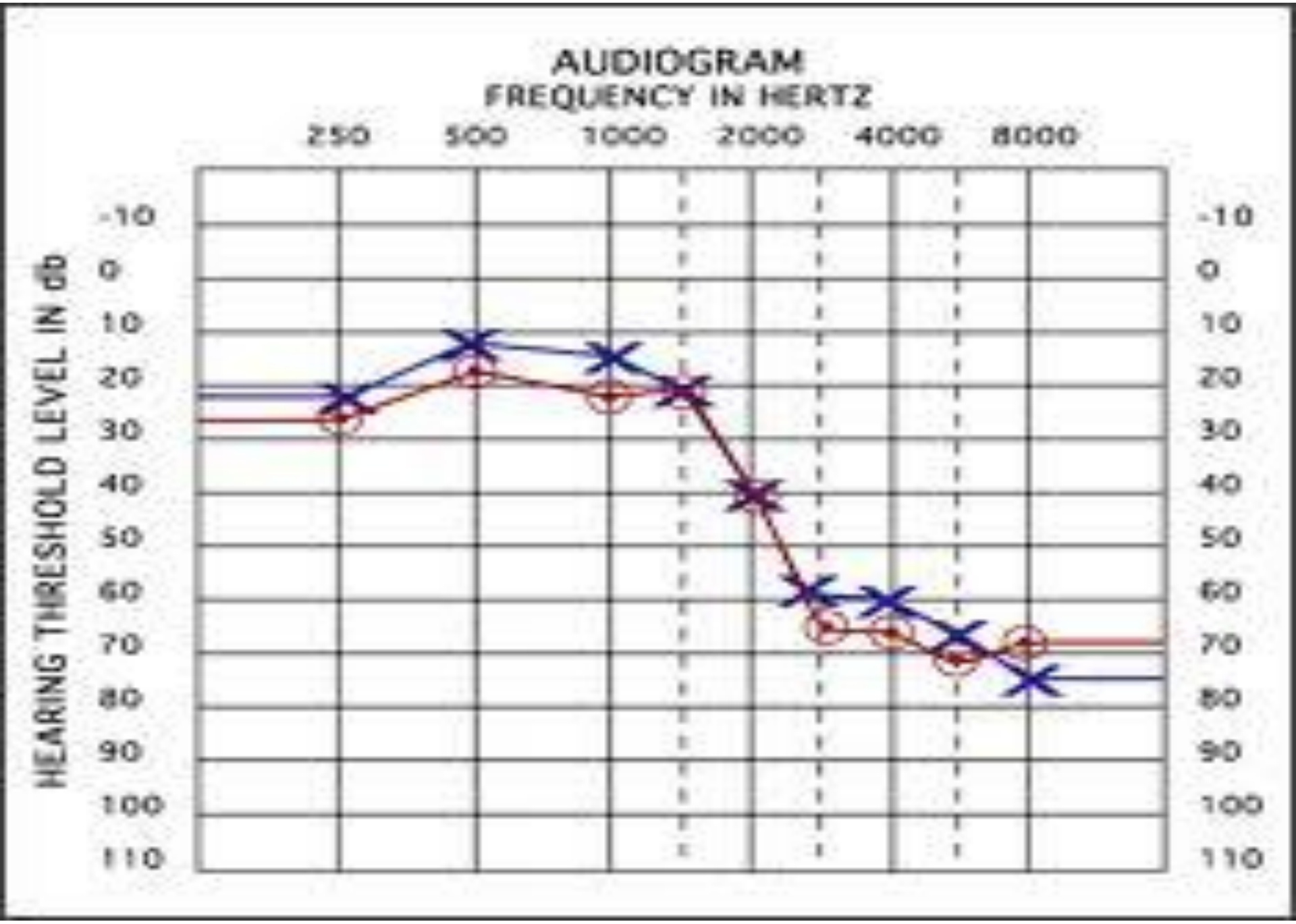
## Test Result Markings used on your audiogram:

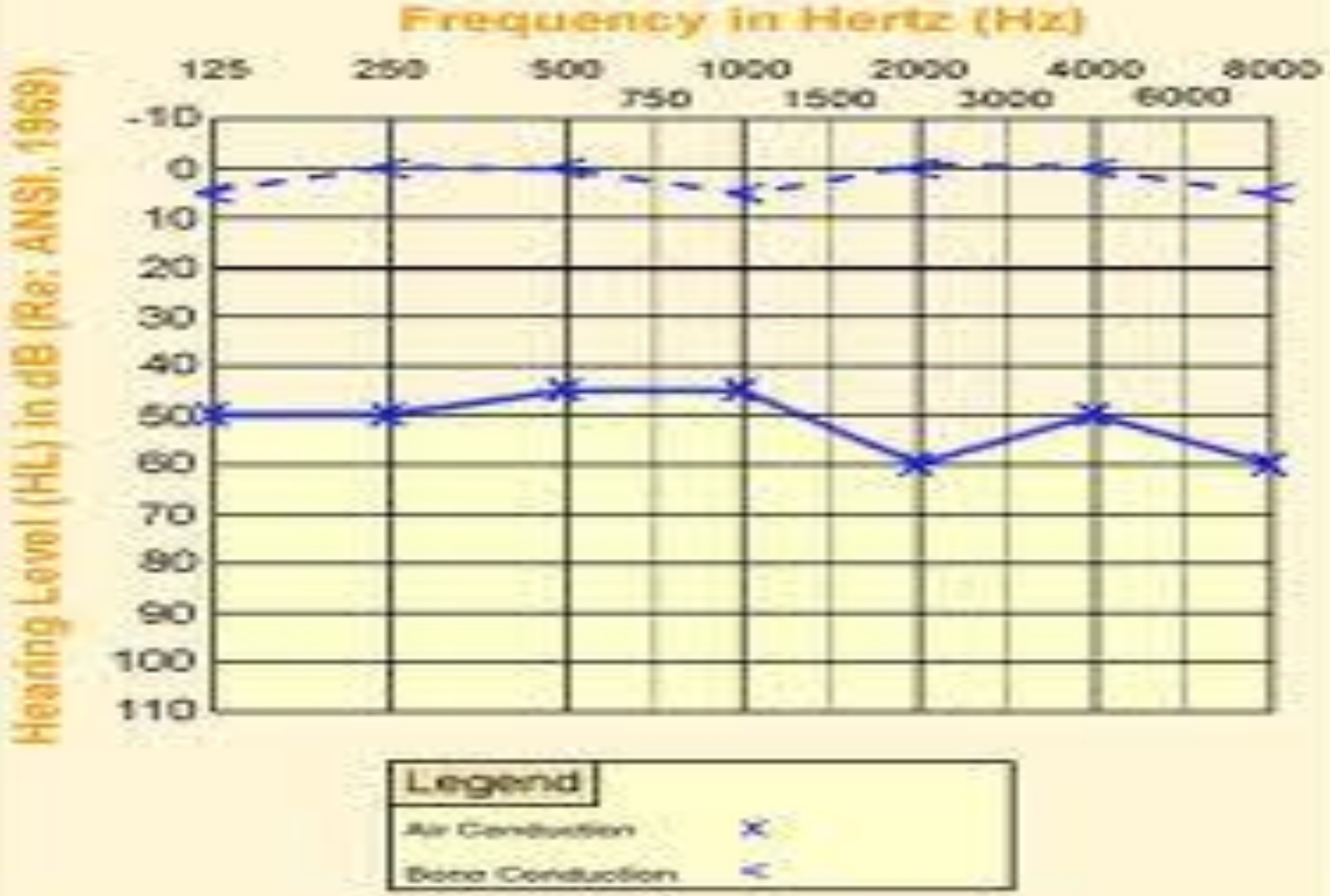
| | Right | Left |
|---|---|---|
| Air Conduction | O | X |
| / with masking | △ | □ |
| Bone Conduction | < | > |
| / with masking | [ | ] |
| No Response | ↙ | ↘ |

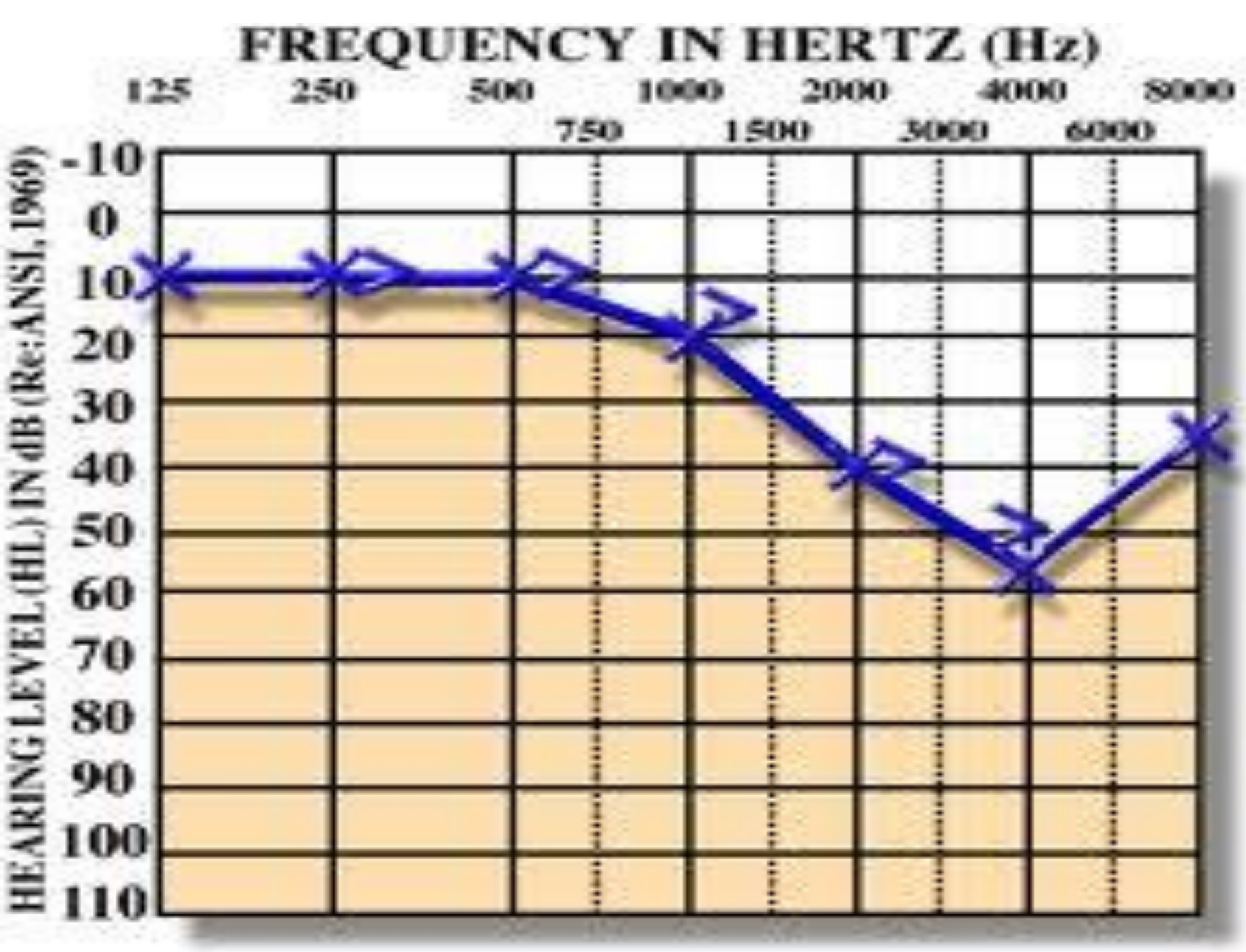
While these symbols are the standard, they are not used by all hearing professionals. Please ask if they are right for your audiogram.

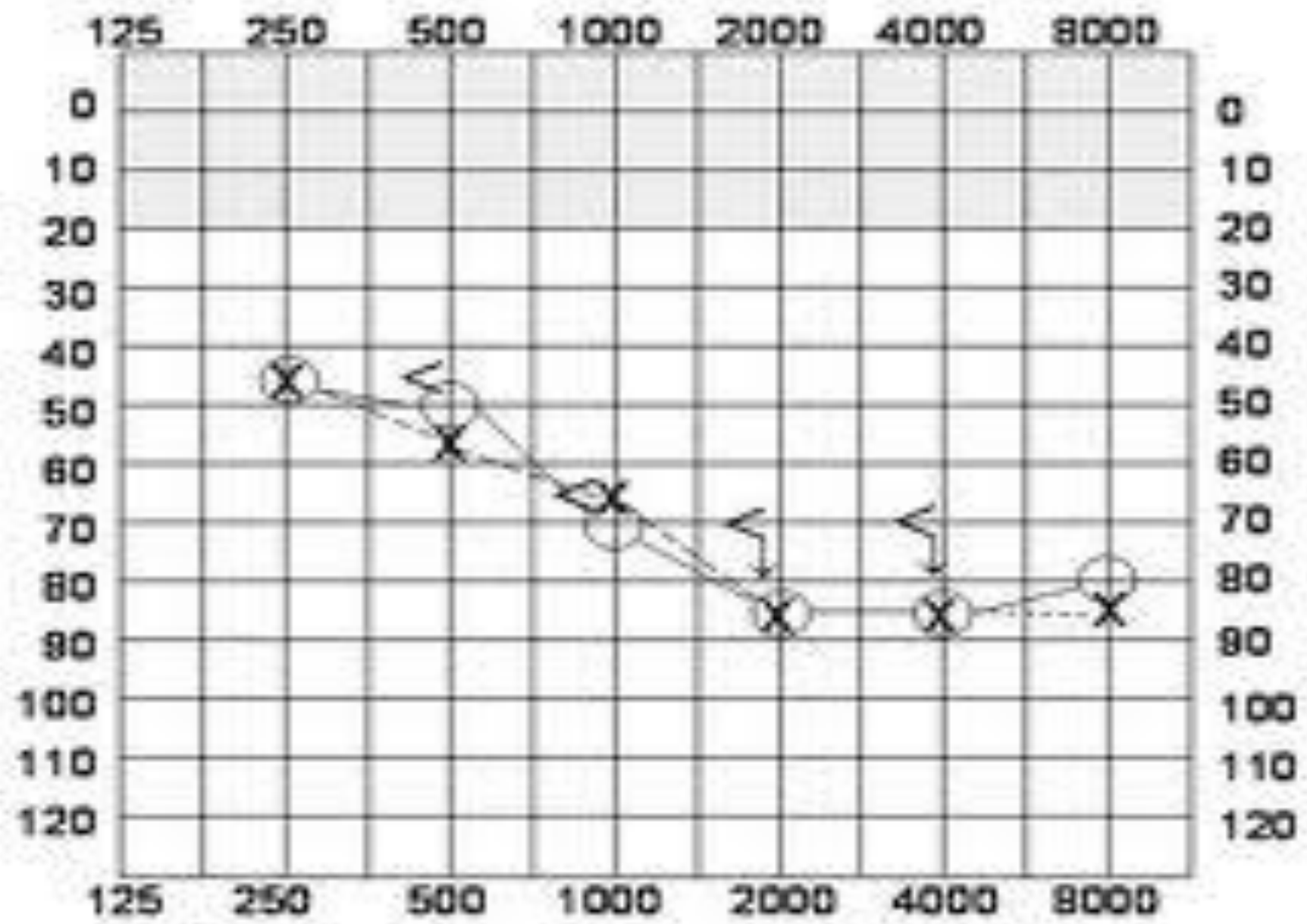
These graphs were done using a computer program for clarity. Unfortunately, sometimes the actual graph may be more difficult to read due to bad handwriting. If you can not read your audiogram, please ask your hearing professional for assistance.

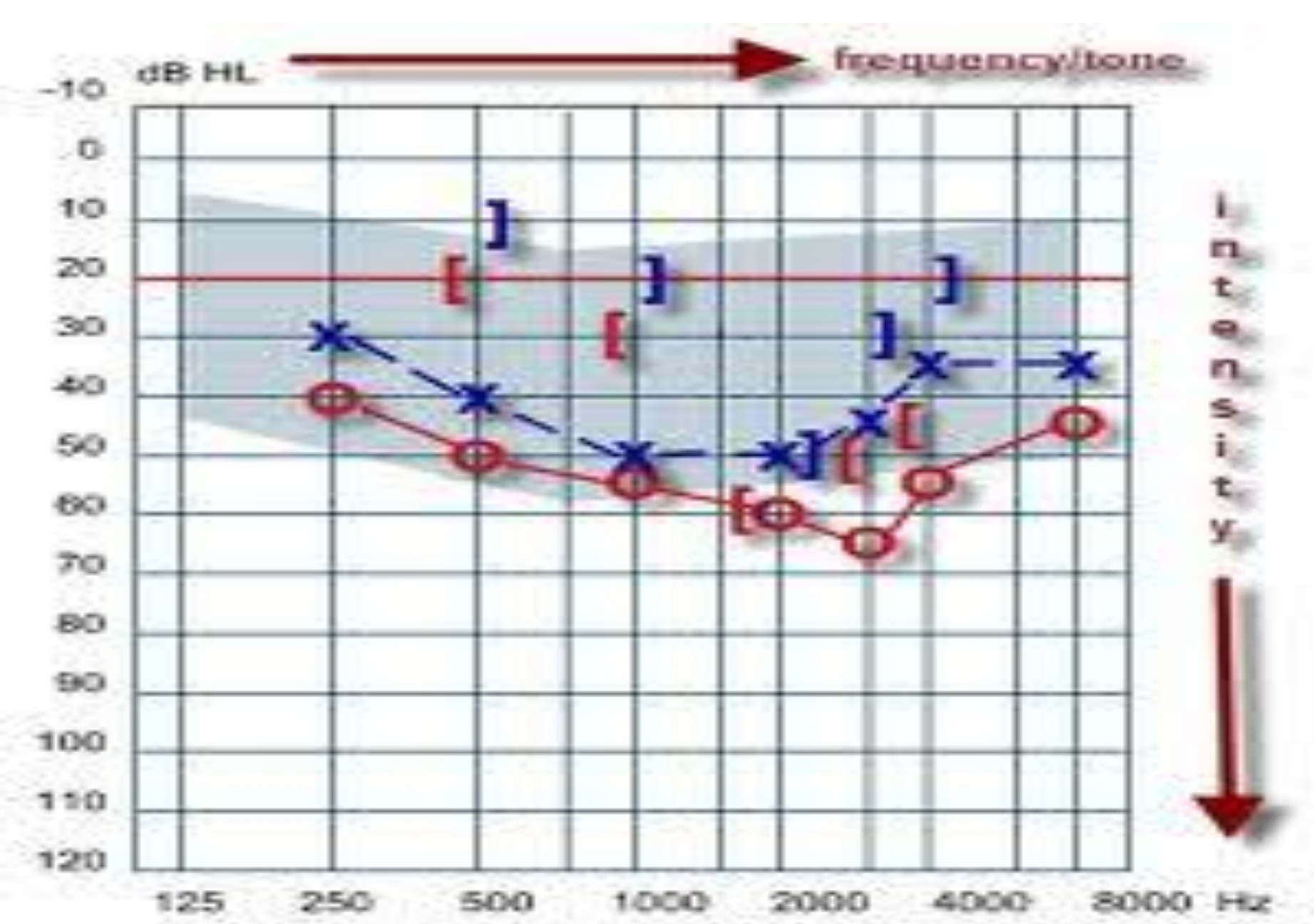

250
500
1000
2000
4000
8000
-10
0
10
20
30
40
50
60
70
80
90
100
110
INTENSITY
(in dBHL)
FREQUENCY (in Hertz)
Right Ear
Left Ear

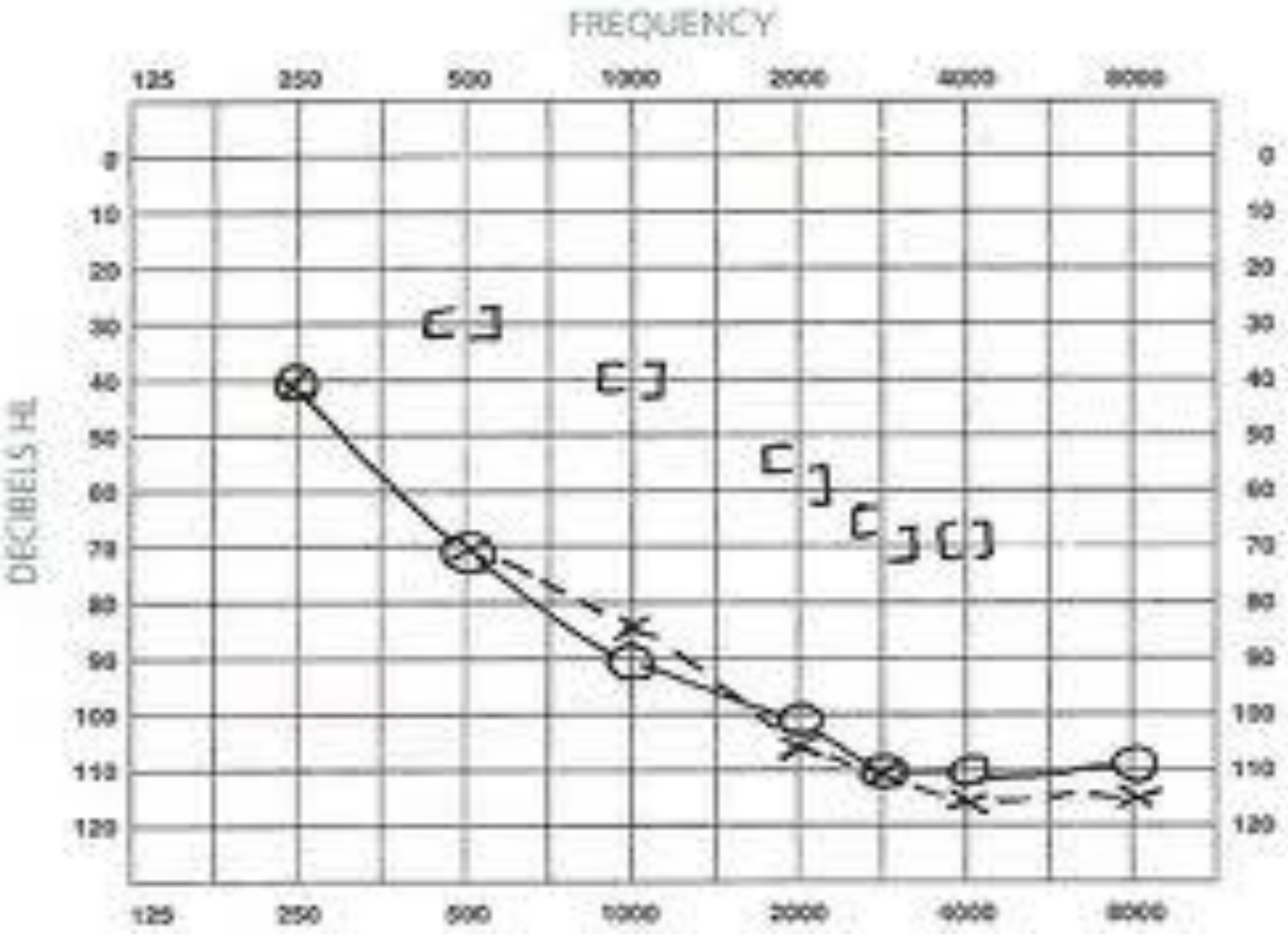

AUDIOGRAM
FREQUENCY IN HERTZ
250
500
1000
2000
4000
8000
HEARING THRESHOLD LEVEL IN db
-10
0
10
20
30
40
50
60
70
80
90
100
110


Conductive Hearing Loss Audiogram
Frequency in Hertz (Hz)
125
250
500
750
1000
1500
2000
3000
4000
6000
8000
-10
0
10
20
30
40
50
60
70
80
90
100
110
Hearing Level (HL) in dB (Re: ANSI, 1969)
Legend
Air Conduction
Bone Conduction


FREQUENCY IN HERTZ (Hz)
125
250
500
750
1000
1500
2000
3000
4000
6000
8000
HEARING LEVEL (HL) IN dB (Re: ANSI, 1969)
-10
0
10
20
30
40
50
60
70
80
90
100
110

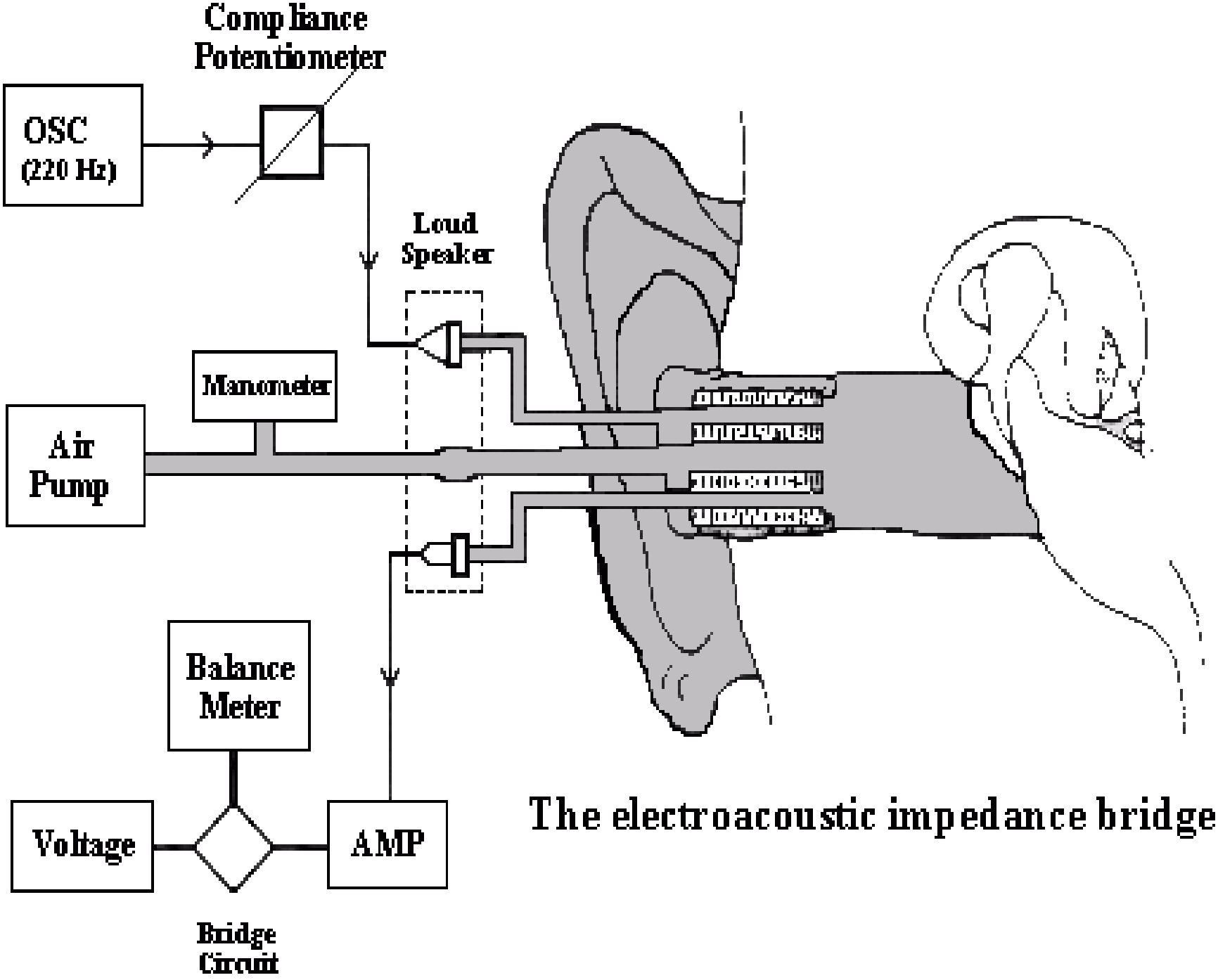

125
250
500
1000
2000
4000
8000
0
10
20
30
40
50
60
70
80
90
100
110
120


dB HL
frequency/tone
-10
0
10
20
30
40
50
60
70
80
90
100
110
120
125
250
500
1000
2000
4000
8000
Hz
intensity

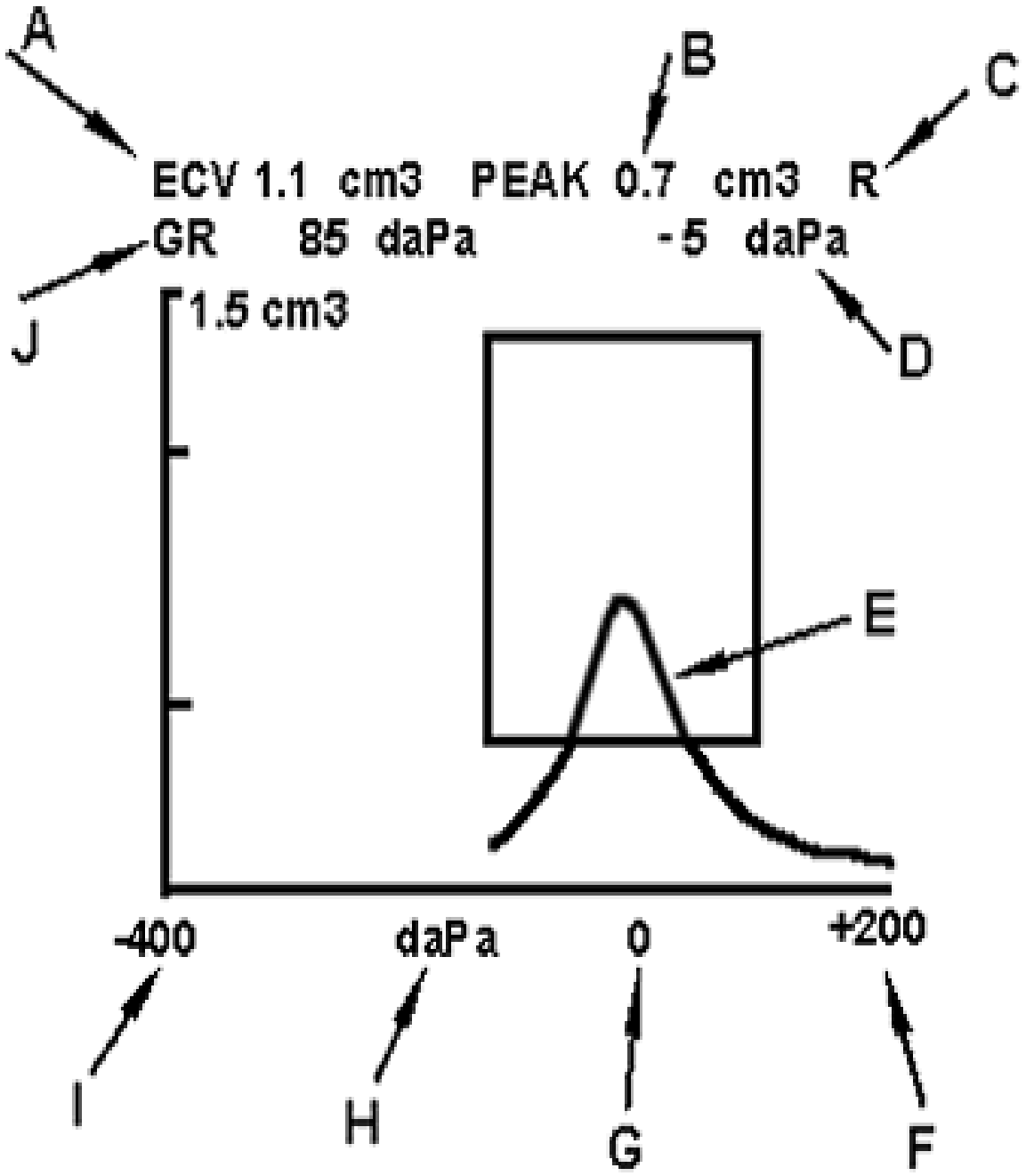

FREQUENCY
125
250
500
1000
2000
4000
8000
DECIBELS HL
0
10
20
30
40
50
60
70
80
90
100
110
120

# Information we get from audiogram

- Degree of hearing loss.
- Type of hearing loss.
- Configuration of hearing loss.



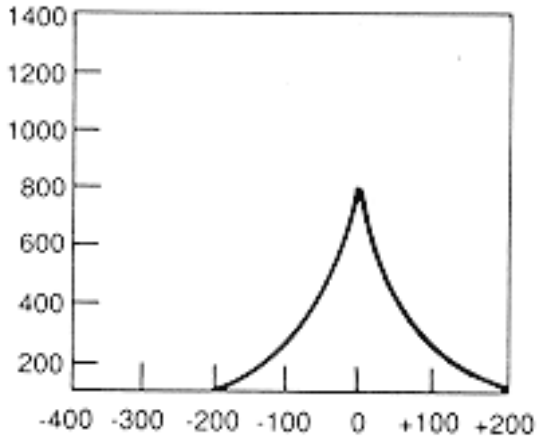

The electroacoustic impedance bridge


A
B
C
ECV 1.1 cm3 PEAK 0.7 cm3 R
GR 85 daPa -5 daPa
J
D
1.5 cm3
E
-400
daPa
0
+200
I
H
G
F

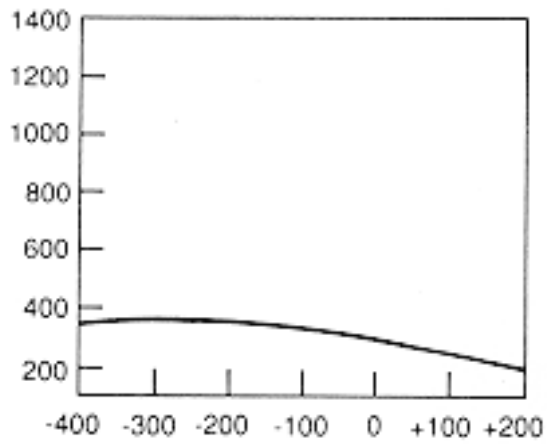
# TYMPANOMETRIC FEATURES

- Tympanometric shapes.
- Static acoustic admittance.
- Tympanometric width (gradient).
- Tympanometric peak pressure.
- Equivalent ear canal volume.

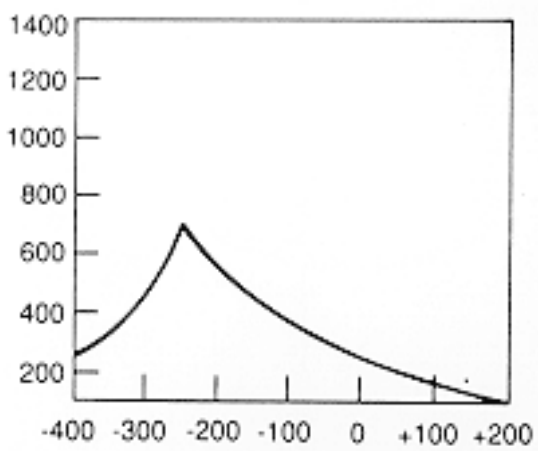
Type A



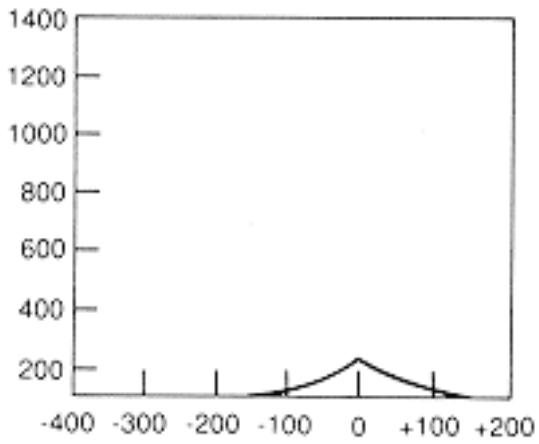

Type B



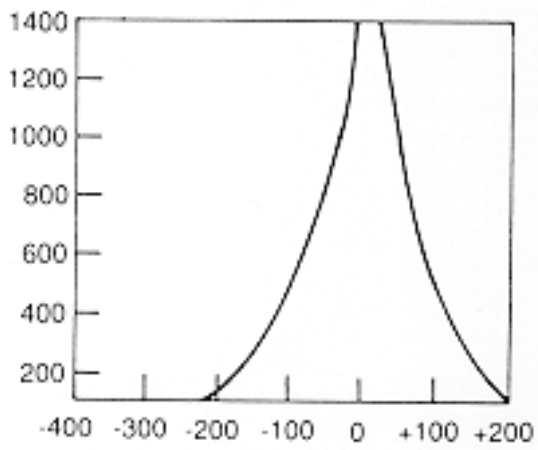

Type C




Type As



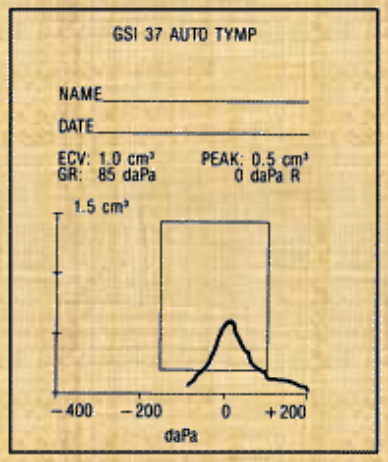

Type AD

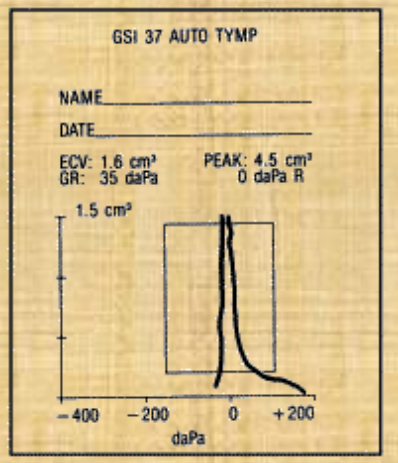


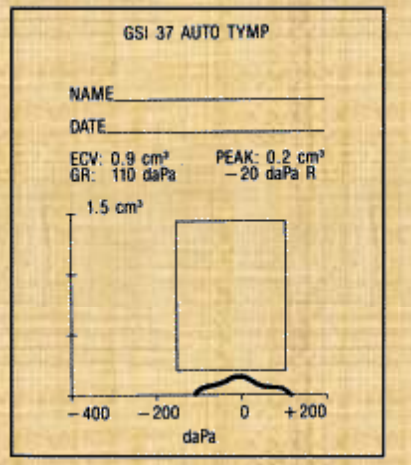
# Sensitivity and specificity

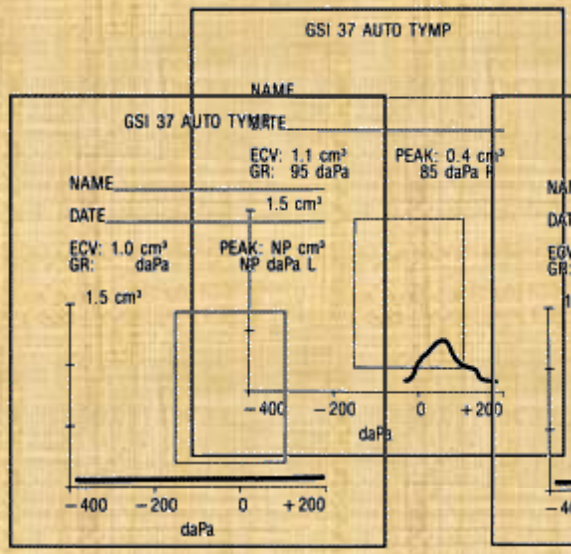
- Sensitivity has been found to be around 82% for MEE.
- Normal type A has 100% specificity.
- Overall sensitivity of around 80% and specificity of around 90%.
- That is good but means we need to interpret results with caution.

# Tympanogram Types



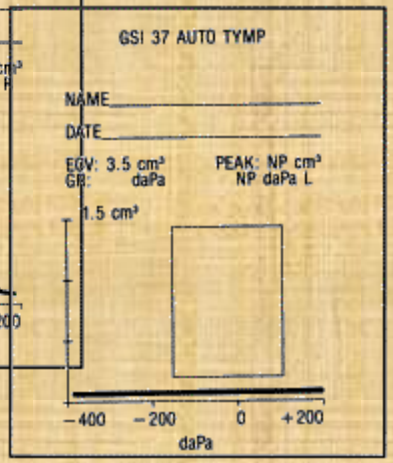



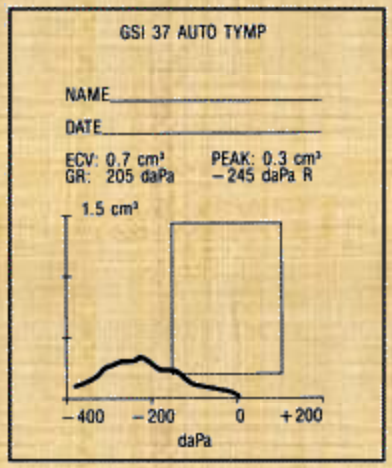









# Type A Tympanogram

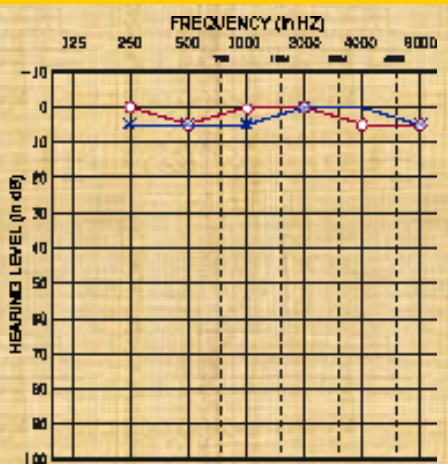
OE | ME | IE | AN | CNS

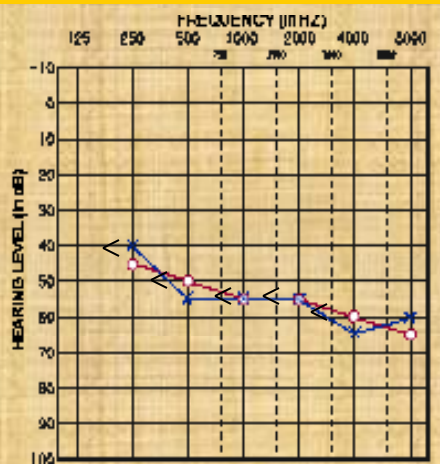
AC

A

Normal or SN

ARS

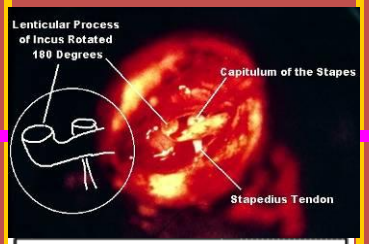


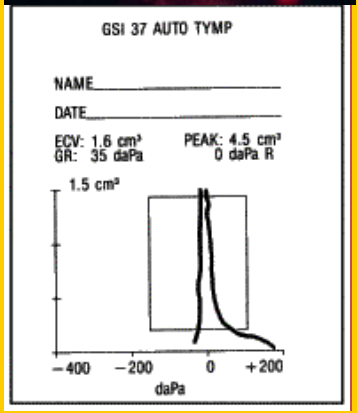



# Type $A_D$ Tympanogram

OE | ME | IE | AN | CNS

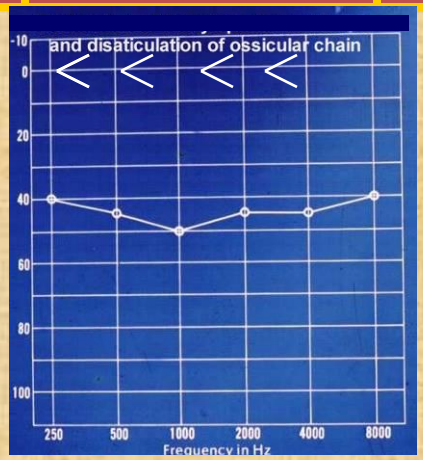
AC




$A_D$

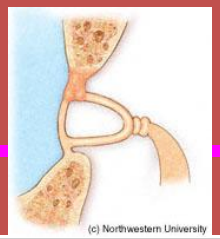
Disarticulation

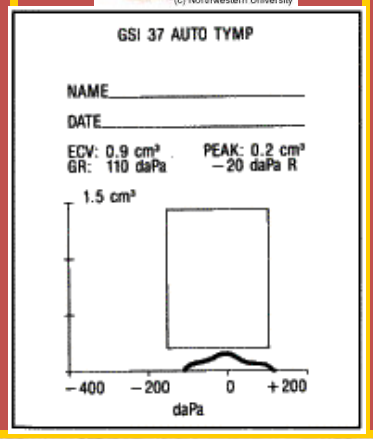


# Type As Tympanogram

| OE | ME | IE | AN | CNS |
|---|---|---|---|---|

AC

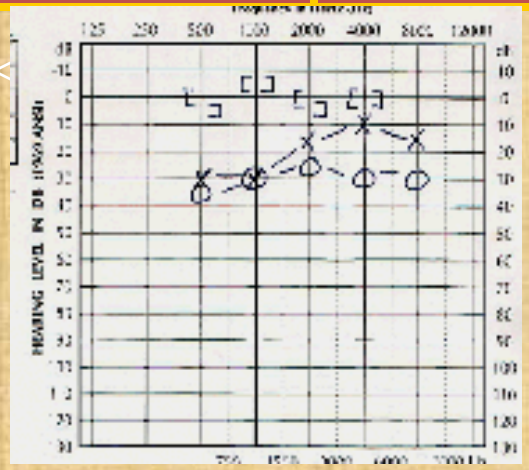



As

BC

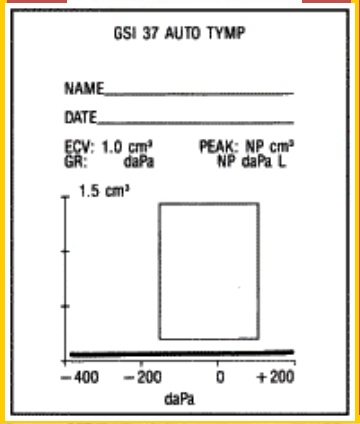
Otosclerosis



# Type $B_{Low}$ Tympanogram

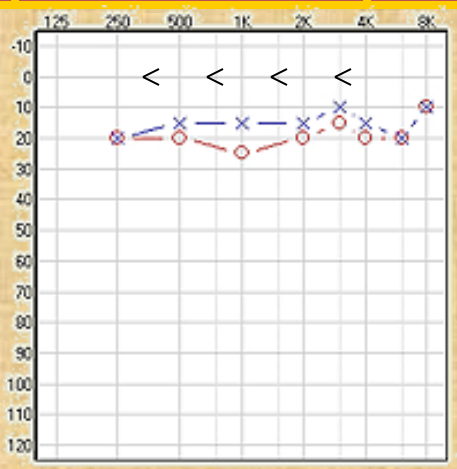
OE | ME | IE | AN | CNS

AC




BLOW OME

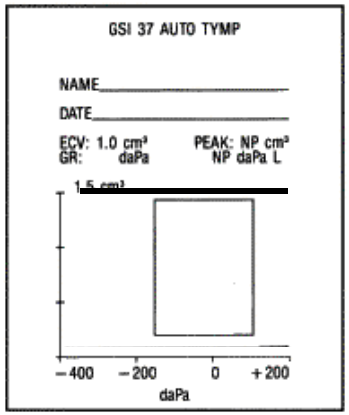
HD



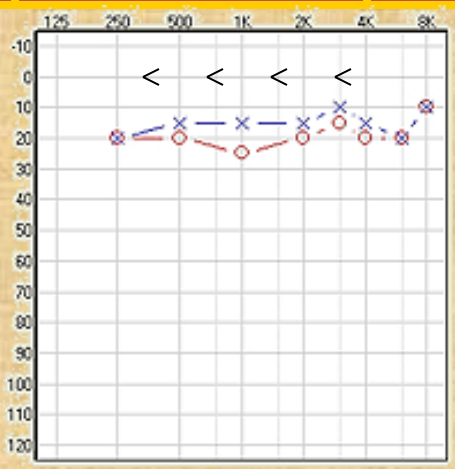
# Type $B_{Hi}$ Tympanogram

| OE | ME | IE | AN | CNS |
|---|---|---|---|---|
| | | | | |

AC



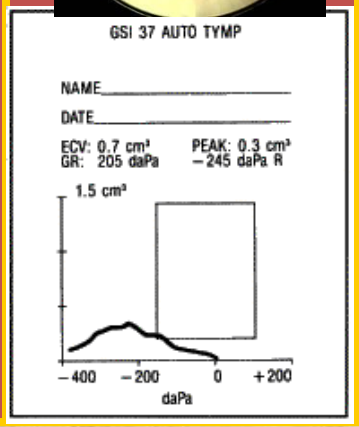

$B_{Hi}$ Perforation



# Type C Tympanogram

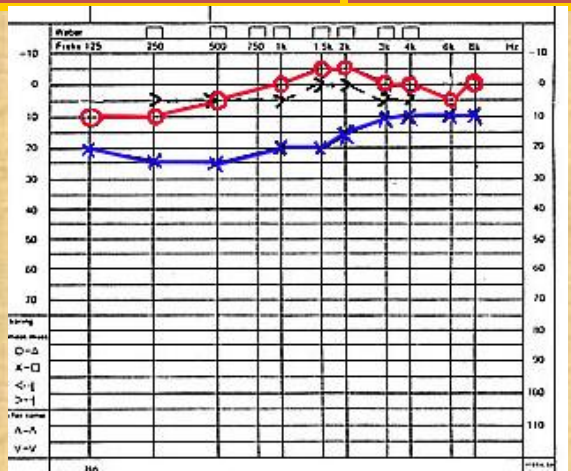
| OE | ME | IE | AN | CNS |
|---|---|---|---|---|

AC




C

Eustachian Tube Dysfunction



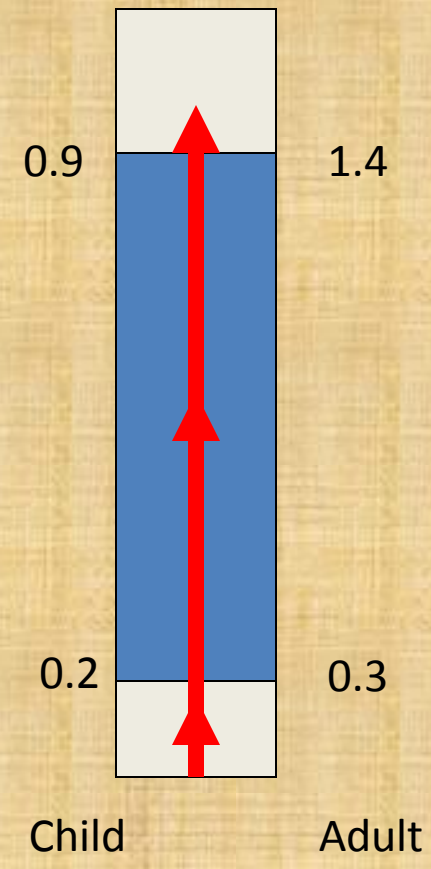
# Static Compliance (Peak Compliance)

## Acceptable Range by Age

| | Peak Compliance (mmho or cc) | Ear Canal Volume (cc) |
|---|---|---|
| Mean | 0.5 | 0.7 |
| 90% range | 0.2 to 0.9 | 0.4 to 1.0 |

*Adults*

| | Peak Compliance (mmho or cc) | Ear Canal Volume (cc) |
|---|---|---|
| Mean | 0.8 | 1.1 |
| 90% range | 0.3 to 1.4 | 0.6 to 1.5 |




Flaccid: disarticulation, flaccid TM, etc.

Normal mobility

Stiff: otosclerosis fluid, tympanosclerosis, etc.

# Tympanometry in infants

- Studies has found frequent occurrence of double peaked tymps.

- Usually we use higher probe frequency when testing infants like 1000 Hz.

# otoacoustic emissions

# Origin of OAE

- Initially reported by Kemp in 1978.
- OAE are considered a by-product of sensory OHCs transduction and represent cochlear amplifier that thought to be as a result of the contraction of OHCs in synchrony with BM displacement.
- The contraction of the OHCs (movement) is then propagated outward toward the middle ear and moves the TM.
- This in turn creates acoustic energy that is picked by the OAE probe.

# Recording OAE's

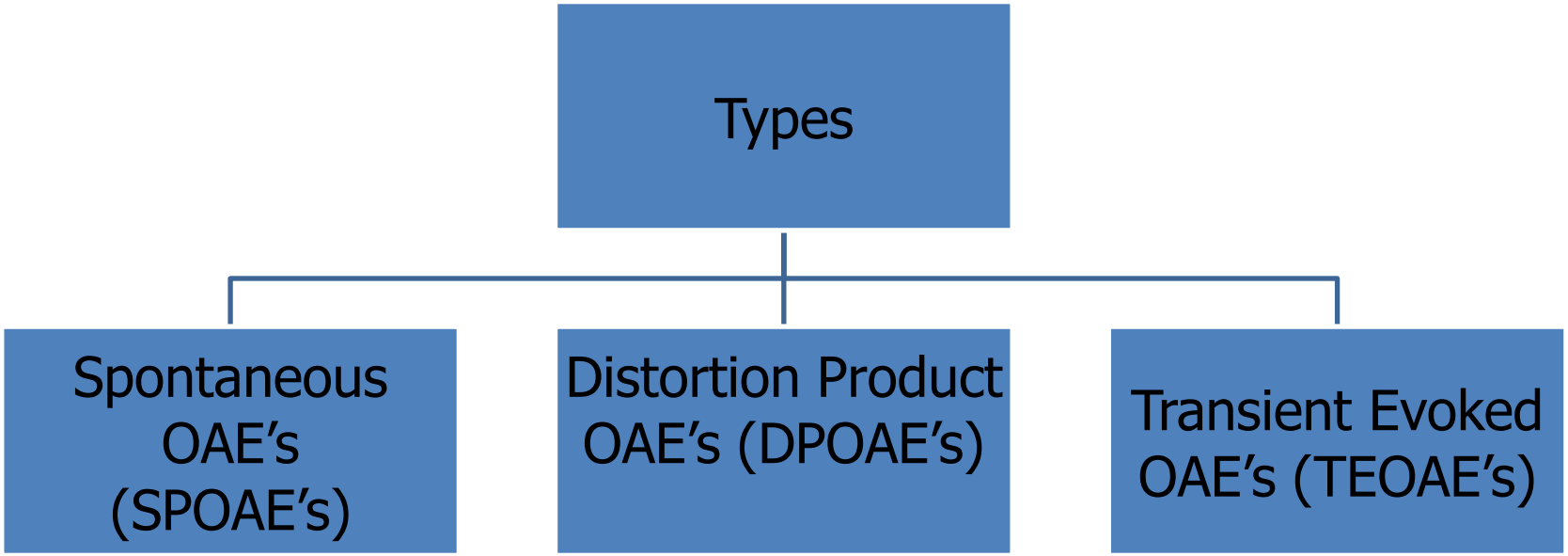
- OAEs are measured by presenting a series of very brief acoustic stimuli, clicks, to the ear through a probe that is inserted in the outer third of the ear canal. The probe contains a loudspeaker that generates clicks and a microphone that measures the resulting OAE's that are produced in the cochlea and are then reflected back through the middle ear into the outer ear canal.
- The resulting sound that is picked up by the microphone is digitized and processed by specially designed hardware and software. The very low-level OAEs are separated by the software from both the background noise and from the contamination of the evoking clicks.

# OAE

- So in order to record OAE in EAC we need to have normal middle ear function.

- Conductive pathologies can prevent the recording of OAE but this does not mean that OAE is not present.

# Types of OAE's



# Spontaneous OAE's

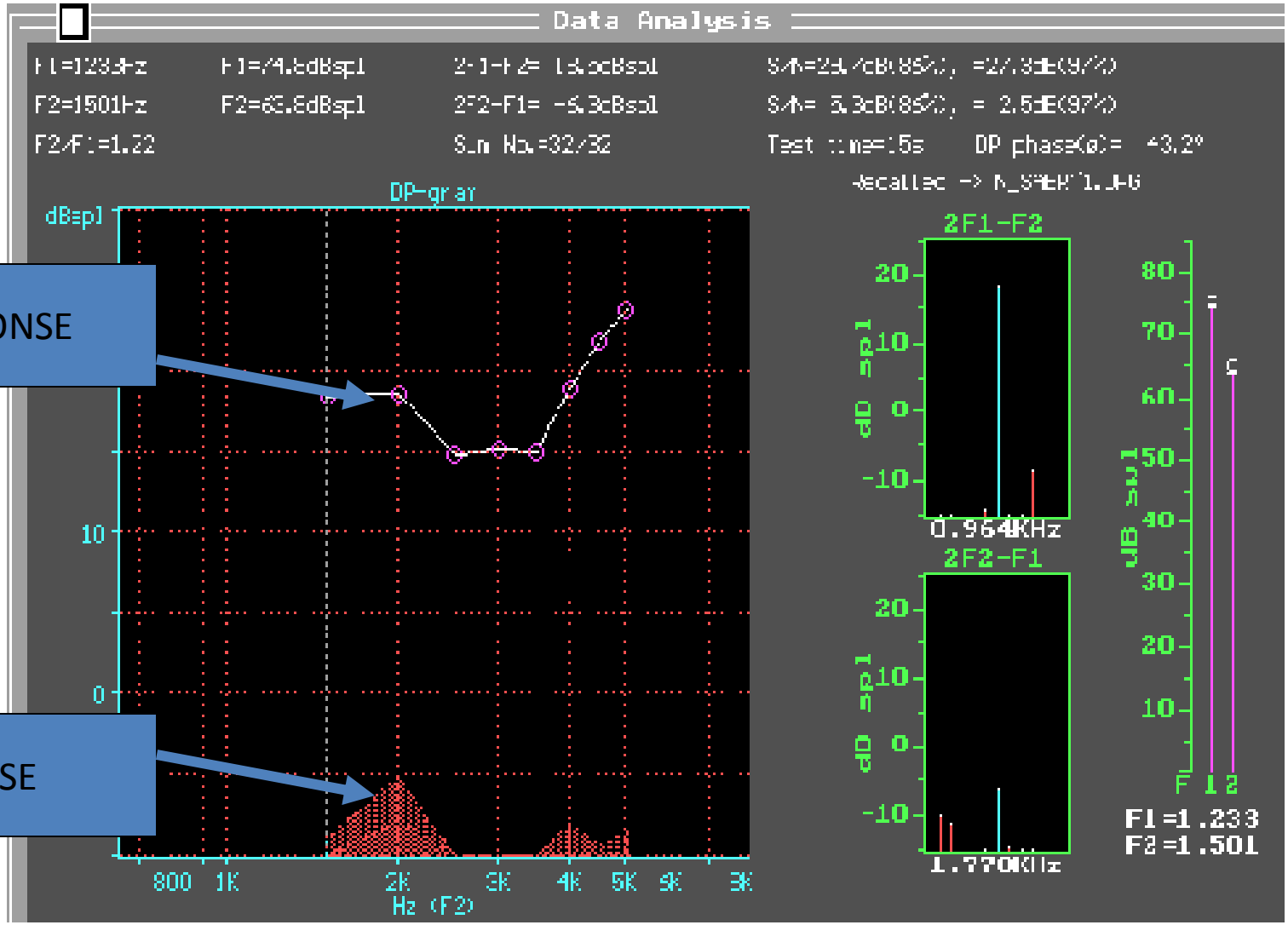
- Occurs in the absence of any intentional stimulation of the ear.
- Prevalence is in about 40-60% of normal hearing people.
- When you record SOAE's, you average the number of samples of sounds in the ear and perform a spectral analysis.

- The presence of SOAE's is usually considered to be a sign of cochlear health, but the absence of SOAE's is not necessarily a sign of abnormality.

# Distortion Product OAE's

- Result from the interaction of two simultaneously presented pure tones.
- Stimuli consist of 2 pure tones at 2 frequencies (ie, f1, f2 [f2>f1]) and 2 intensity levels (ie, L1, L2). The relationship between L1-L2 and f1-f2 dictates the frequency response.
- DPOAEs allow for a greater frequency specificity and can be used to record at higher frequencies than TOAE's. Therefore, DPOAE's may be useful for early detection of cochlear damage as they are for ototoxicity and noise-induced damage.

# DPOAE data from a normal subject: High level protocol 75 -65

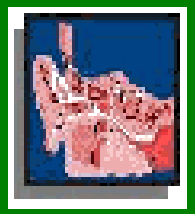



RESPONSE

NOISE

# Transient Evoked OAE

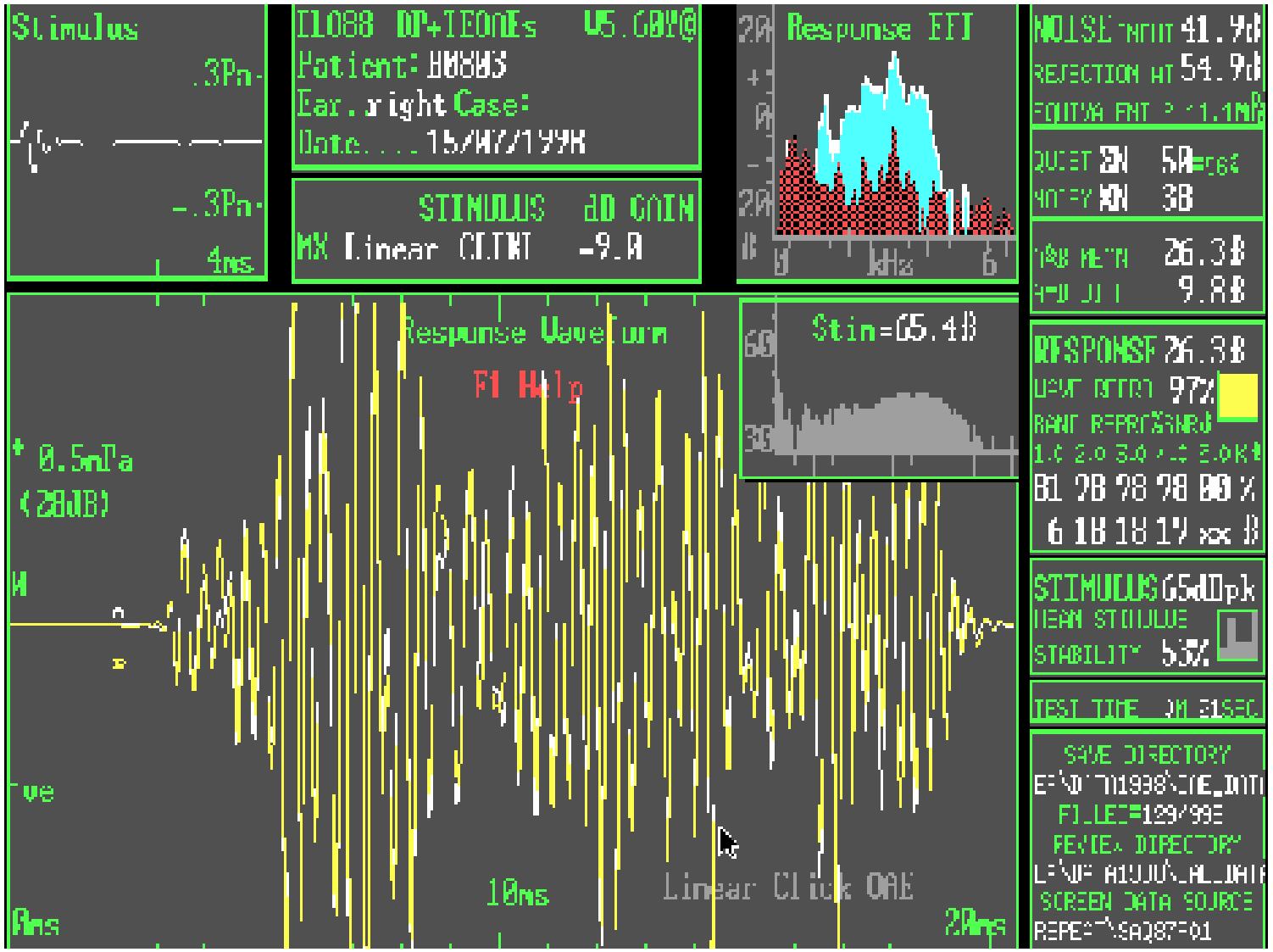
- TEOAE's are frequency responses that follow
  a brief acoustic stimulus, such as a click or tone burst.
- The evoked response from this type of stimulus covers the frequency range up to around 4 kHz.
- In normal adult ears, the click-elicited TEOAE typically falls off for frequencies more than 2 kHz, and is rarely present over 4 kHz, because of both technical limitations in the ear-speaker at higher frequencies and the physical features of adult ear canals so that is why DPOAE's would be more efficacious.
- For newborns and older infants, the TEOAE is much more robust by about 10 dB and typically can be measured out to about 6 kHz indicating that smaller ear canals influence the acoustic characteristics of standard click stimuli much differently than do adult ears.
- TEOAE's do not occur in people with a hearing loss greater than 30dB.



# TEOAEs

Stimulus

TEOAE response

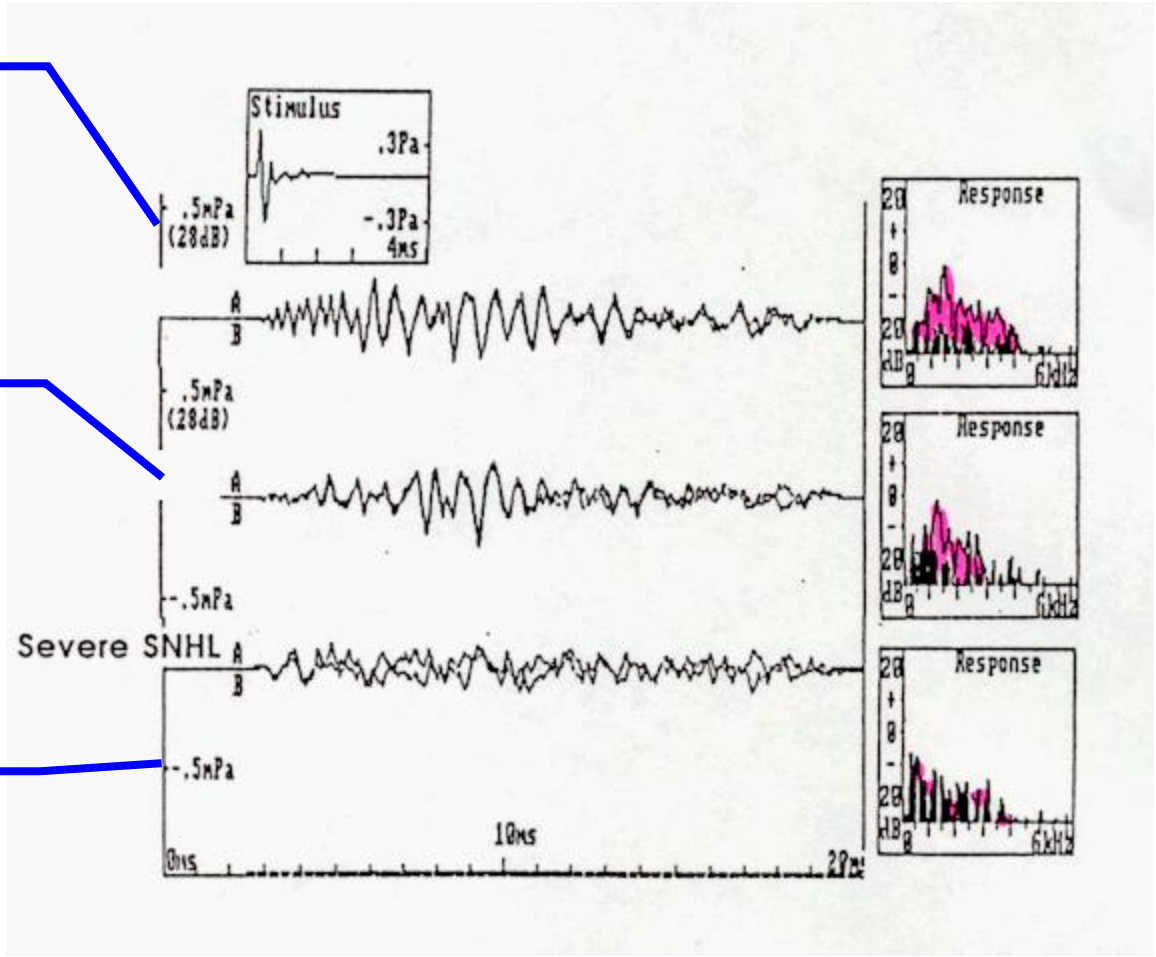


# TEOAE results

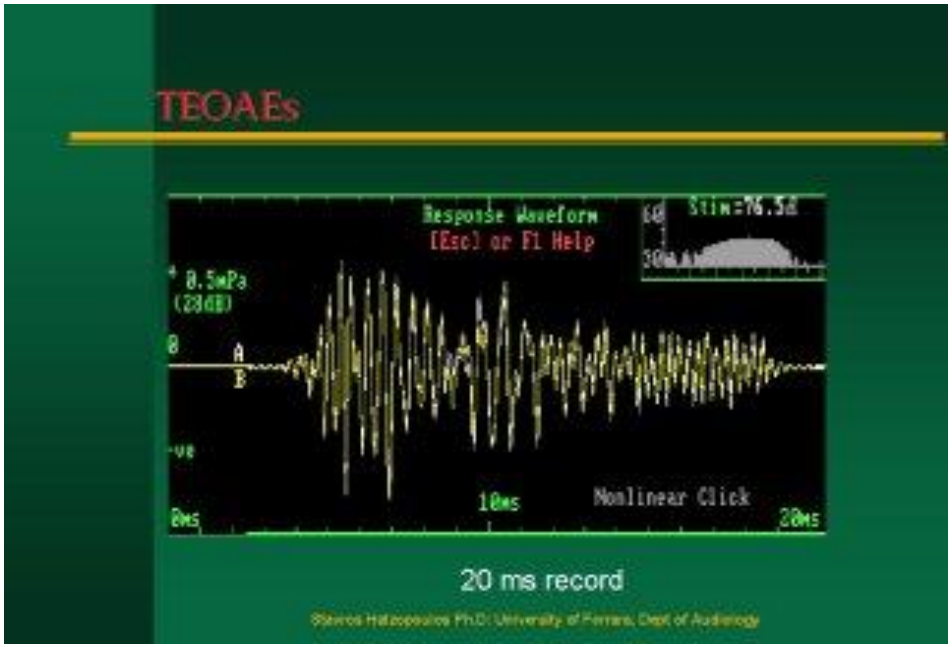
Normal hearing

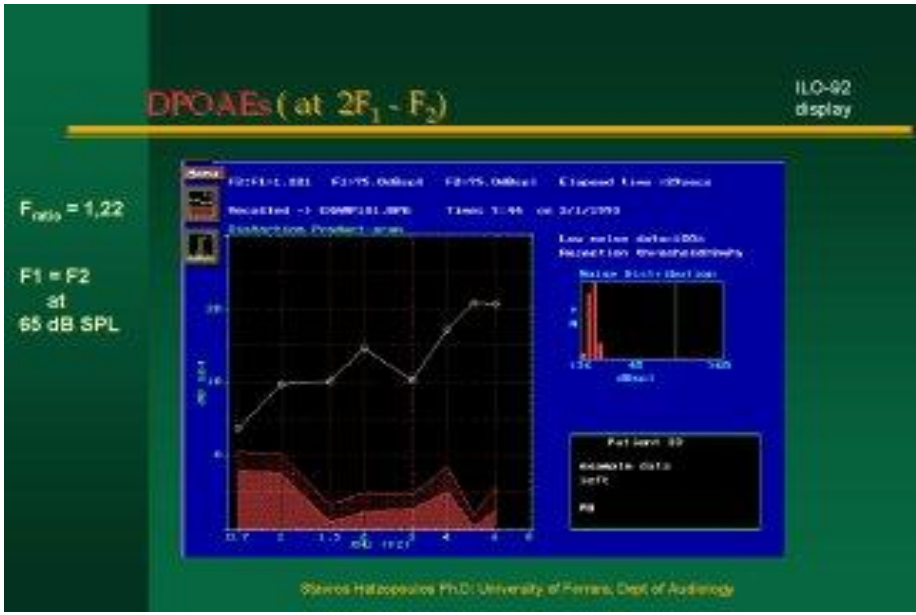
High frequency HL

Severe SN HL



# TEOAE & DPOAE


TEOAEs
Response Waveform
[Esc] or F1 Help
Stim=76.5d
0.5mPa
(28dB)
10ms
Nonlinear Click
20ms
20 ms record


DPOAEs ( at 2F1 - F2)
ILO-92
display
Fratio = 1,22
F1 = F2
at
65 dB SPL

# Acquisition

- Not affected by sleep but needs test subject to be still and compliant
- Very quick

# Clinical applications of EOAE

- 1- can be used in newborn hearing screening. The results will indicate either fail or pass. Fail means that hearing thresholds are worse than 30 dB HL. Pass results means hearing thresholds are 30 dB HL or better.

  – So, we can not use this tool to measure threshold of hearing.

# Applications of OAE

- TEOAE can be recorded in all non-pathologic ears that do not display hearing loss of greater than 30 dB.
- OAE can be recorded in both adults and infants.
- Accordingly TEOAE and DPOAE can be used to screen for hearing loss in infants.
- DPOAE provide more frequency specific evaluation that TEOAE.

# Clinical applications of EOAE

- 2- in differential diagnosis of hearing loss (site of lesion). This can help in differentiating sensory from neural hearing loss.

- 3- monitoring of the effect of ototoxicity or noise exposure.

- 4- although still under research: DPOAE can be used to screen for the carriers of the recessive hearing loss genes: many studies found that DPOAE is larger (especially at high frequencies) in carriers than in non carriers when using f2/f1 of 1.3 and low stimulus levels of 50-60 dB.

# clinical limitations

- Problems because of middle ear disease
- Not sensitive for neonates within 24 hours of birth
- Results affected by test conditions
  - Noise

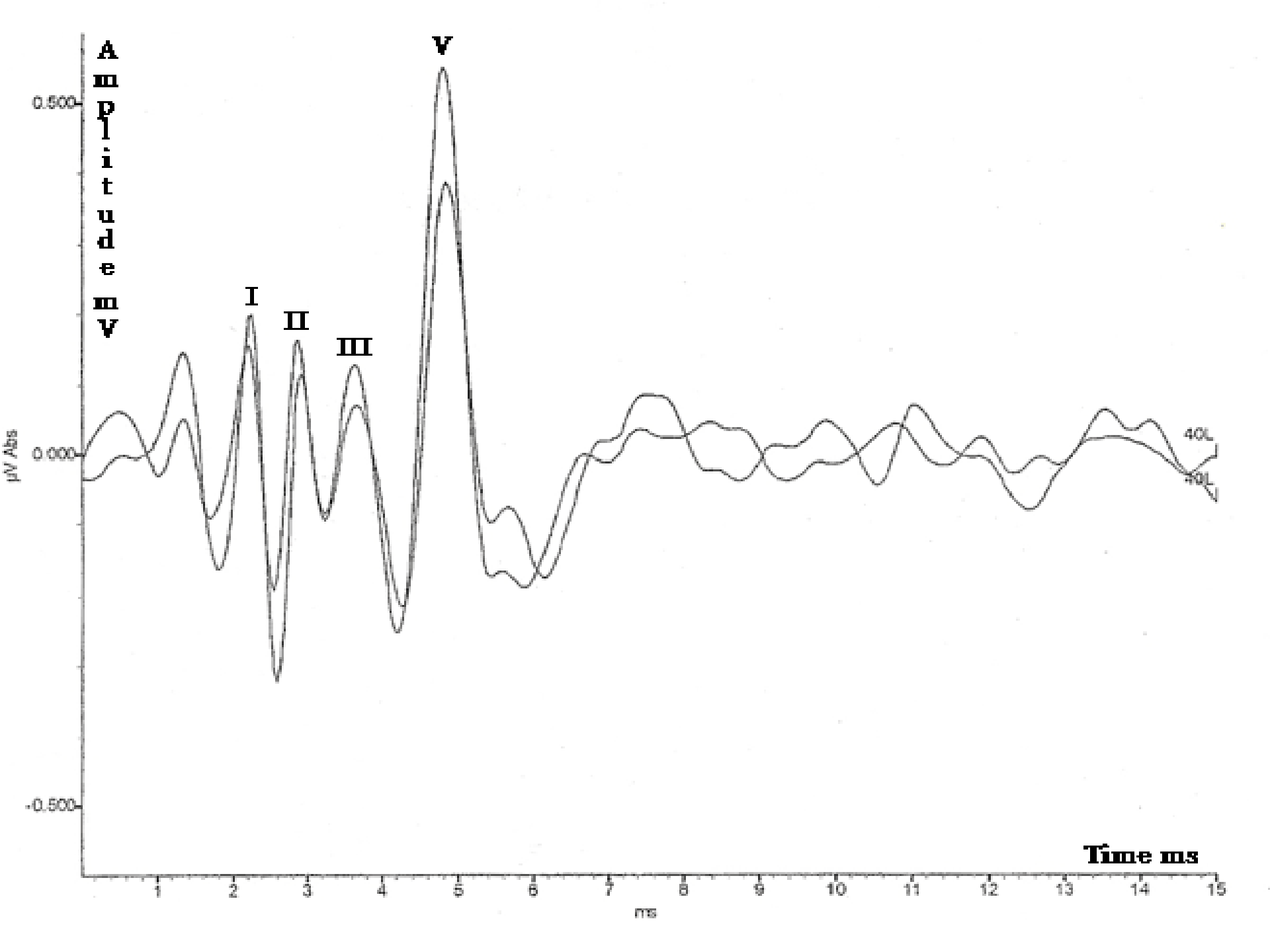
- Not a test of hearing- limited application

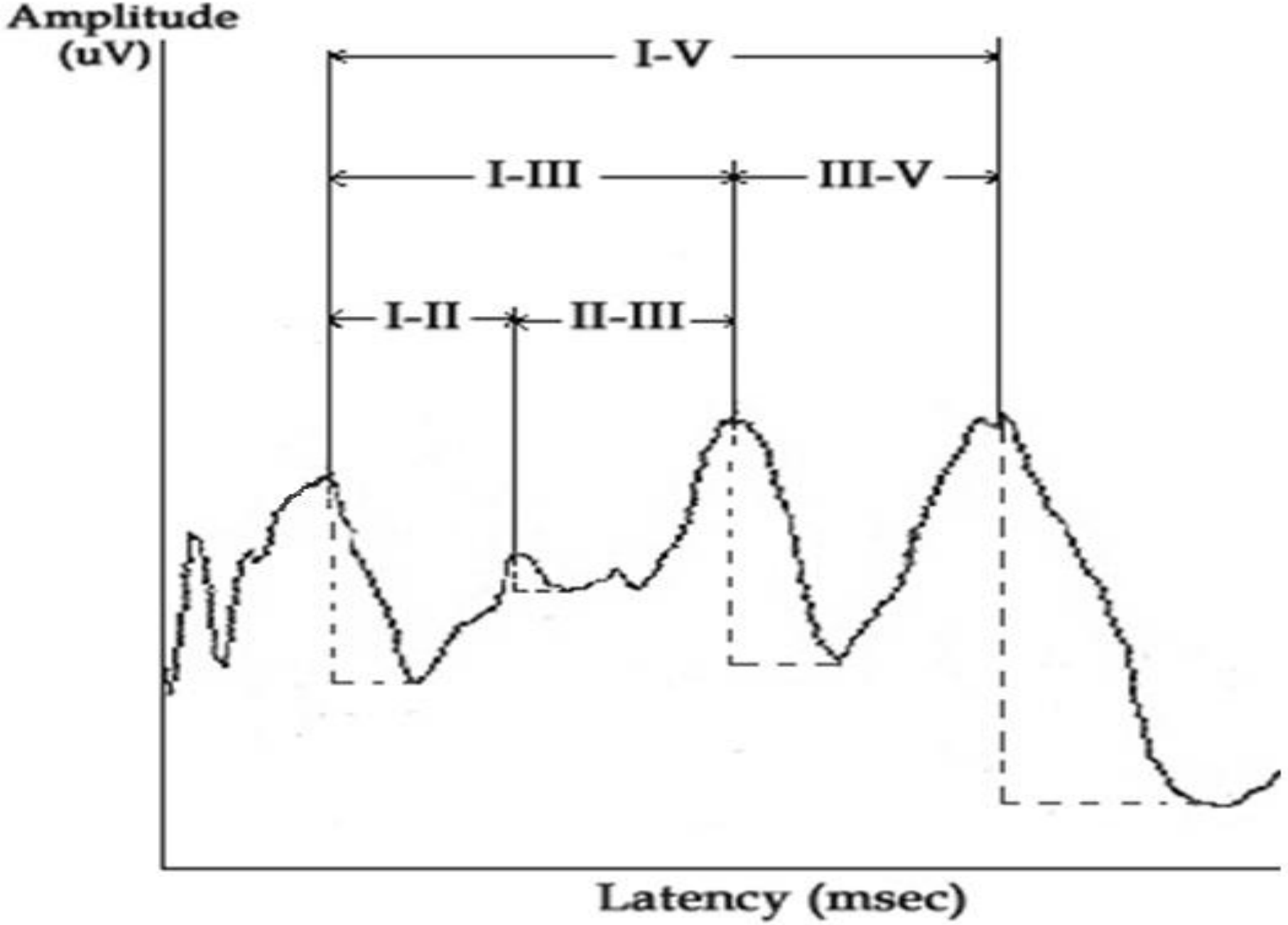
# Clinical applications of ABR

Murad Almomani, Ph.D., CCC-A, FAAA

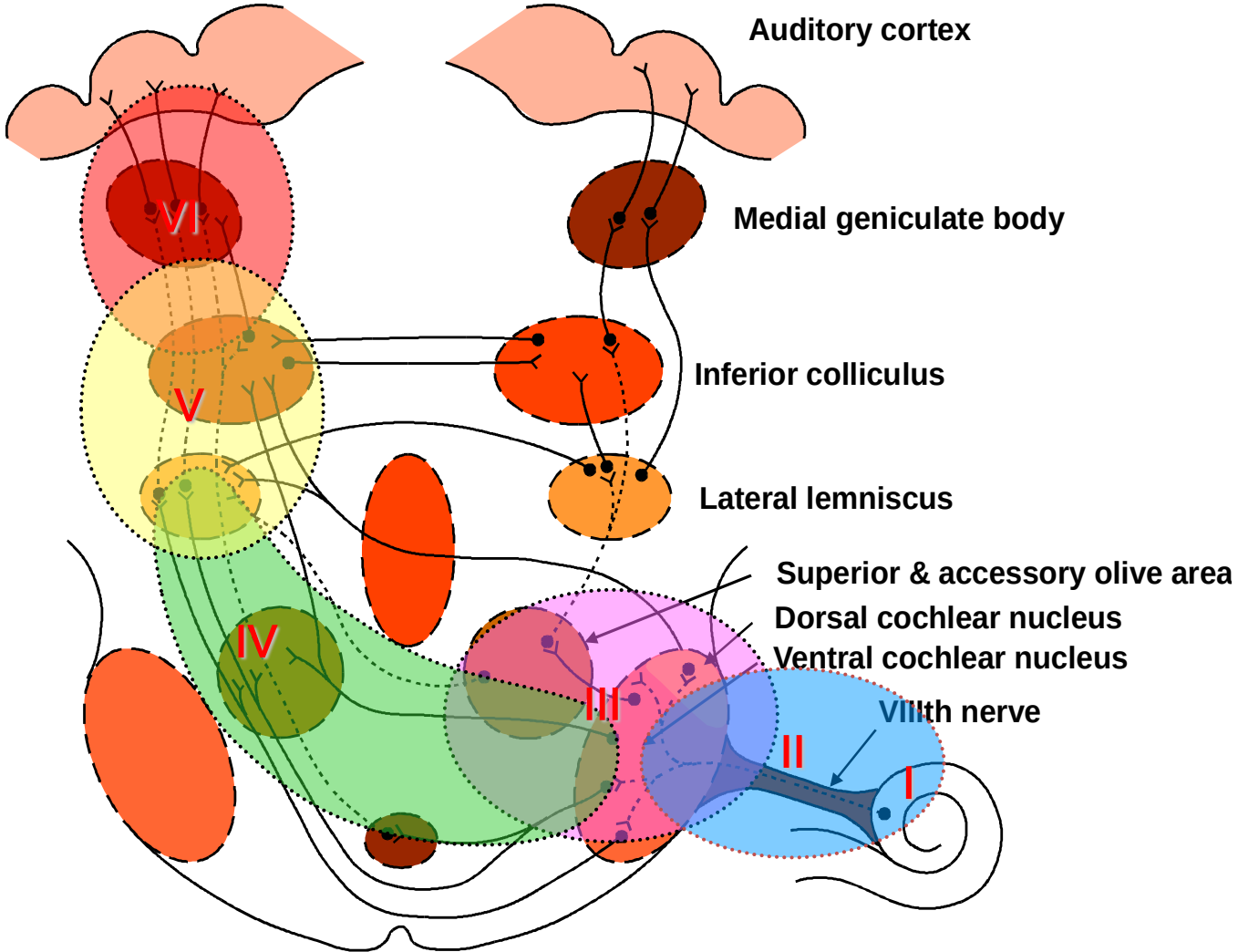
# The normal ABR waveform

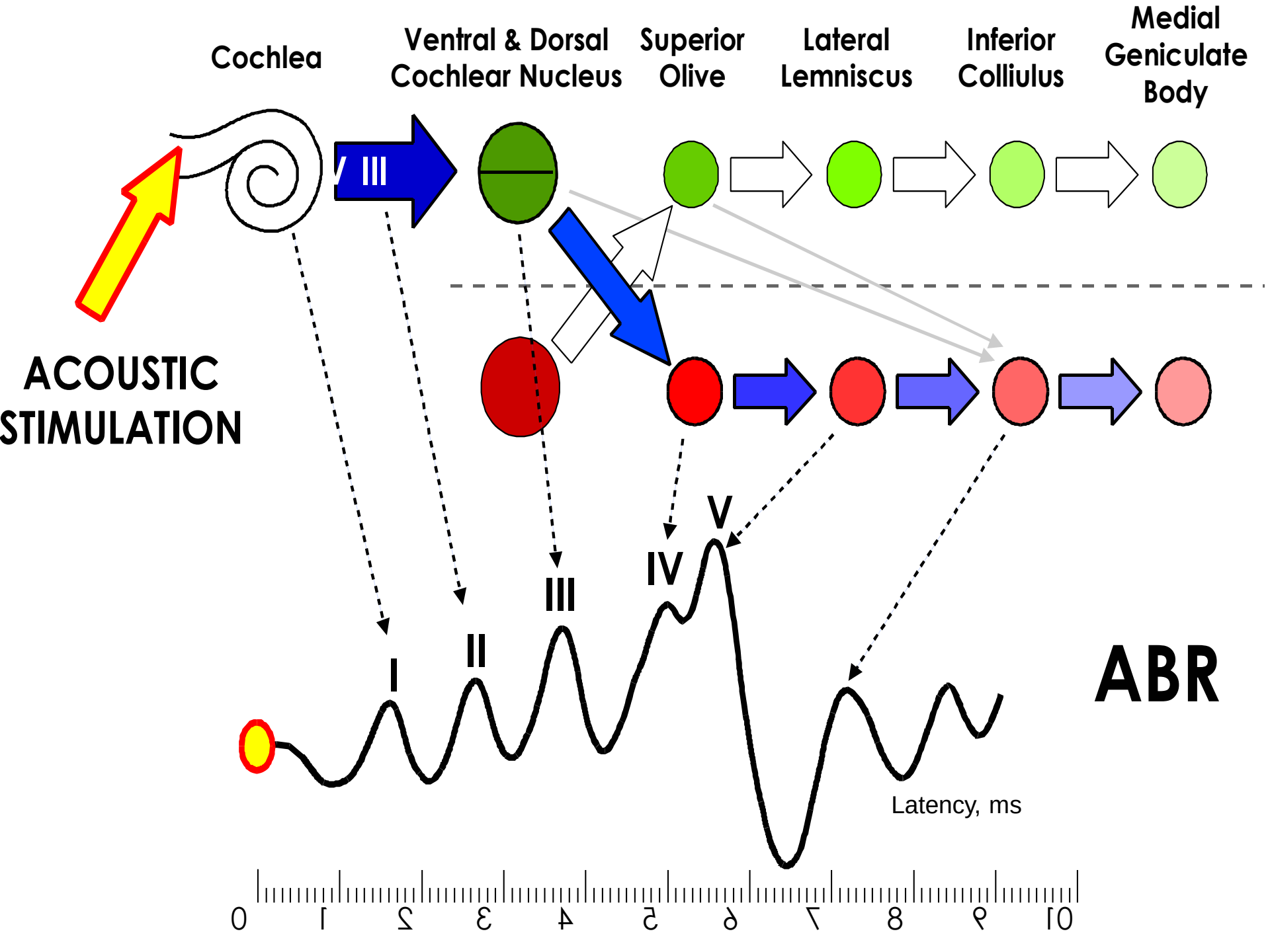
- Is characterized by 5-7 peaks.
- Occurs in a latency epoch of 1.4 – 8.0 ms.
- Responses are usually displayed with positive peaks reflecting neural activity toward the vertex.
- These peaks are labeled with the roman numerals I through XII.
- The most prominent waves are I, III, and V.


Amplitude mV
V
I
II
III
0.500
0.000
-0.500
μV Abs
40L
-40L
Time ms
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
ms


Amplitude
(uV)
I-V
I-III
III-V
I-II
II-III
Latency (msec)

# Generators of the ABR




Cochlea
Ventral & Dorsal Cochlear Nucleus
Superior Olive
Lateral Lemniscus
Inferior Colliulus
Medial Geniculate Body
ACOUSTIC STIMULATION
I
II
III
IV
V
ABR
Latency, ms
0 1 2 3 4 5 6 7 8 9 10

# Characteristics of normal ABR

- Information to determine normal ABR waveform depends on:
  - Waves absolute latency.
  - Waves interpeak intervals.
  - Latency-intensity function.
  - Wave V/I amplitude ratio.
  - Interaural wave V latency difference.

- Research established normal ranges of the above parameters.

# Characteristics of normal ABR

- Normal ranges for the above parameters are not universal.
- There are some variation among different research findings.
- Many factors affects normal values including age, sex, temp and other factors.
- It is always better for each practice to establish its own norms.

# Characteristics of normal ABR

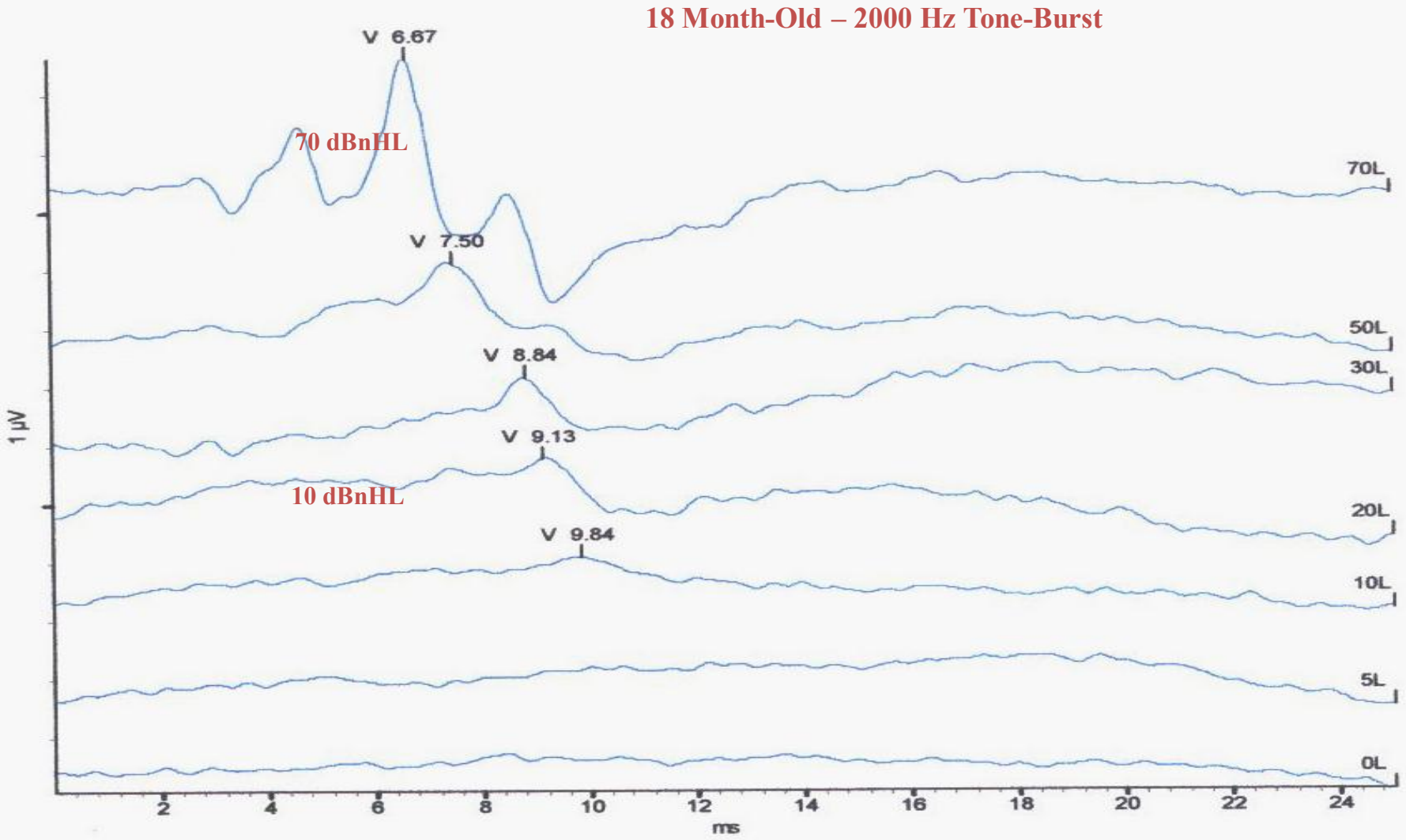
- Absolute latency of ABR waves in adults:
  - Wave I: at around 1.6 ms +/- 0.2 ms.
  - Wave III: at around 3.7 ms +/- 0.2 ms.
  - Wave V: at around 5.6 ms +/- 0.2 ms.

- Interwave latency intervals:
  - I-III: 2.0 ms+/- 0.4 ms.
  - III-V: 1.8 ms +/- 0.4 ms.
  - I-V: 3.8 ms +/- 0.4 ms.

# Characteristics of normal ABR

- Wave V latency-intensity function: increases by around 0.3 ms per 10 dB decrease of the stimulus level.
- V/I amplitude ratio: greater than 1.0.
- Wave V latency difference: less than 0.4 ms.

# Example Normal Hearing



# Clinical applications of ABR

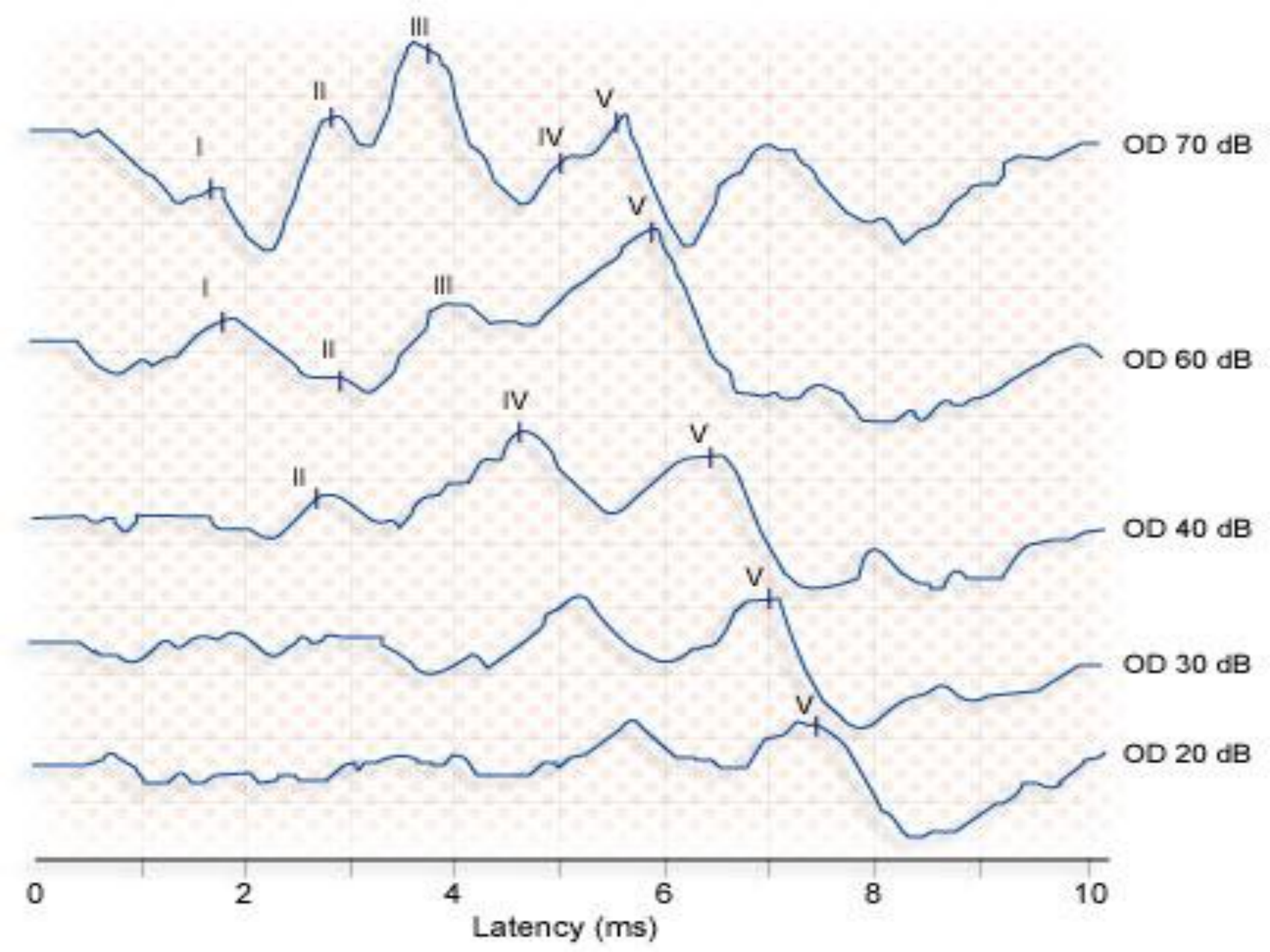
- There are two main applications for ABR in the clinical settings:
  - Neurodiagnosis: to assess the auditory pathway. This feature is specially used in adult populations.
    - Waves absolute latency.
    - Interpeak intervals.
    - Interaural wave V latency difference.
    - Absence of waves.
  - Hearing thresholds estimation: mainly used in infants and children population.
    - Wave V threshold.
    - Wave V latency-intensity function.

# Neurodiagnosis

- Who should be tested? Patients with:
  - Dizziness.
  - Unilateral tinnitus.
  - Asymmetrical hearing loss.
  - Sudden onset of hearing loss.
  - Progressive hearing loss.

# Using ABR to estimate hearing thresholds

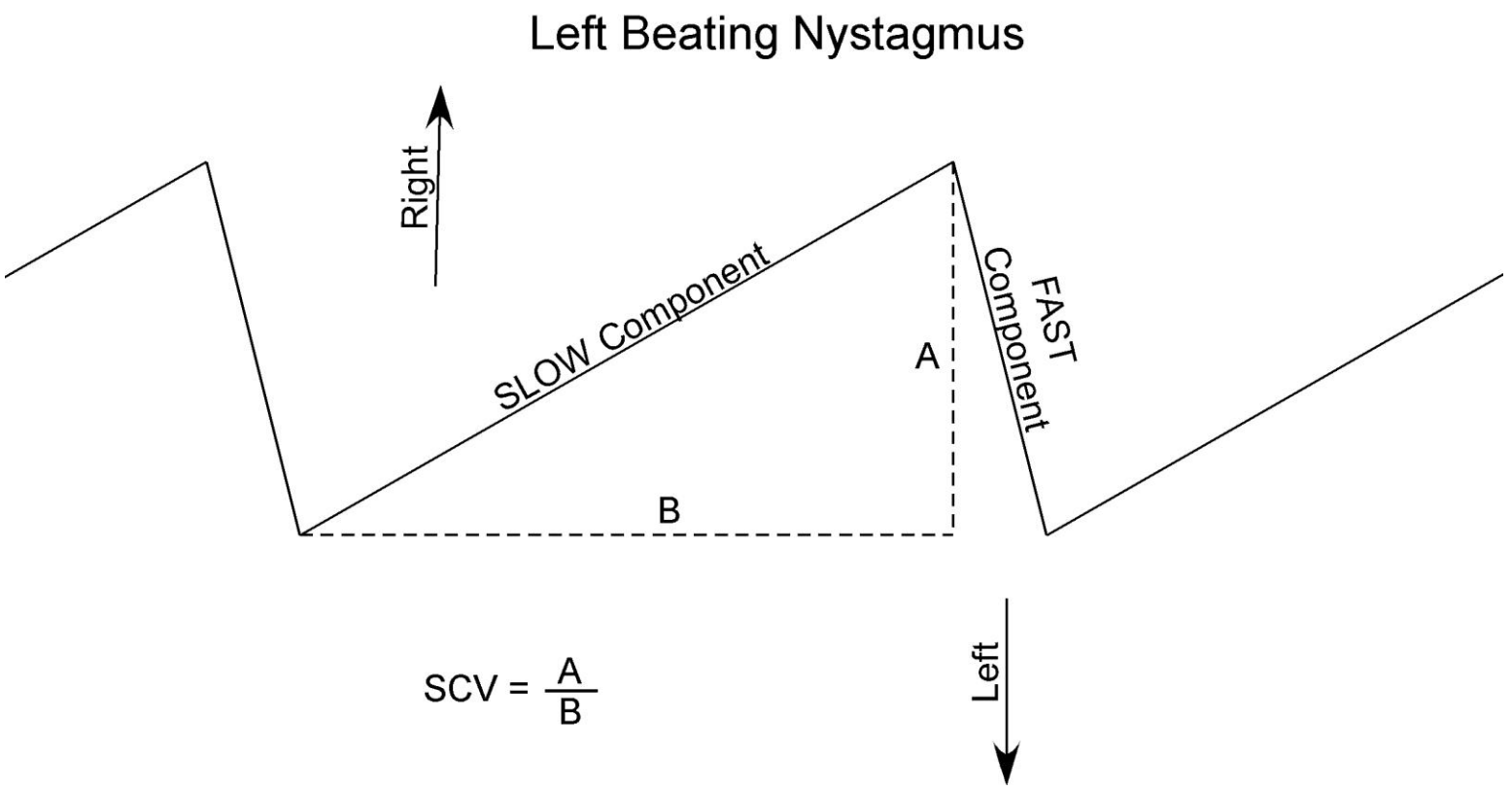
- Can be obtained by progressively decreasing intensity of the stimulus (click or toneburst) and observing wave V.
- The last intensity that wave V appears at is considered its threshold.
- ABR threshold is within 10-20 dB from the subjective threshold.


I
II
III
IV
V
OD 70 dB
I
II
III
V
OD 60 dB
II
IV
V
OD 40 dB
V
OD 30 dB
V
OD 20 dB
0
2
4
6
8
10
Latency (ms)

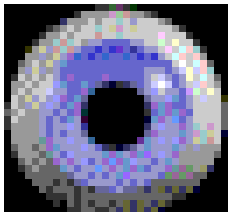
# Eye Movement Recording

- In performing ENG/VNG, the patient eye movements are measured relative to head position, which can be achieved in a number of ways.
- Measuring electric potentials, measuring magnetic potentials, using video cameras or using infrared technology and direct observation.

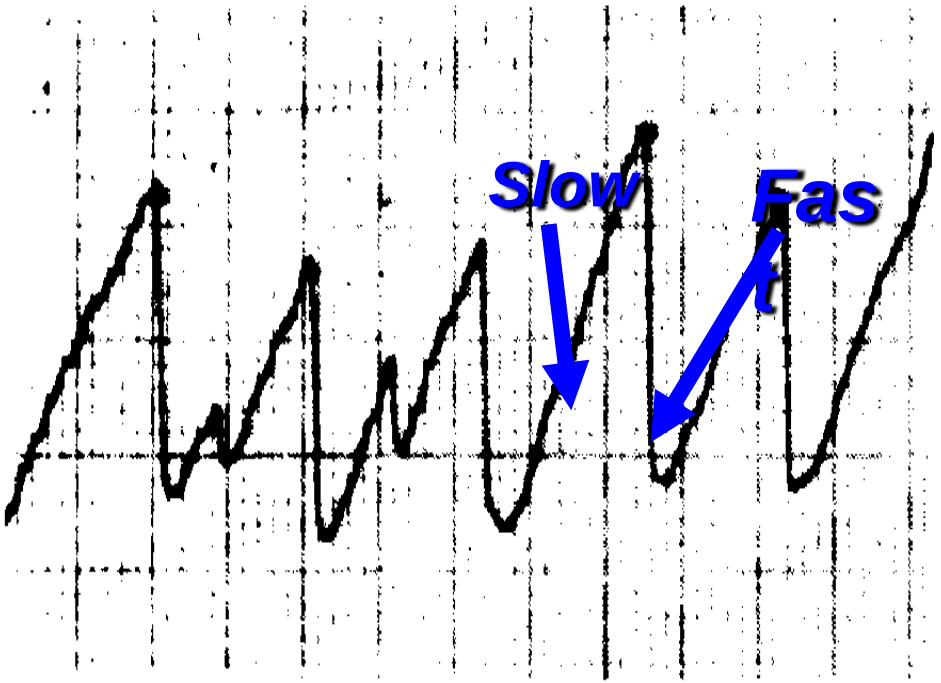
# Nystagmus

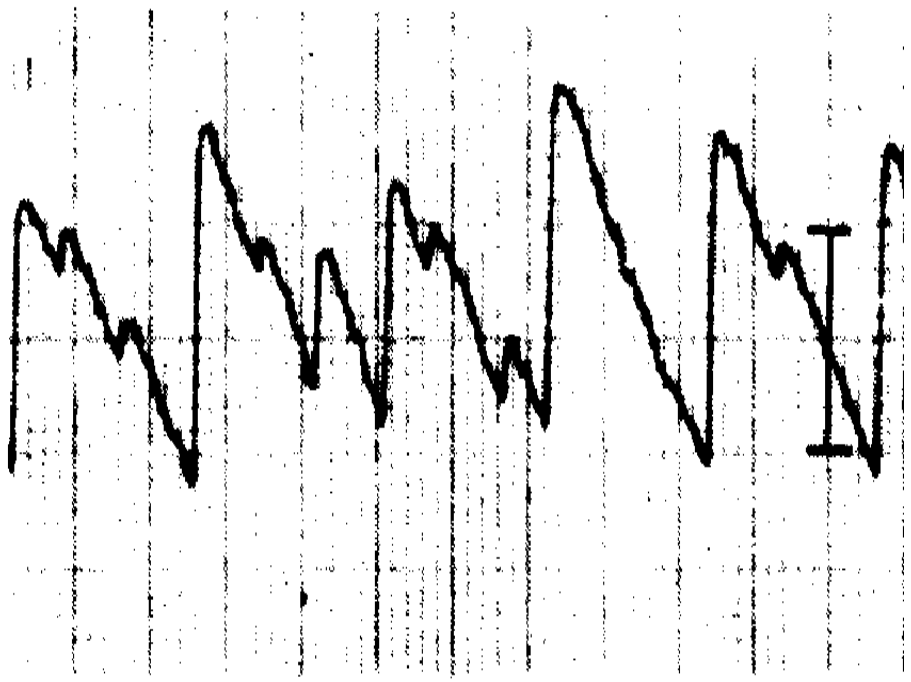

Left Beating Nystagmus
Right
SLOW Component
FAST Component
A
B
Left
SCV = A/B

Left Beating



Right Beating



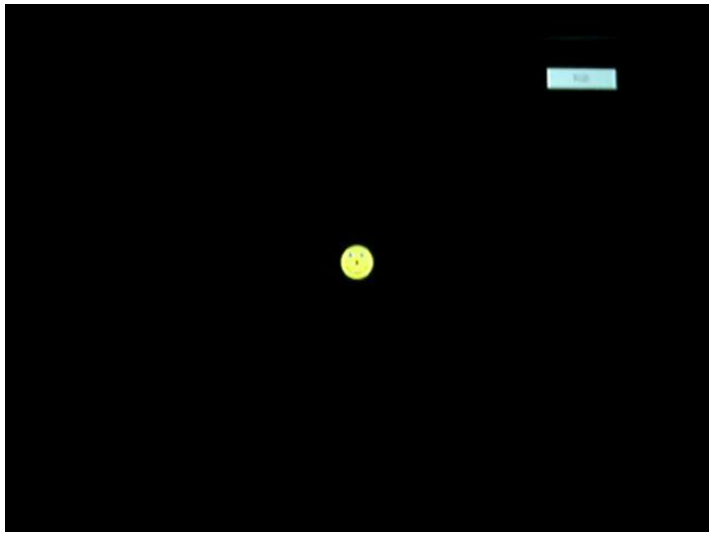



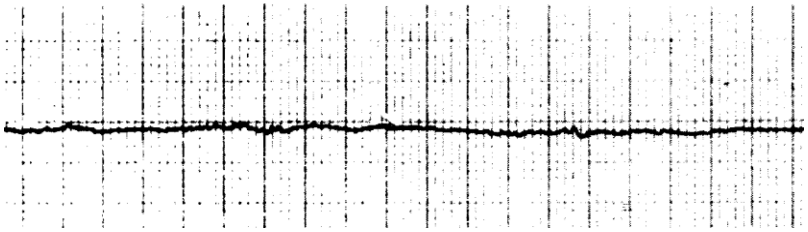
# VNG Test Battery

- Calibration
- Gaze
- Saccade
- Pursuit
- Optokinetic
- Positional
- Hallpike
- Caloric

# Gaze Test

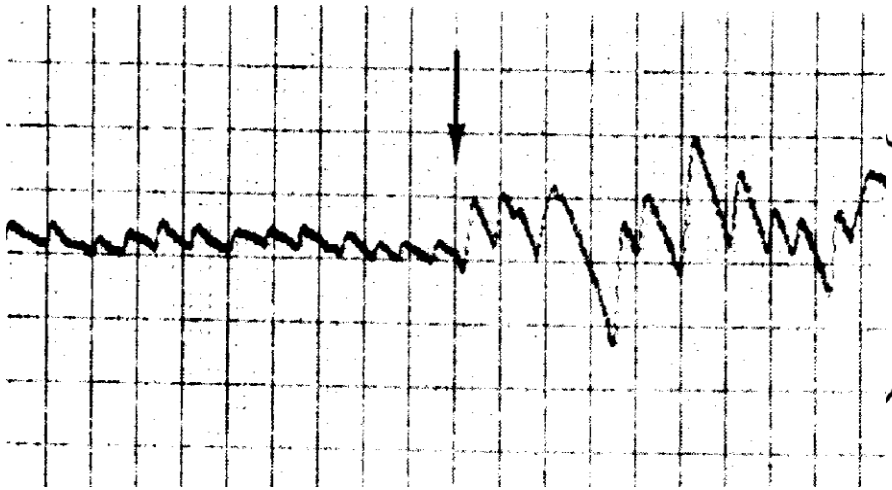
- The function of the gaze system is to maintain visual fixation of an object on the fovea of the eye.
- To identify the presence of spontanoues eye movement.
- Normal gaze, patient able to maintain position with eyes opened and closed.





# Gaze results with peripheral &central lesions

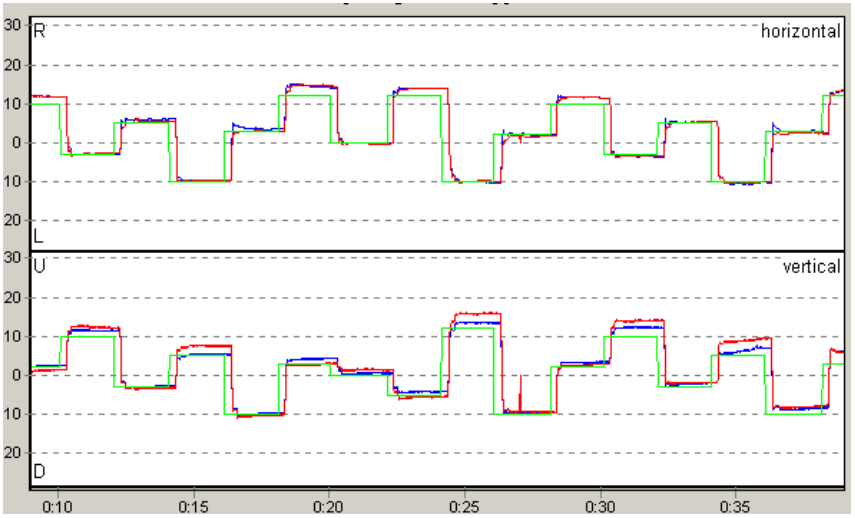
- Horizontal.
  - Horizontal, vertical or rotatory.
- Directional fixed.
  - Directional changing.
- Suppressed with visual fixation.
  - Enhanced with visual fixation.



# Saccade (refixation ) Test.

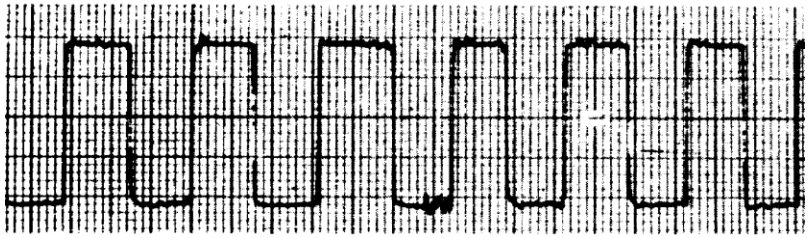
- The function of saccadic eye movement system is to redirect the eye from one target to another in the shortest possible time.
- Inaccurate eye movement, where the eye either undershot or overshot the target is abnormal and seen frequently in patients with cerebellar dysfunction.

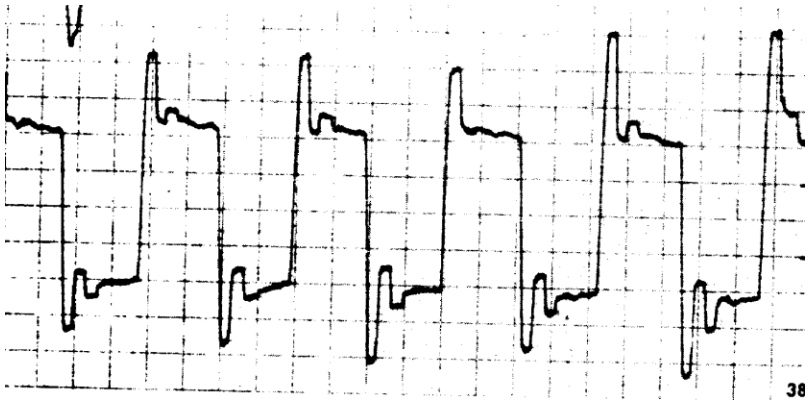
# Saccade Test



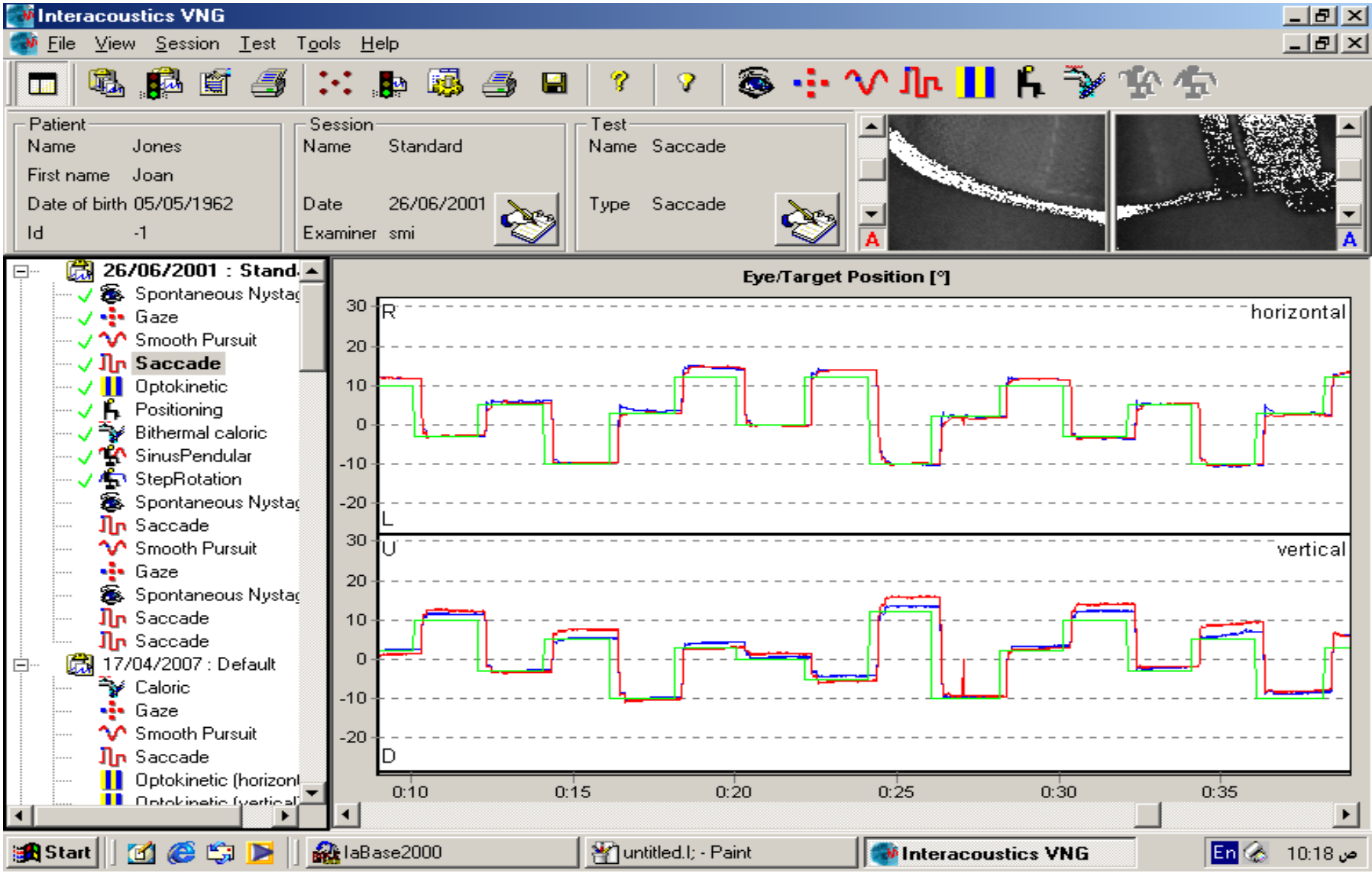
# Results:

- Normal saccadic eye movement test should produce rapid and accurate eye movement.
- Inaccurate eye movement, where the eyes overshot or undershot the target .



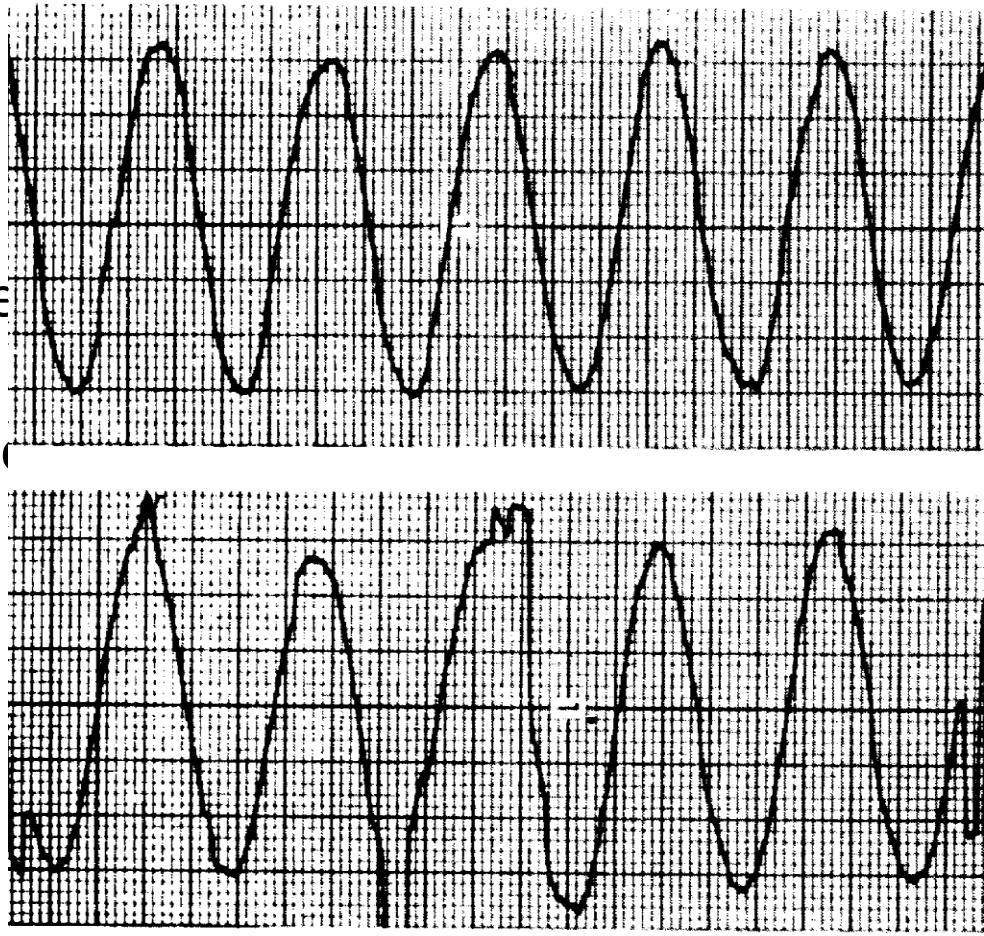


# Saccade

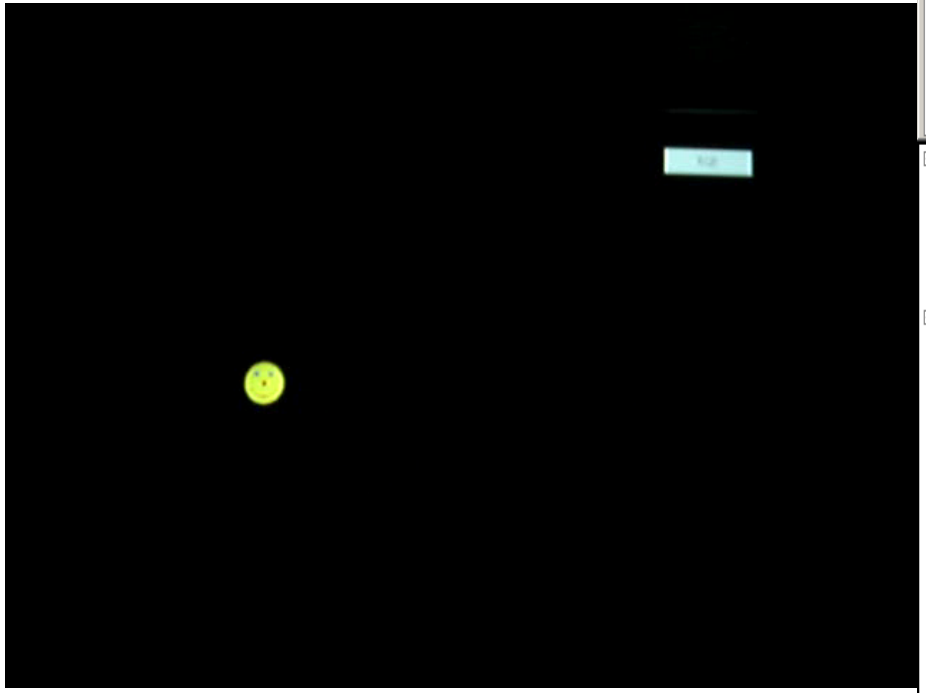

Interacoustics VNG
File View Session Test Tools Help
Patient
Name Jones
First name Joan
Date of birth 05/05/1962
Id -1
Session
Name Standard
Date 26/06/2001
Examiner smi
Test
Name Saccade
Type Saccade
26/06/2001 : Stand
Spontaneous Nystag
Gaze
Smooth Pursuit
Saccade
Optokinetic
Positioning
Bithermal caloric
SinusPendular
StepRotation
Spontaneous Nystag
Saccade
Smooth Pursuit
Gaze
Spontaneous Nystag
Saccade
Saccade
17/04/2007 : Default
Caloric
Gaze
Smooth Pursuit
Saccade
Optokinetic (horizont
Eye/Target Position [°]
horizontal
vertical
R
L
U
D
30
20
10
0
-10
-20
0:10
0:15
0:20
0:25
0:30
0:35
Start
laBase2000
untitled.I; - Paint
Interacoustics VNG
En
10:18 ص

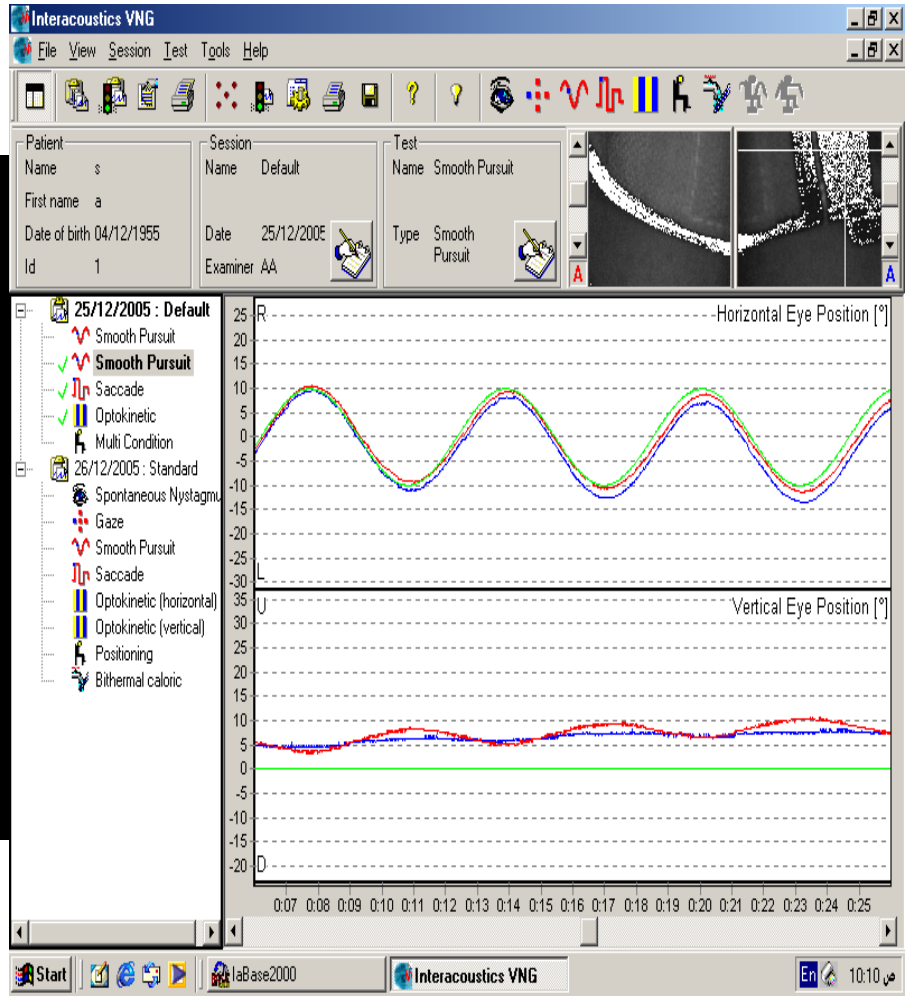
# Ocular Pursuit Test

- The function of ocular pursuit system is to stabilize a slowly moving object on the fovea of the eye by matching the angular velocity of the eye with that of the moving object.



# Pursuit Test

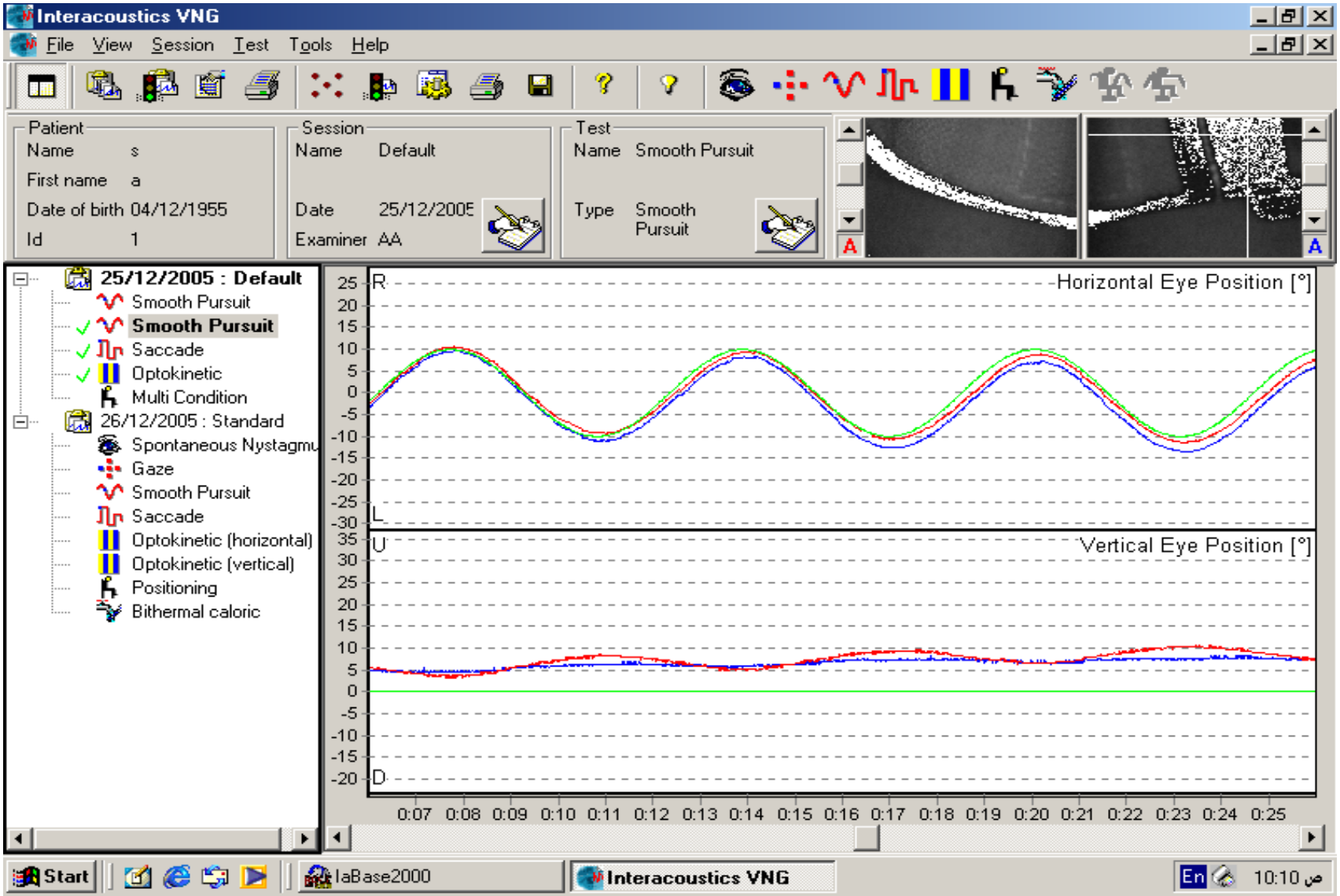




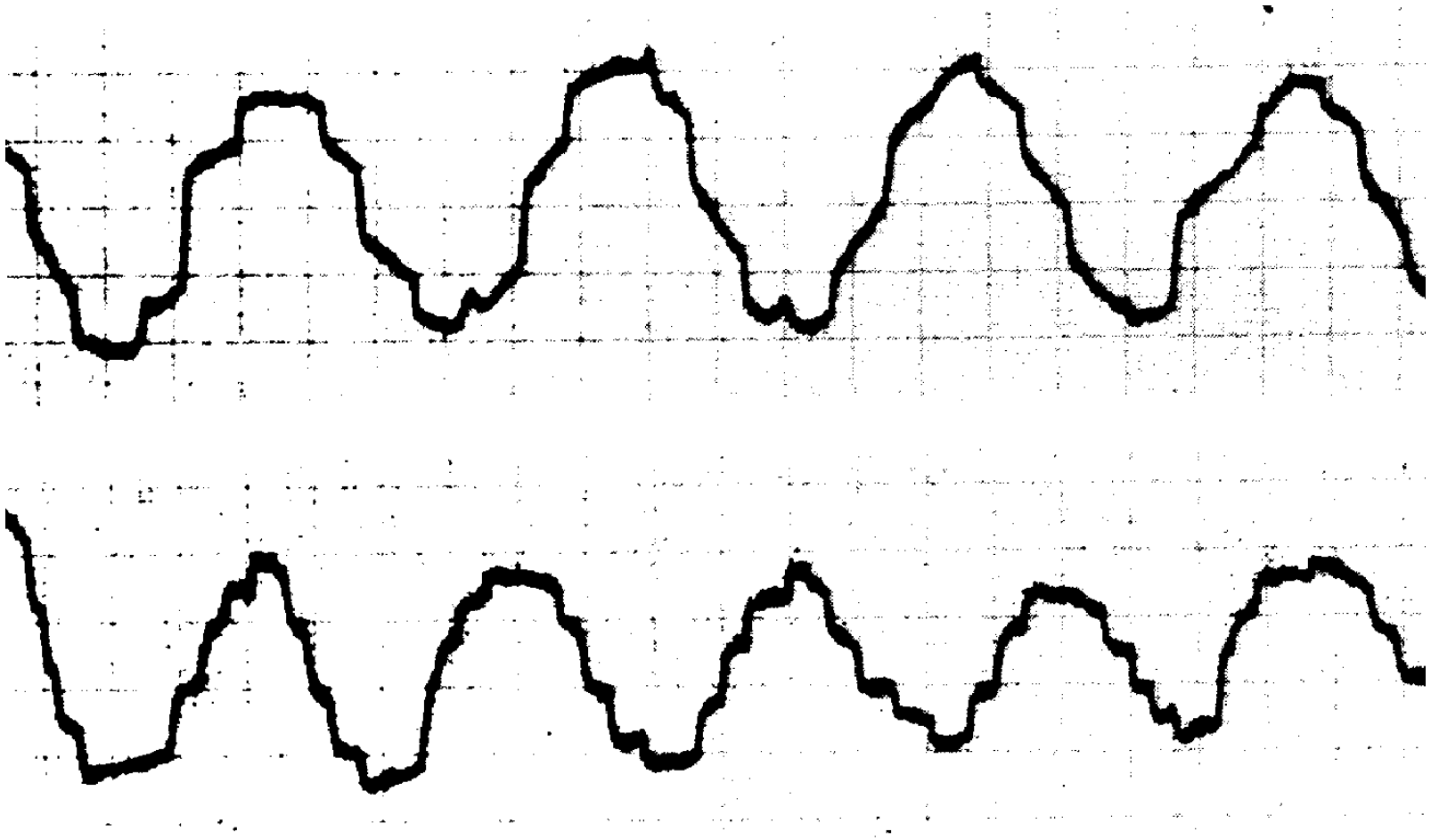
# Results:

- When the pursuit system is impaired, small corrective saccadic movements replace the smooth pursuit movement, so the eye can catch up the moving target.
- It may be the most sensitive subtest in ENG battery for detection of brainstem and cerebellar disorders.

# Pursuit


Interacoustics VNG
File View Session Test Tools Help
Patient
Name s
First name a
Date of birth 04/12/1955
Id 1
Session
Name Default
Date 25/12/2005
Examiner AA
Test
Name Smooth Pursuit
Type Smooth Pursuit
25/12/2005 : Default
Smooth Pursuit
Smooth Pursuit
Saccade
Optokinetic
Multi Condition
26/12/2005 : Standard
Spontaneous Nystagmu
Gaze
Smooth Pursuit
Saccade
Optokinetic (horizontal)
Optokinetic (vertical)
Positioning
Bithermal caloric
Horizontal Eye Position [°]
Vertical Eye Position [°]
R
L
U
D
0:07 0:08 0:09 0:10 0:11 0:12 0:13 0:14 0:15 0:16 0:17 0:18 0:19 0:20 0:21 0:22 0:23 0:24 0:25
Start
IaBase2000
Interacoustics VNG
10:10

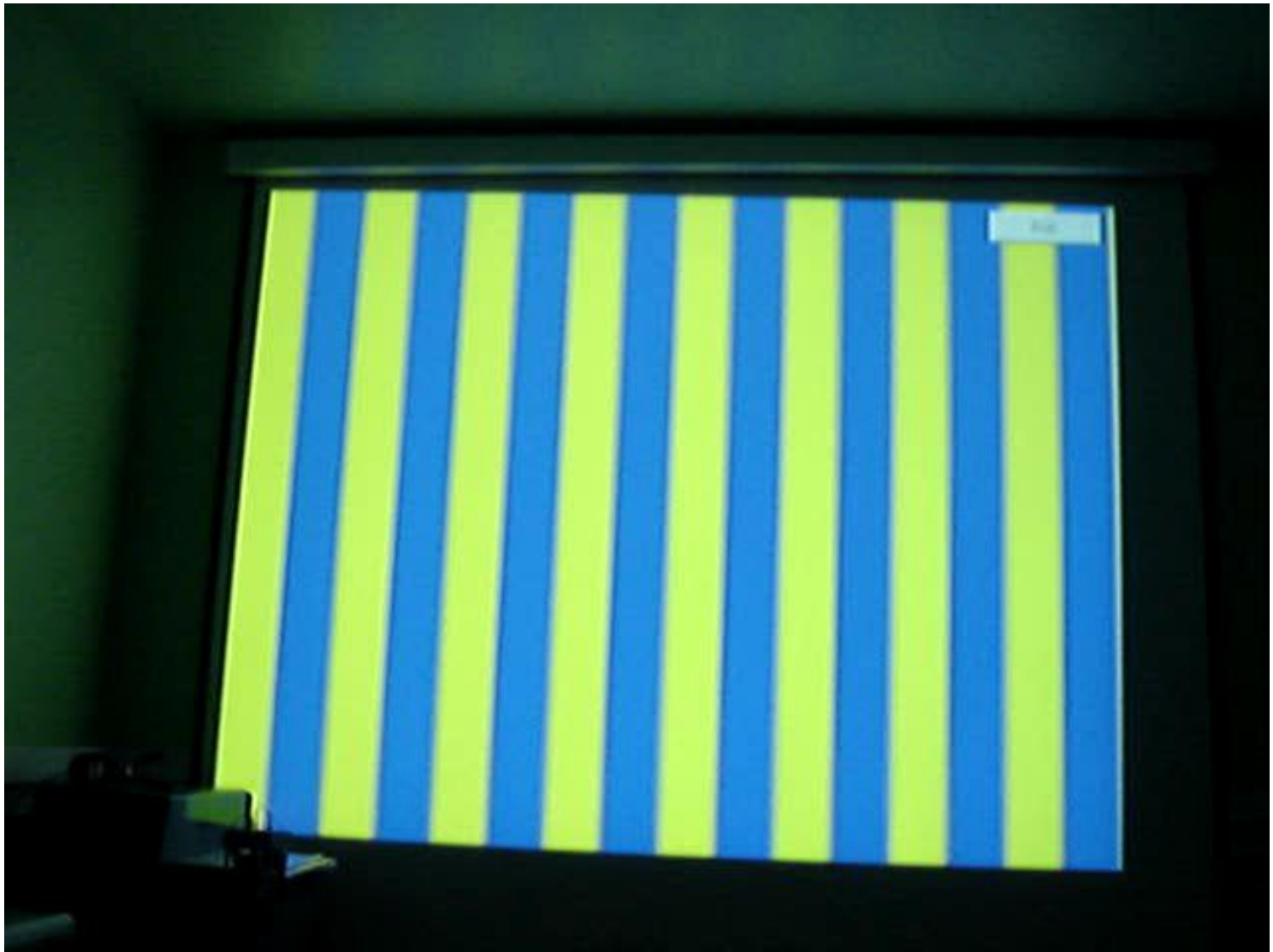
# Abnormal Pursuit



# Optokinetic Test

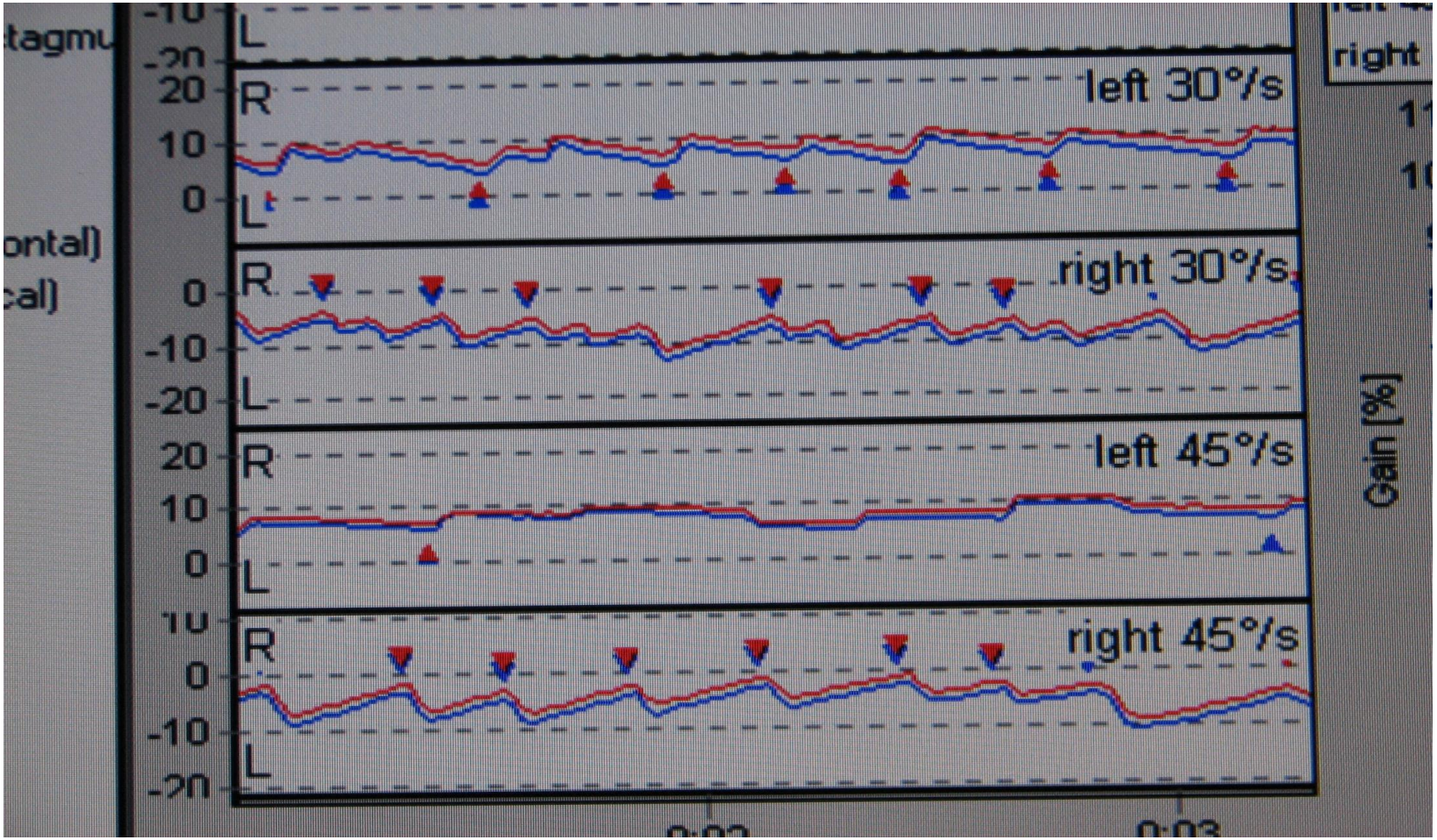
- Optokinetic system maintain visual fixation when the head is in motion.
- Target is rapidly passed in front of the subject in one direction, then the other.
- Eye movements are recorded and compared in each direction.
- Asymmetry suggestive of central lesion

# Optokinetic



# Optokinetic

# Optokinetic



# Dynamic Positional Test ( Hallpike )

- The patient complains a motion related vertigo at certain position
- It is maneuver that places the patient head in the position that creates the response.
- Criteria: Latency period, subjective vertigo, Transient nystagmus, fatigable, lesion in the undermost ear,

# Dix Hallpike maneuver

- Used to provoke nystagmus and vertigo commonly associated with BPPV.
- Head turned 45 degree to maximally stimulate posterior semicircular canal.
- Head supported and rapidly placed into head hanging position.
- Frenzel glasses eliminate visual fixation suppression of response or can be tested Using VNG.

# Dix Hallpike Maneuver

# Caloric Test

# Caloric Tests

- Caloric test is a part of ENG/VNG.
- It reflects an attempt to discover the degree to which the vestibular system is responsive and also how symmetric the responses are, between left and right.
- It is a test of the lateral semicircular canals.
- Most caloric tests are nowadays are done using computerized systems, the computer analyzes the caloric data, computing peak slow-phase velocity.

# Caloric Test

# Caloric Test (Procedure )

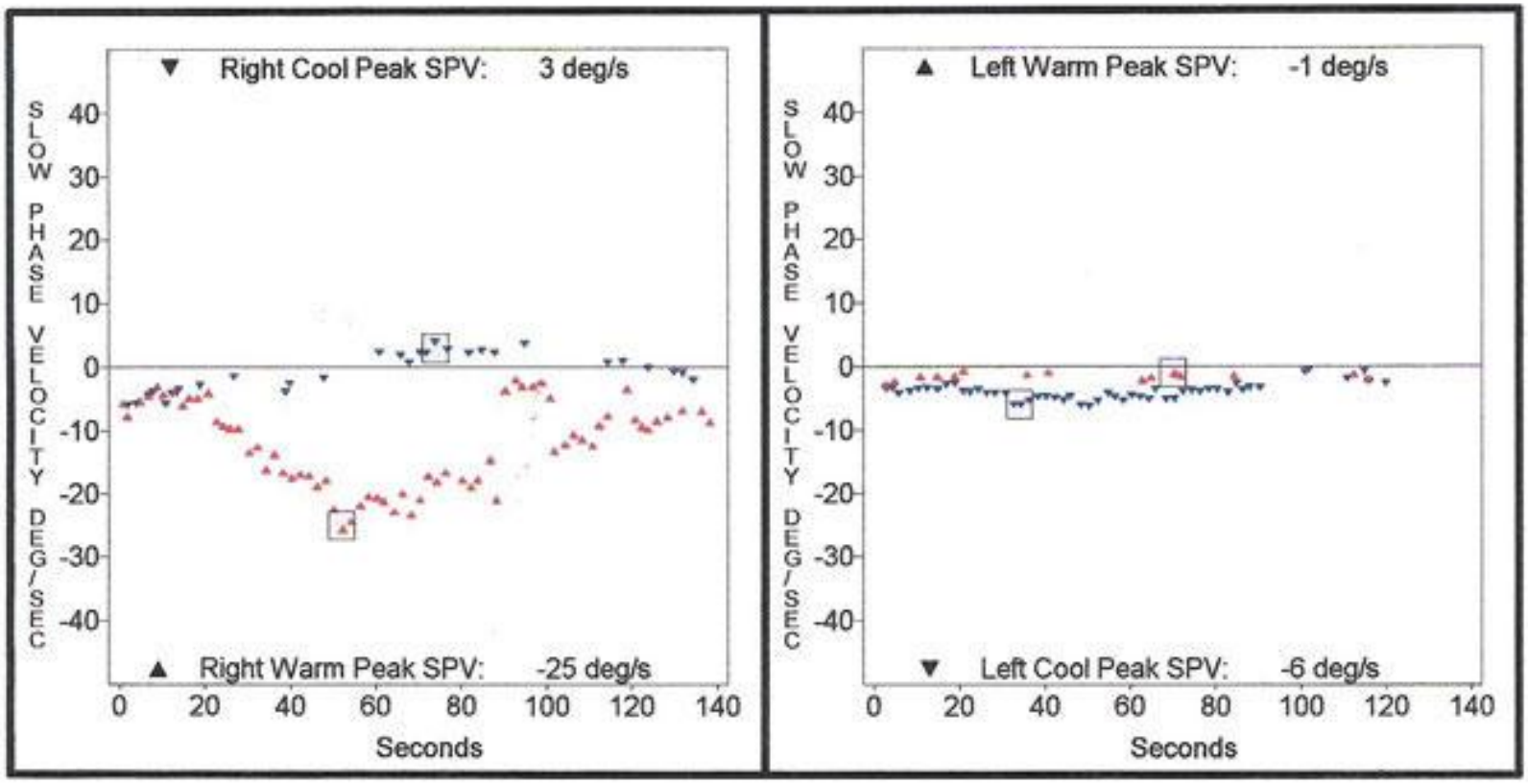
- Irrigations of EEC performed with cold and warm water or air.
- Water - cool = 30 C; warm = 44 C
- Air - cool = 24 C; warm = 50 C
- Response pattern follows the form of COWS
- Nystagmus induced results are calculated to obtain *Unilateral Weakness* and *Directional Preponderance*

# Caloric Test

# Caloric Test

Patient Name: Patient ID: Session Date: 27/08/05

## Caloric - Both Eyes

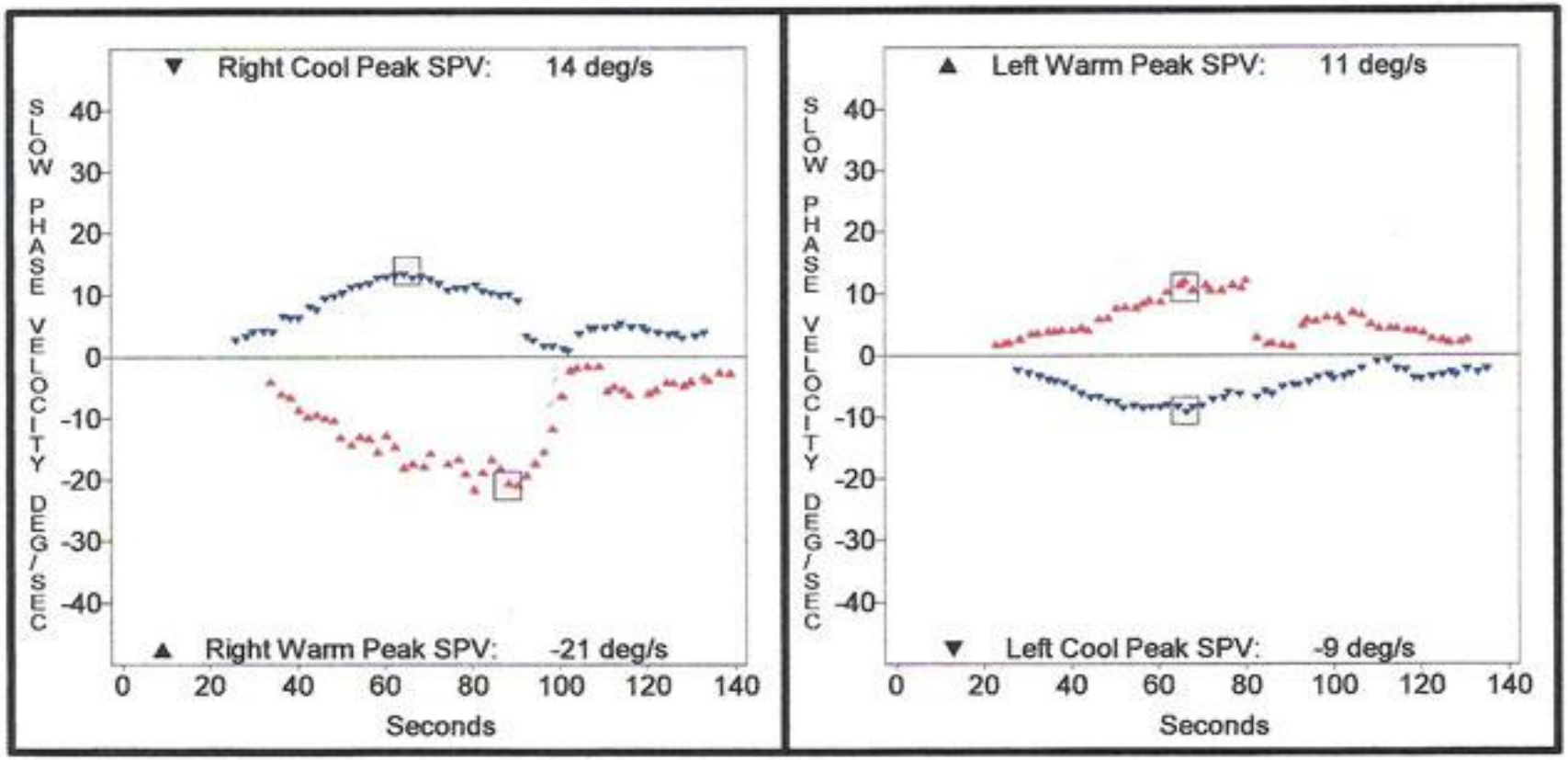



Caloric Weakness: 70% in the left ear
Directional Preponderance: 88% to the right

# Caloric Test

Patient Name: Patient ID: Session Date: 22/07/06

## Caloric - Both Eyes




Caloric Weakness: 27% in the left ear
Directional Preponderance: 9% to the right