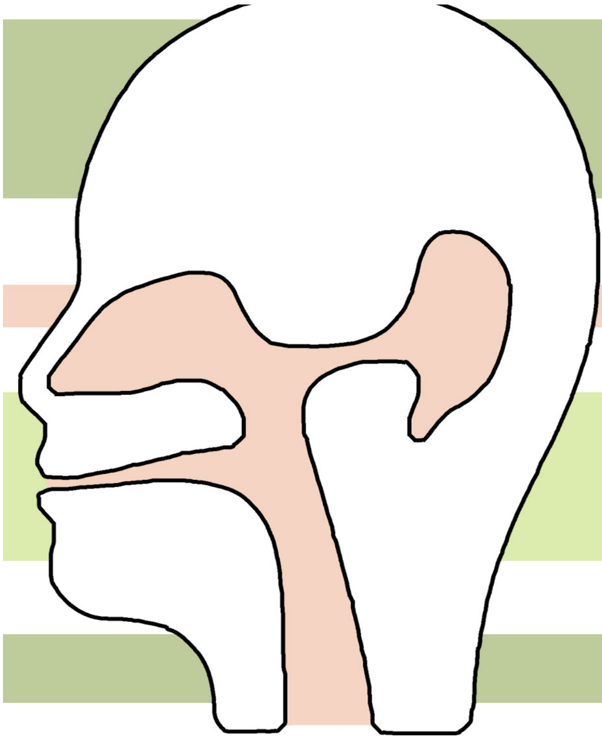


EAR, NOSE AND THROAT

(2) Audiology

Leader: Maha Allhaidan

Done by: Amal Alsinan and Maha Allhaidan

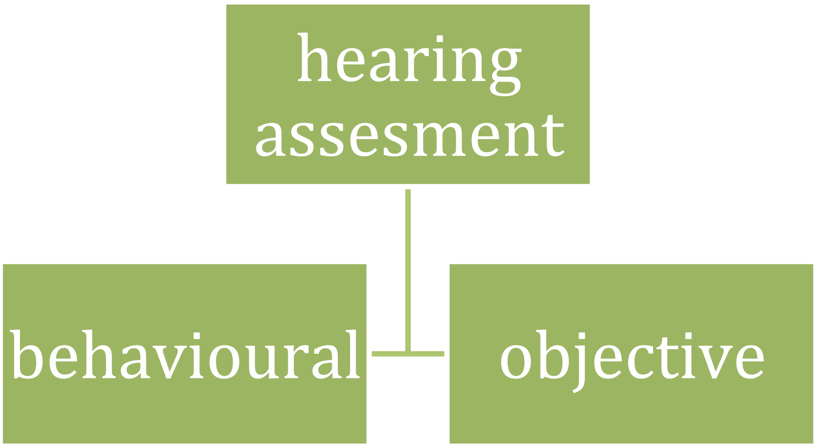
Revised by: Alanoud Alyousef

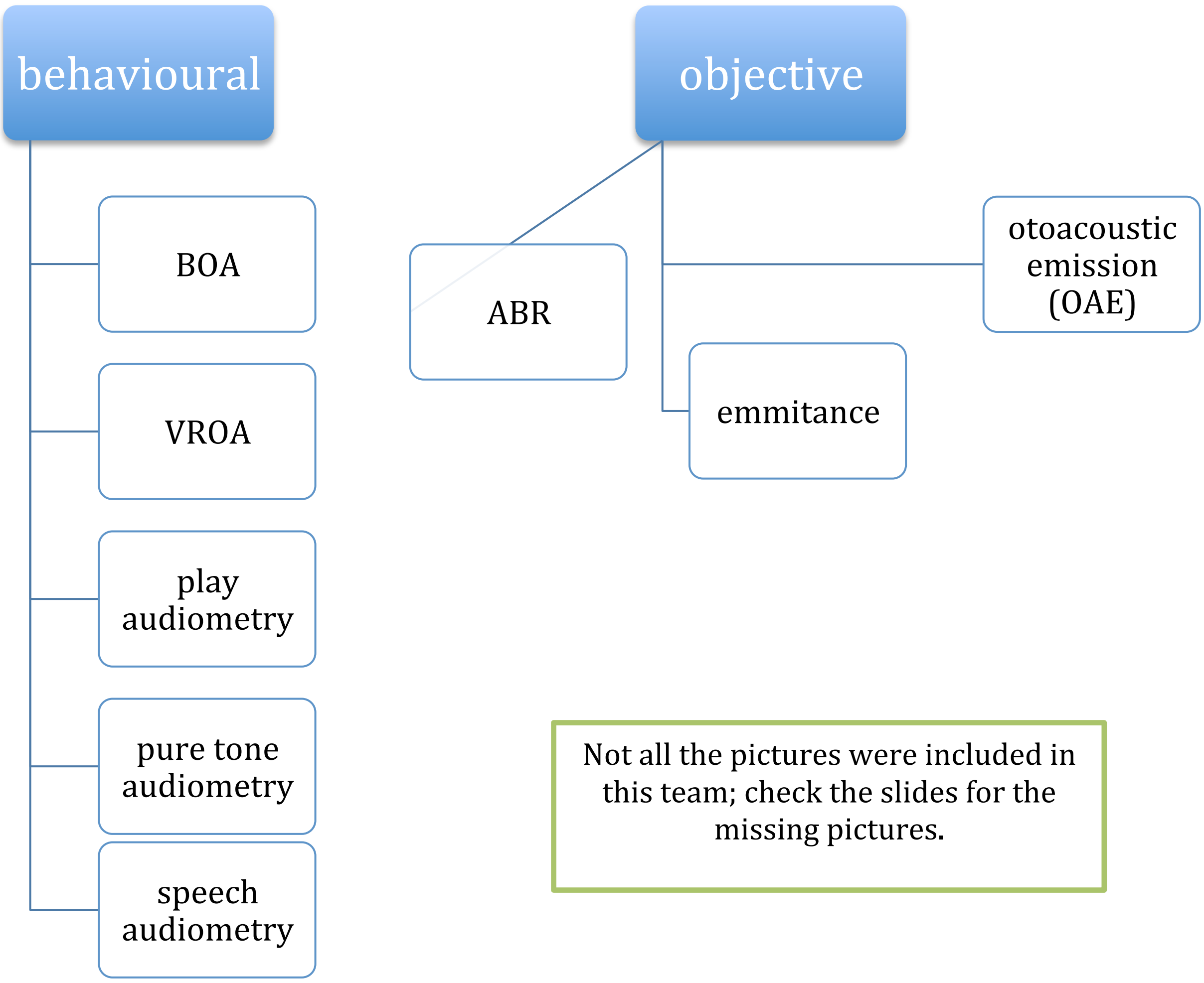
Doctor's note Team's note Not important Important 431 teamwork

(431 teamwork do not highlight it in yellow, but put it in a yellow "box")

Objectives:

Not given

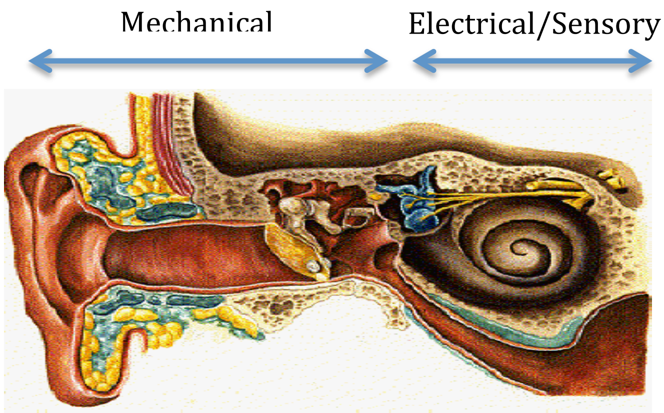




Not all the pictures were included in this team; check the slides for the missing pictures.

Audiology

Audiology: The study of sound and hearing
Sound: The physical stimulus that evoke sensation of hearing.
Audiometry: The measurement of hearing sensitivity.

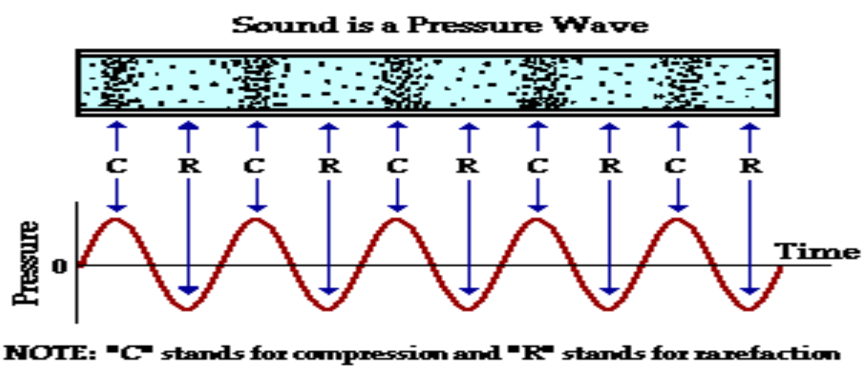


The nature of sound hearing goes through the 3 parts of the ear:
External/middle ear >> conductive hearing
Internal ear >> sensory hearing

Wave: is a series of condensations and refractions.

Sound:
Is a form of vibration.
Vibration:
Is the to-and-fro motion of an object (guitar string, vocal folds, and diaphragm on an earphone or loudspeaker, tuning fork).
For sound to occur, must have:

- **SOURCE**: Something has to be disturbed.
- **FORCE**: Something has to disturb it.
- **MEDIUM** (e.g. air): Something has to carry the disturbances.



CYCLE:
One complete period of compression and rarefaction of a sound wave.

PERIOD:
The amount of time that it takes to complete one vibratory cycle.

Characteristics of the waveform (amplitude x time)

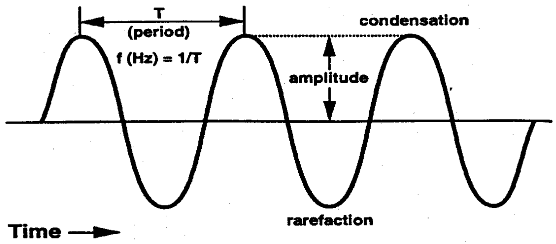
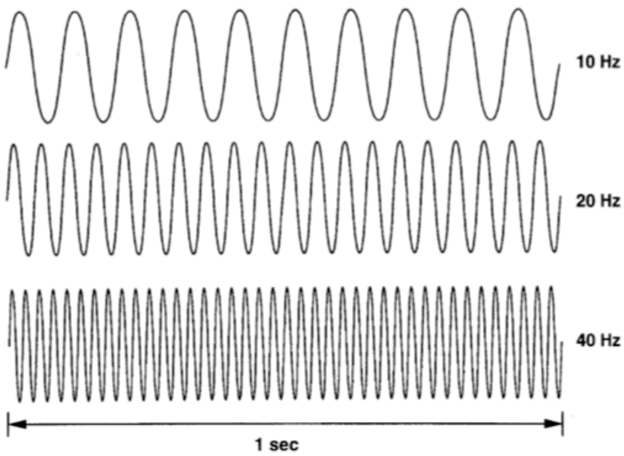


Figure 2-5. A sinusoidal waveform, describing the various properties of sound, including amplitude and frequency (f).

Frequency: The number of cycles that occur in one second (cycle/sec).
Pitch: Psychological percept of frequency.
e.g., low frequency sounds = low pitch
Psychoacoustic >> is the perception of sound from human beings points of view (how people differentiate the sounds, e.g. the sound of your mother from your sister)
Hertz (Hz): Unit of measurement of frequency.
100 cycles per second = 100 Hz



Different frequencies in one second

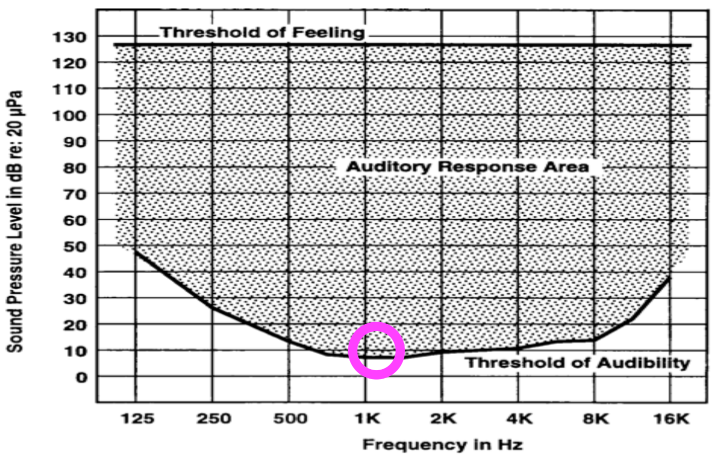
Humans:

20 Hz to 20 kHz. (20-20000HZ)

- Below 20 Hz, we feel a vibration rather than hear a sound. Most of the common sounds that humans hear are from (500-8000HZ)
- Most people have very diminished sensitivity for frequencies > 8000-10, 000 Hz.

Bats (auditory specialists): 2 kHz-100 kHz.

The Minimal Audible Pressure Curve (dB SPL):



- **Threshold of feeling** (above the normal limit): result in vibration of objects. IT'S NOT A HEARING IT'S A FEELING
- **Threshold of audibility**: the lowest intensity that can be detected by hearing.

Indicates the minimum average sound pressure levels by frequency for a group of people with normal hearing

(Zero is a value it doesn't mean that there is no sound here)

Amplitude/ intensity:

The quantity or magnitude of sound.

Decibel (dB):

Unit of amplitude used most frequently in clinical audiology. (Unit of intensity)

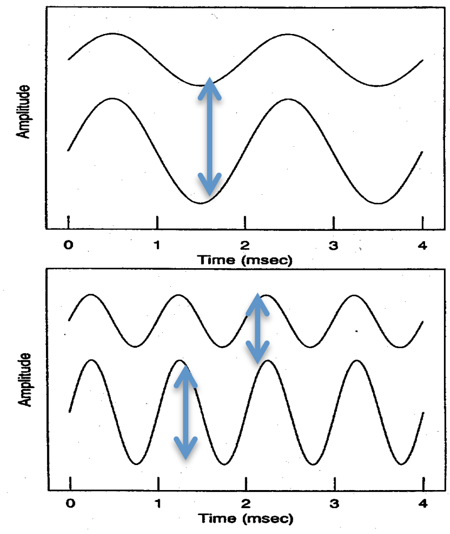
Loudness:

The psychological correlate of amplitude (measured in sones, phons).

Sones and phons: it's a unit of loudness.

High intensity >> damage the ear cells

When the intensity so high it will affect the area around the ear and you'll feel like a vibration.



The arrows represent different magnitudes/intensitie

Hearing loss prevention:

- Noise controls, hearing protectors
  - Primary prevention ➔ reduction or elimination of HL (HL= hearing loss)
- Screening neonates, school age, elderly, industrial
  - Secondary prevention ➔ early identification to reduce negative effect of HL
- Audiology services (hearing aids, rehab)
  - Tertiary prevention ➔ services to deal with adverse effects of HL

Type of Tests (Age based hearing assessment)

1. BEHAVIOURAL:

(e.g. ask him a question and he gives you an answer)

- Reliable & consistent response to sound
- Developmental age
- Not used in newborn screening

2. OBJECTIVE:

- No voluntary response
- Infants and young children
- Non compliant subjects
- People with developmental level that doesn't allow other testing.

Behavioral:	Objective:
PURE TONE AUDIOMERTY **PLAY AUDIOMETRY** **VROA** **BOA**	**Measure responses**

I. BEHAVIOURAL:

A) Behavioural Observation Audiometry (BOA):

Observing changes in behaviour in response to sounds

Who? Very young babies (under 6mths corrected) or with similar functional age.

Test sounds & materials

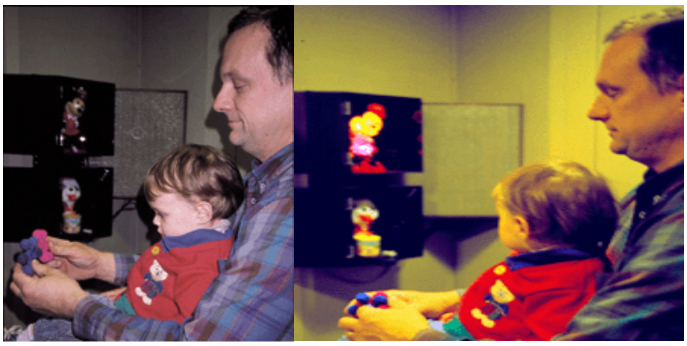
- Calibrated (known frequency and intensity) noisemakers
- Audiologist records sound level (from sound level meter), sound type & observed response- observer determines whether response is present/absent

For Infants 7 months-3 years:

- Typically used behavioral techniques:
  - **Visual Reinforcement Orientation Audiometry** (VROA) for 6-18 months
  - **Play audiometry**
- Aim: to detect hearing impairment greater than 20-30 dB HL
- May incorporate objective testing if non-compliant or very difficult to test

B) Visual Reinforcement Orientation Audiometry (VROA):

  - Uses operant conditioned response and visual reinforcement
- Response typically head turn. Eye turn also possible
- Complex visual reinforcement usually lighted puppet theatre-color movement and light are important



C) Play audiometry (skipped by the doctor)**:** For kids from 3-9 years

- **Before testing**
  - Subjective check of audiometer
  - Check test environment, audibility of tones
  - Avoid visual clues
  - Instruct client, demonstrate procedure
  - Position headphones
  - Present orienting tone (40dBHL) and check client's response. Re-instruct if necessary

Screening:

- Use pegboard, blocks etc.
  - If very young get parents to train child at home
- Headphones on desk present 100dB tone
- Train child without headphones- Stimulus -Response
- Introduce headphones
- Present 40dB HL tone with headphones on. Repeat
- Decrease tone to 20dB HL for screen

D) Pure Tone Audiometry: (very important)

- Most common test
- Threshold of audibility (measures the threshold)
- Activation of auditory system
- Energy formatted into neural code
- Air conduction assesses entire system
- Bone conduction assesses cochlea onwards

The pure tone audiometry tests a single frequency>> tests one part of the cochlea>> to get a specific frequency information.

Pure Tones:

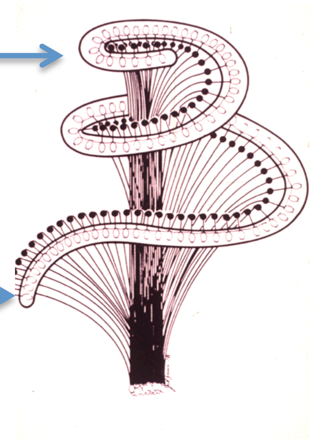
- Auditory acuity
- Spectrally specific
- High frequency tones stimulate basal turn of the cochlea
- Low frequency tones stimulate apical turn of the cochlea

Tonotopic organization >> means that the frequencies are organized from the highest frequency to the lowest.

In general people loose the high frequency before the low

Apex:
Most low frequencie

Base:
Most high frequencie

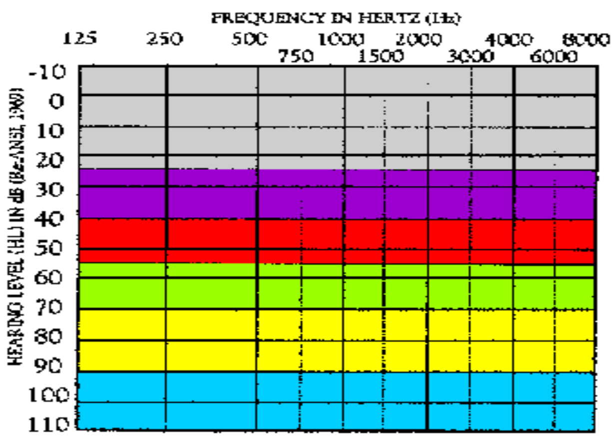


Assessment of thresholds:

- Octave (octave=interval between 2 frequencies) frequencies tested
- Bone conduction thresholds
- Mastoid or forehead used
- Mastoid preferred because less intensity required
- Occlusion effect
- Ascending series of tone presentations

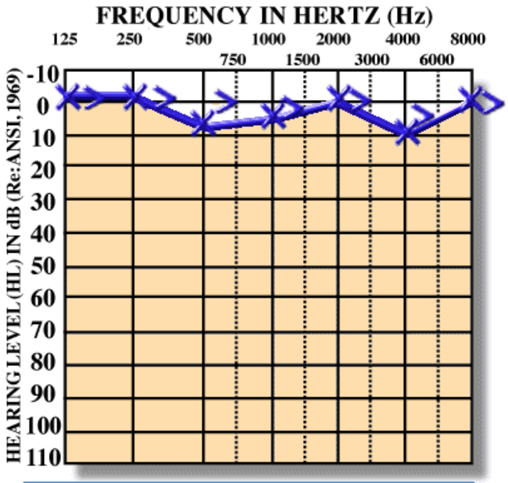
The normal process of hearing is through the air conduction, and from it we can know the degree of hearing loss. Bone conduction is not normal, here we bypass the external and the middle ear, and we use it to test the nerve, which is affected by sensory neural hearing loss.

Ranges of hearing loss:

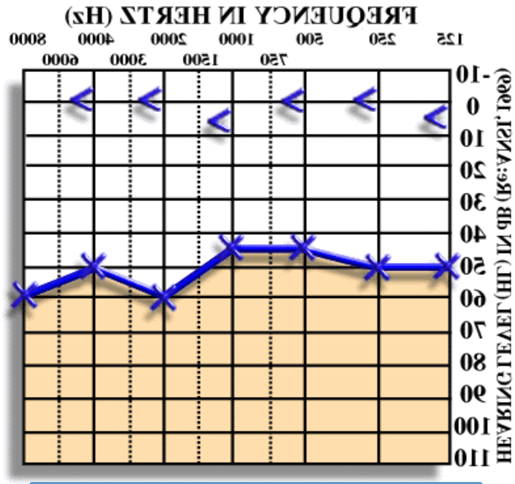


- -10 – 25 dB HL = Normal range
- 26 – 40 dB HL = Mild hearing loss
- 41 – 55 dB HL = Moderate
- 56 – 70 dB HL = Moderately Severe
- 71 – 90 dB HL= Severe
- Greater than 90 dB HL = Profound

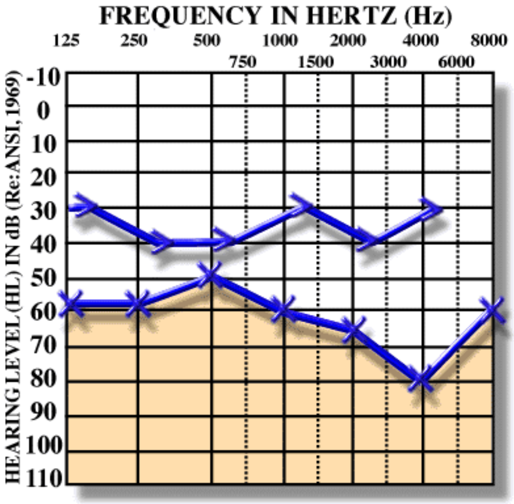
Important to memorize



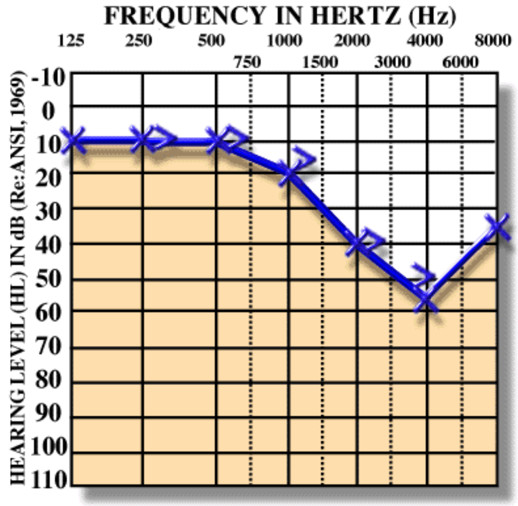
Normal hearing



Conductive hearing loss



Mixed hearing loss



Sensorineural hearing loss

E) Speech Audiometry: it tests a group of frequencies at the same time (500-8000)

- Speech Reception Threshold using spondaic words
- Standardized word lists
- Familiarization with spondees
- Ascending series of presentation
- Excellent speech discrimination in conductive hearing loss patients
- Poor speech discrimination in cochlear hearing loss patients
- Poorest speech discrimination in retrocochlear hearing loss patients

Clinical Masking:

- Nontest ear can influence thresholds of test ear
- Shadow curve apparent without masking
- Interaural attenuation varies from 40 to 80 dB with air conduction
- Interaural attenuation is about 0 dB with bone conduction
- Compare bone conduction threshold of nontest ear with air conduction threshold of test ear to determine whether masking is necessary

Masking is exclusion of one ear while doing the test; we do it when there is a possibility of crossing over. Crossing over gives false results in the test

Plateau method:

- Mask the nontest ear with progressively greater amounts of sound until threshold does not rise.
- Masking Dilemma

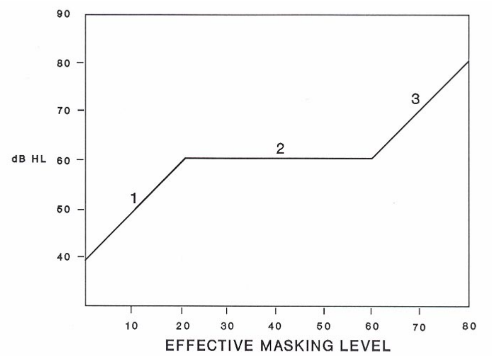


Figure 5. Function illustrating the masking plateau.

The Dr. did not explain the picture

II. Objective Audiological Tests:

Electrophysiological Tests

1- Immittance

a. Ear Canal Volume
b. Tympanometry (test for middle ear)
c. Static Compliance
d. Acoustic Reflex, Decay, & Latency

Middle ear is a box shaped structure that is filled with air. Tested by: tympanometry. Which can assess:
- If the middle ear filled with air or fluid
- If there is fixation, fracture or dislocation of the ossicular bones
- If the tympanic membrane is perforated
- If there is eustachian tube dysfunction

a. Ear Canal Volume

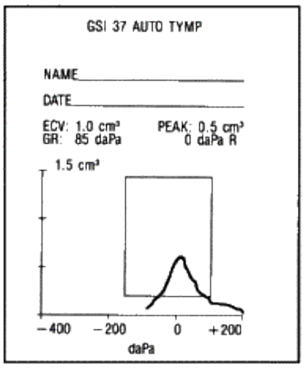
- Measure at +200 mmH20
- Provides measure of volume of external ear canal
- Volumes based on age
- Volumes greater than 2.5 suggest:
  - Perforation or
  - Patent V. tube

b. Tympanometry

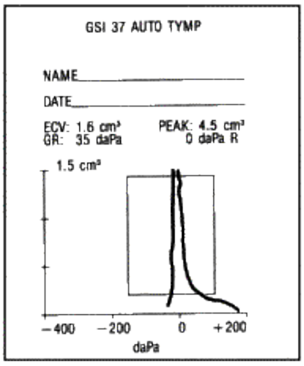
- Objective measure of the function of the TM and middle ear
- 5 or 6 basic shapes

Objective measure means that it can be used in infants, young children, mentally retarded, non-cooperative, & critically ill patients
Benefits:
1- Not time consuming
2- No special preparations
3- No sedation

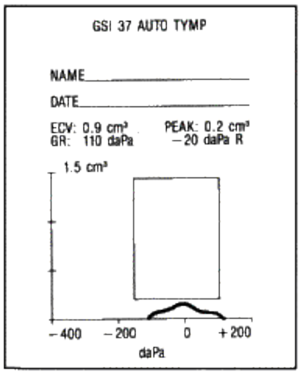
Tympanogram Types:



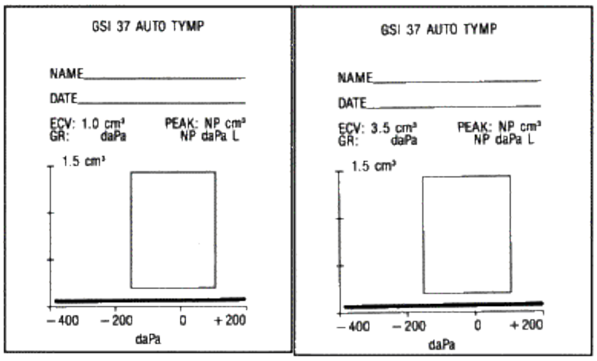
- Type A tympanogram (normal).
- Peak at zero pressure



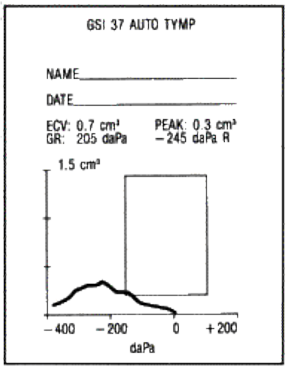
- High amplitude
- Pathology: ossicular dislocation



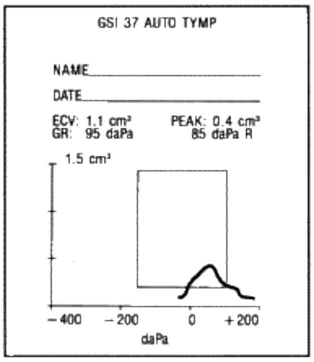
- Low amplitude
- Pathology: ossicular fixation



- Type B tympanogram (flat curve).
- Pathology: effusion (fluid) or perforation



- Type C tympanogram. Pathology: eustachian tube dysfunction



- Positive pressure
- Doesn't reflect pathological process (it happens when there is a lot of air inside the ear)

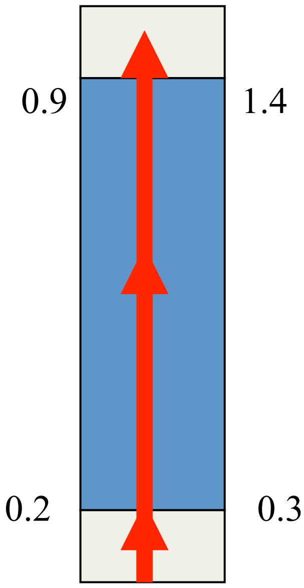
c. Static Compliance (Peak Compliance)

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

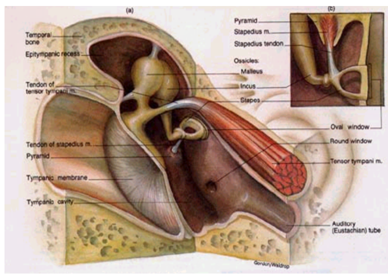


Flaccid: disarticulation, flaccid TM, etc.

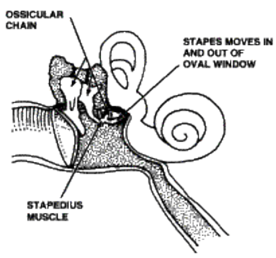
Normal mobility

Stiff: otosclerosis fluid, tympanosclerosis, etc.

d. Acoustic Reflex Threshold (ART)



- Stapedial muscle contraction
- Temporary increase in middle impedance
- Bilateral Stimulation
- Adaptation
- Neural network in lower brainstem



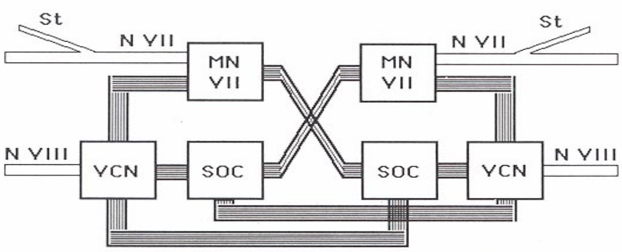
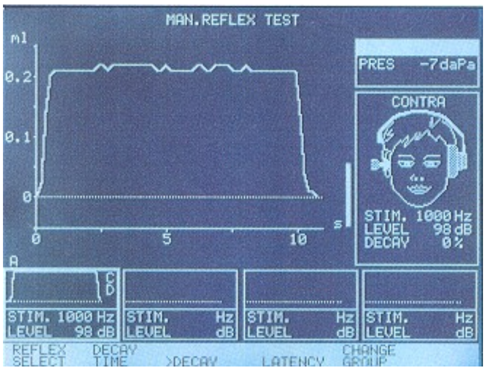


Figure 1. Acoustic-stapedius reflex (ASR) pathways. The afferent input to the ASR arc is the eighth cranial (auditory) nerve (N VIII). The central projections of N VIII synapse with dendrites in the ventral cochlear nucleus (VCN). The VCN sends projections to the ipsilateral and contralateral superior olivary complex (SOC) and to a region near the ipsilateral medial nucleus of the seventh cranial (facial) nerve (MN VII). The motoneurons of the stapedius muscle originate near MN VII and project via N VII to the stapedial nerve (St), which innervates the stapedius muscle in its bony canal in the posterior wall of the middle ear.

Clinical application of ASR (Acoustic stapedial reflexes)

- Middle Ear Disease
- Otosclerosis
- Cochlear hearing loss and loudness recruitment
- Retrocochlear lesions may abolish the ASR
- Brainstem lesions may abolish the contralateral reflexes
- Determination of site of a seventh nerve lesion
- Acoustic Reflex Decay



2- **Otoacoustic emissions** (oto= ear, acoustic= sound, emission= coming out) "objective test"

Background

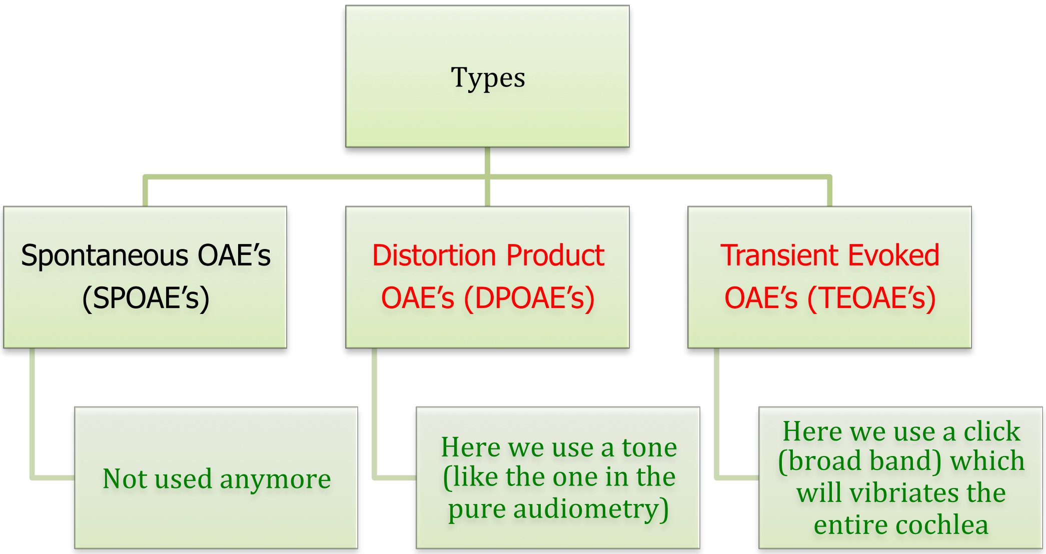
- The presence of cochlear emissions was hypothesized in the 1940's on the basis of mathematical models of cochlear nonlinearity.
- However, OAEs could not be measured until the late 1970s, when technology created the extremely sensitive low-noise microphones needed to record these responses.
- David Kemp first discovered Otoacoustic emissions in 1978.

- Otoacoustic emissions are sounds that are produced by healthy ears (in the cochlea) in response to acoustic stimulation.
- OAE's arise because our ears have evolved a special mechanism to give us extra hearing sensitivity and frequency responsiveness. The mechanism is known as the cochlear amplifier and it depends on a specialized type of cell called "outer hair cells."
- It's the job of the cochlea to receive the sound energy collected by the outer and middle ear and to prepare it for neural transmission.

Purpose of OAE's (test for the outer hair cells of the cochlea)

- The primary purpose of otoacoustic emission (OAE) tests is to determine cochlear status, specifically hair cell function (if we recorded emissions coming from the cochlea it means I have a normal or near normal cochlea)
- This information can be used to
  - Screen hearing
  - Partially estimate hearing sensitivity within a limited range
  - Differentiate between the sensory and neural components of sensorineural hearing loss
  - Test for functional hearing loss.

Types of OAE's

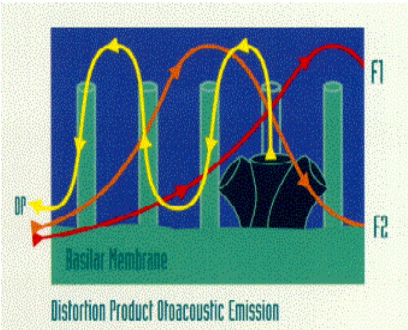


Spontaneous OAE's

- 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 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.
- DPOAEs often can be recorded in individuals with mild-to-moderate
  - Hearing losses for whom TOAE's are absent.
  - *DPOAE's do not occur in the frequency
  - Regions with more than 50-55dB Hearing loss.
  - DPOAE's can be elicited from ears that
  - Have a greater hearing loss than TEOAE's.



DPOAEs

- 2 tone stimuli (F1 and F2)
- Cochlea hair cells generate a resonance

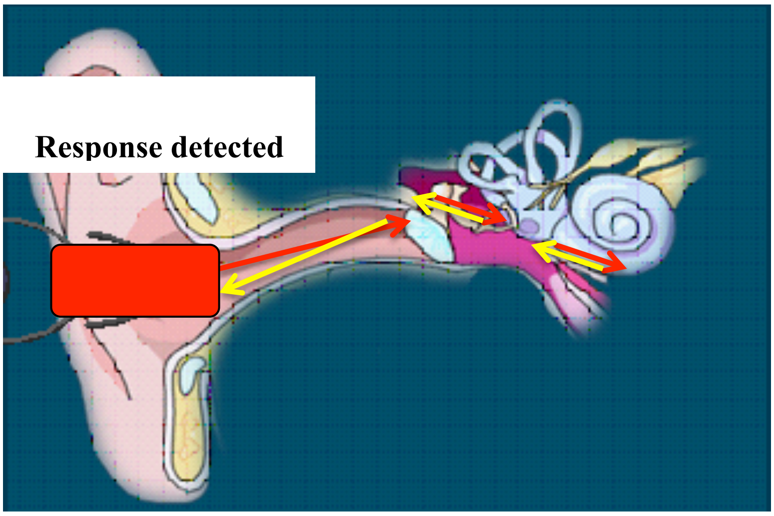
Transient Evoked OAE

- 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.

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.

SOUND IN EAR CANAL → TRAVEL THRU ME → FWD COCHLE → BWD COCHLE → TRAVEL THRU ME → SOUND IN EAR CANAL



OAEs

- Otoacoustic emissions
- "Echo"-like response of outer hair cells of the cochlea
- Can only indicate functioning outer hair cells and good middle ear function.

Types of OAEs

- Spontaneous
  - 20-60% of population, related to age
  - Not clinically useful
  - Not related to tinnitus
- Evoked
  - Present in normal ears
  - Not present in ears with SNHL greater than 25-30 dB
  - Absent in presence of conductive hearing loss. WHY?

Types of Evoked OAEs

- Click (transient) evoked OAE- TEOAE
  - Absent for sensori neural loss greater than 20-30 dB HL
- Distortion product OAE (DPOAE)
  - Absent in sensori neural losses greater than 45-55 dB HL

Acquisition

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

Clinical applications (doctor skipped it)

- Quick screening tool
- Good indicator of cochlear reserve- correlated with hearing
- Monitoring
- TEOAE present with hearing loss up to 30dB HL
- DPOAE present with hearing loss up to 50dB HL
- Monitoring of drug ototoxicity (can affect OAE before HL present)
- Sensory vs. neural HL

Clinical limitations (doctor skipped it)

- Problems because of middle ear disease
- Not sensitive for neonates within 24 hours of birth
- Results affected by test conditions
  - Noise
  - Electrical interference
- Not a test of hearing- limited application

Electrocochleography (doctor skipped it)

History

- Little confusion in the literature, apart from what letters of the original appear in the abbreviation
- Animal models first discovered in 1930s
- Clinical applications started in 1960s

Components

- Cochlear microphonic: outer hair cell response
- Summating potential: cochlear activity
- Action potential: Firing of auditory nerve (same as ABR wave 1)
- All occur within the first 1.5-2 ms after an acoustic stimulus

stimulus & acquisition

- Recording electrode must be as close to response as possible (transtympanic)
- Children: general anaesthetic
- Adults: may be done without anaesthetic
- resistant to effects of drugs and subject state of arousal
- Can be used in pre-implant assessment to test cochlear function

clinical applications

- Diagnosis of Meniere's disease
- Diagnosis of cochlear hearing loss/auditory dysynchrony, sensory vs neural.
- Assessment of hearing status for difficult to test subjects

clinical limitations

- Auditory information only provided to cochlea
- Very invasive
- Results can vary up to 20dB from actual hearing
- Limited frequency specificity
- expensive

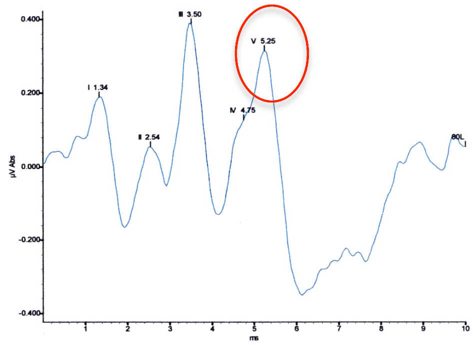
> The sound first starts as acoustic then ends in the nerve as electric signal to be analyzed by the auditory centers in the brain

Auditory brainstem response (ABR)

The most sensitive & accurate test in infants & young children

History

- First complete description in 1970s
- Response found between 1-15ms after stimulation.
- Recording has 7 peaks, peak five being the most prominent.
  - The amplitudes, latencies and relationship of those peaks can be used to diagnose certain pathological conditions.



What is an ABR?

- The Auditory Brainstem Response is the representation of electrical activity generated by the eighth cranial nerve and brainstem in response to auditory stimulation

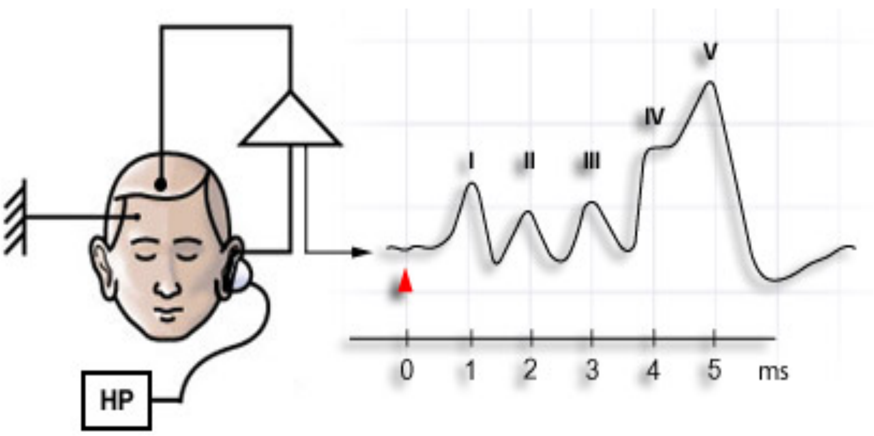
Wave V is the most important one. Normally we can record it after 5 milliseconds

How is an ABR recorded?

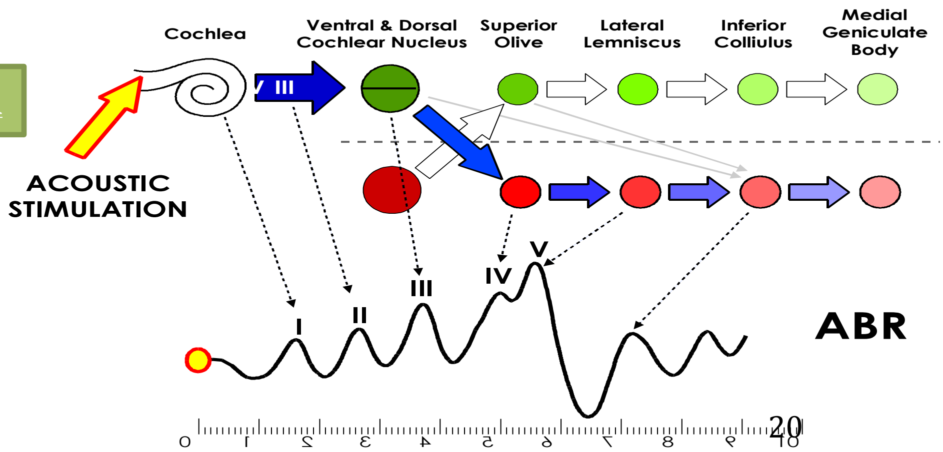
- Electrodes are placed on the scalp and coupled via leads to an amplifier and signal averager. EEG activity from the scalp is recorded while the ear(s) are stimulated via earphones with brief clicks or tones.
- A series of waveforms unique to the auditory neural structures is viewed after time locking the EEG recording to each auditory stimulus and averaging several thousand recordings.

I will give acoustic signal in the external ear, and I will put electrodes over the bones of the skull.
If I was able to record auditory signals from the brainstem after stimulating the auditory system with sound >> this is an ABR wave (normal)
Before the test we ask the adults to be quite and in case of children, we give them sedation.

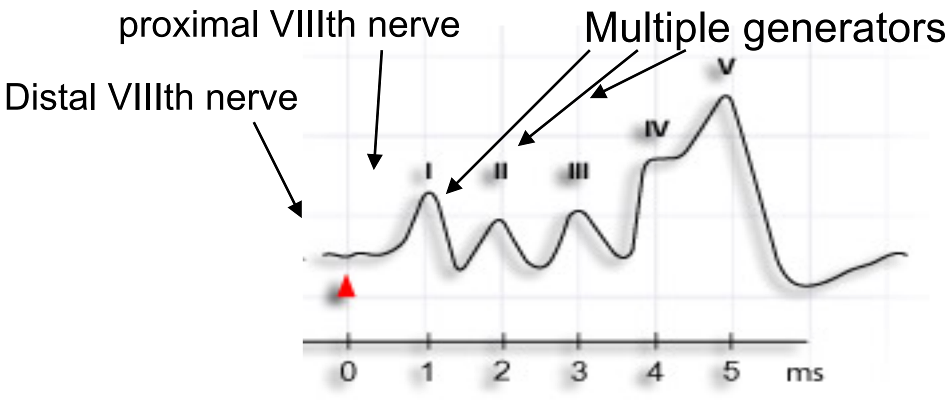
Components



Generators of the ABR

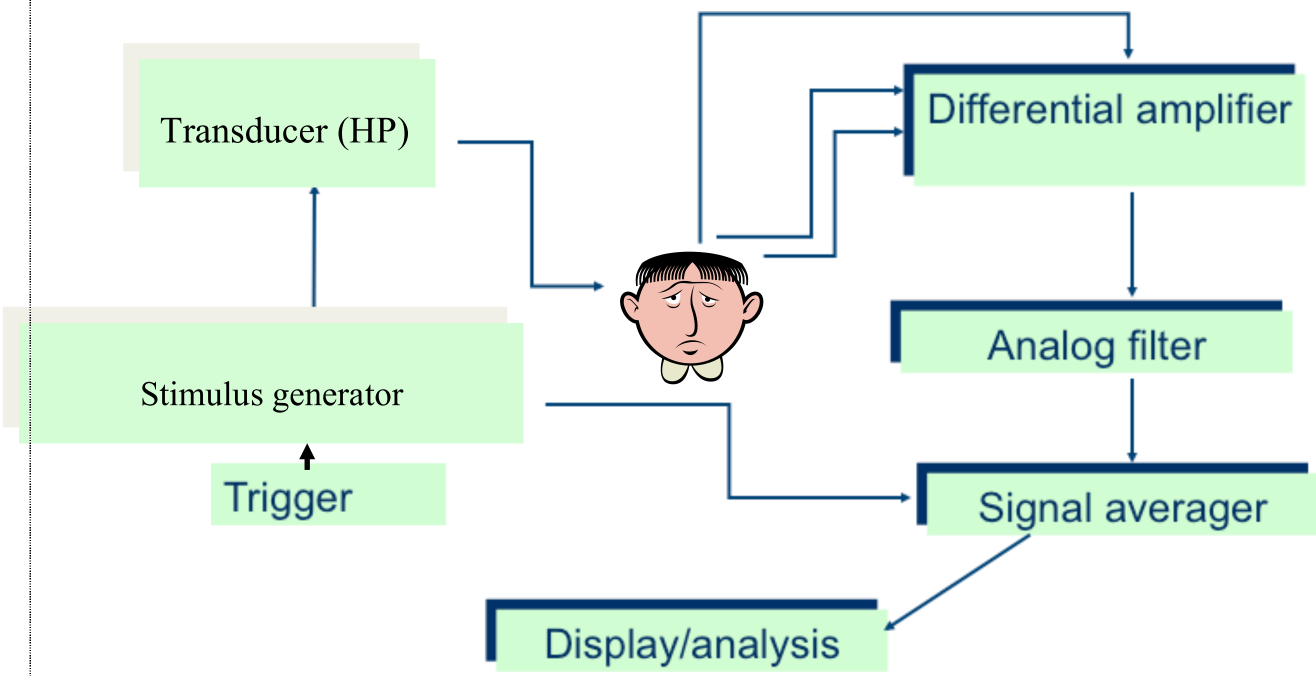


Anatomy

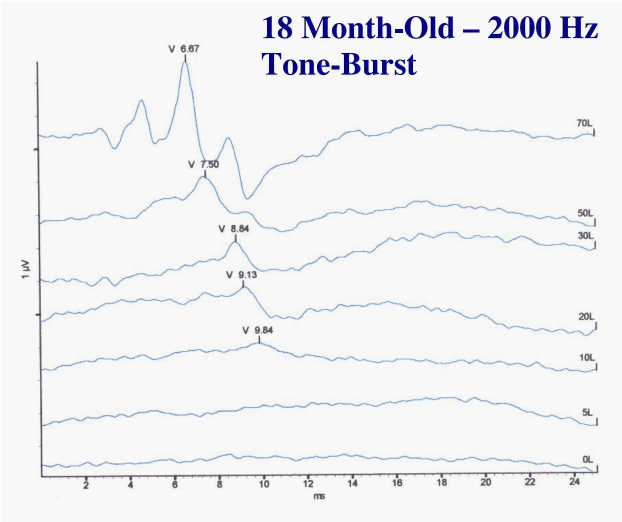


Stimulus & acquisition

- Short clicks or tone bursts used
- Rate of around 20/sec or faster
- Responses can be + or – 20dB on true thresholds, mixed in with EEG
- Electrodes on head (surface electrodes)
- Can be influenced by subject characteristics (age, gender, body temperature)
- Not affected by arousal state or most drugs



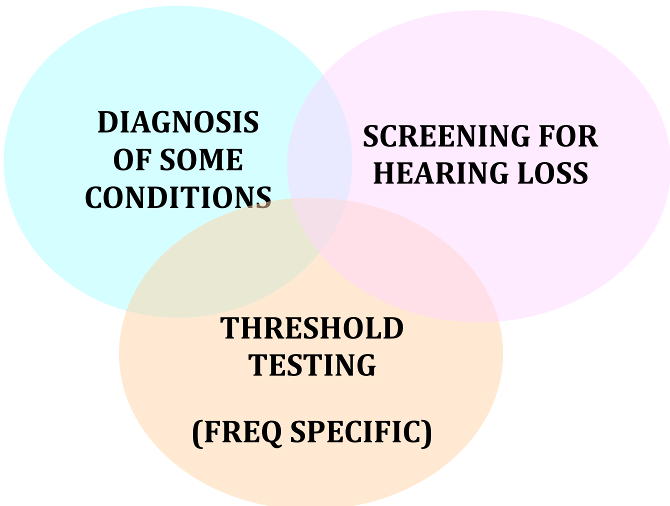
Example Normal Hearing



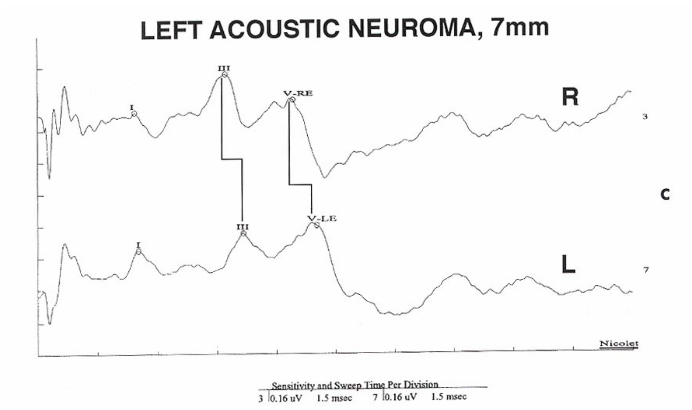
Clinical applications

- Basis of Newborn screening tests: non-invasive, high success rate
- Estimation of thresholds for difficult to test people
- Neurodiagnosis of VIIIth nerve/ brainstem problems
- Intraoperative monitoring
- Cochlear implant evoked responses
- Test-retest reliability

Why use ABR testing?



Retrocochlear lesion:



Summary

- **Types of Hearing Loss** (from Toronto Notes)
  1. Conductive Hearing Loss (CHL)
  • the conduction of sound to the cochlea is impaired
  • can be caused by external and middle ear disease

  2. Sensorineural Hearing Loss (SNHL)
  • due to a defect in the conversion of sound into neural signals or in the transmission of those signals to the cortex
  • can be caused by disease of the cochlea, acoustic nerve (CN VIII), brainstem, or cortex

  3. Mixed Hearing Loss
  • both a conductive hearing loss and a sensorineural hearing loss are present

- Frequency = pitch of the sound and its unit is Hertz (Hz)

- Intensity = loudness and its unit is Decibel (dB)

- Most of the common sounds that humans hear are from 500-8000HZ

- Behavioral tests depend on behavioral responses to sounds

- **Pure tone audiometry:** assess both air and bone conduction
  Assessment of air conduction gives us information about the degree of hearing loss (mild, moderate, severe, or profound) and the **assessment of bone conduction** gives us information about the type of hearing loss (Conductive, Sensorineural, or Mixed)

- Masking: exclusion of one ear from the test
  when to mask? If there is a possibility of crossing-over

- Objective tests: can be used in infants, young children, mentally retarded, non-cooperative, & critically ill patients. Benefits: not time consuming – no special preparations needed

- **Tympanometry:** objective measure to test the middle ear

- **Otoacoustic emissions:** objective measure to test the outer hair cells in the cochlea

- **Auditory brainstem response (ARB):** objective measure. Needs test subject to be still and quite. It records 7 peaks, peak five being the most prominent.

MCQ's :

Q1: A hearing loss caused by the inability of the ear drum to vibrate in response to sound can be described as a:

A) Sensori-neural hearing loss.
B) Conductive hearing loss.
C) Congenital hearing loss.
D) Prenatal hearing loss.

Q2: A hearing loss caused by a build-up of fluid in the ear canal could be described as a:

A) Sensori-neural hearing loss.
B) Conductive hearing loss.
C) Congenital hearing loss.
D) Prenatal hearing loss.

Q3: Which range best describes a mild hearing loss?

A) 26 – 40 dB
B) –10 - 25 dB
C) 41- 55 dB
D) > 90 dB

Q4: The perception of frequency is referred to as:

A) Loudness
B) Tone
C) Acuity
D) Pitch

For mistakes or feedback

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Answers:
Q1 – B
Q2 – B
Q3 – A
Q4 – D