430 Teams

Diseases of the Ear, Nose and Throat



1st Lecture:

Audiological Evaluation

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The slides were provided by doctor (Name)
Important Notes in red
Copied slides in black
Your notes in green/ blue
Titles and subtitles in this color
Highlight possible MCQs mentioned or pointed by the doctor

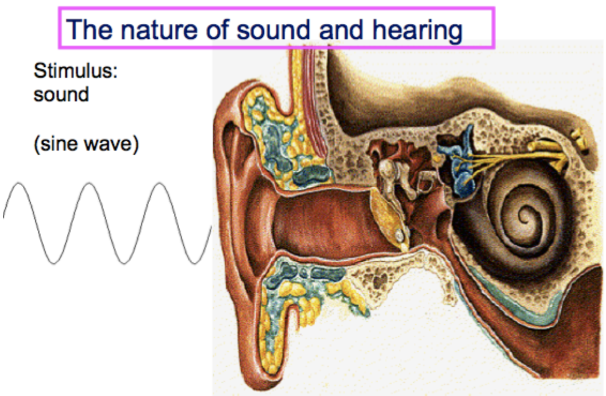
Physically to hear we need a sound.
Sound is a physical stimulus that evokes the sensation of hearing. And it is a pressure changes around the …. It transmitted through any medium (solid or air) to reach a sensor and stimulate it.
So to hear we need a sound source, a vibrating source like vocal cord as such, which will produce a wave of condensations and refractions transmitted through a medium that is the air in this case to reach the sensor of the ear which will be activated by this sound.

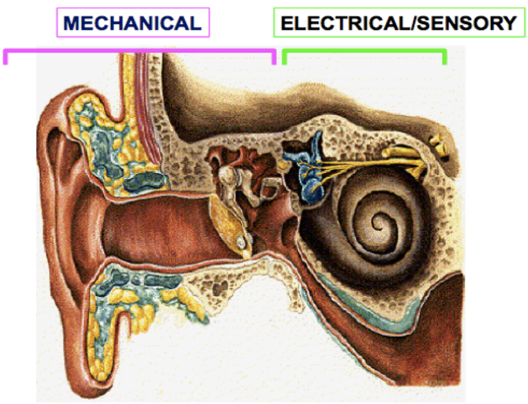
The sensor/ auditory system made of two parts mechanical and electrical.
The mechanical part is the external ear and the middle ear: the sound wave will pass through the external ear to the middle ear when the stapes moved over the oval window the energy will be conducted to the fluid of the inner ear. The movement of the fluid will take the basilar membrane up and down and then this will move the cilia and hair cells. The hair cells will go to biochemical activity result in sharing action between cilia of hair cell and tectorial membrane above it. Then it will be conducted into electric signal as firing in auditory nerve which is the sensory part.

And according to this hearing loss could be conductive when the problem is either in the external or middle ear, sensory if the problem in the inner ear and the ascending neural connections , or mixed.

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

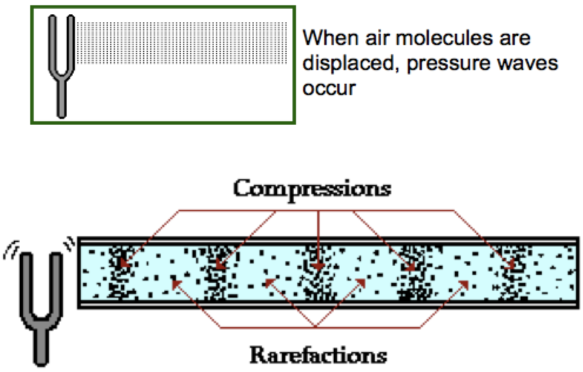
Sound:
Sound is a form of vibration
Vibration is the to-and-fro motion of an object (guitar string, vocal folds, diaphragm on an earphone or loudspeaker, tuning fork)



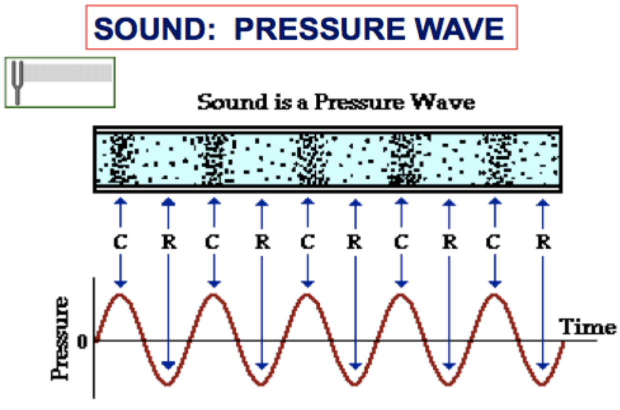


For sound to occur, must have a:

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



http://www.glenbrook.k12.il.us/gbssci/phys/Class/sound/u11l1c.html



NOTE: "C" stands for compression and "R" stands for rarefaction

The particles after the sound wave started will go into motion and in order to stay longer it goes into rarefaction and compressions. This wave drown in a graph called sine wave. Where it goes from resting point (0) to maximum condensation (C), resting again, and then to rarefaction (R).

Characteristics of the waveform (amplitude x time):

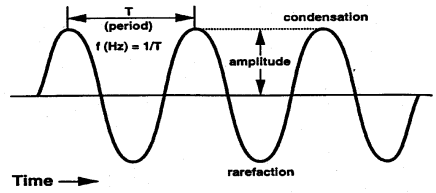
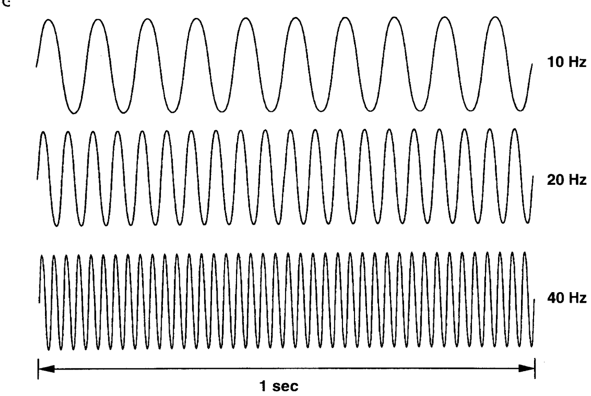


Figure 2-5. A sinusoidal waveform, describing the various properties of sound, including amplitude and frequency (f).

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.

B. A. Stach (1998). Clinical Audiology: An Introduction. San Diego: Singular Publishing



FREQUENCY: The number of cycles that occur in one second.

Hertz (Hz): Unit of measurement of frequency
100 cycles per second = 100 Hz

Pitch: Psychological percept of frequency.
e.g., low frequency sounds = low pitch

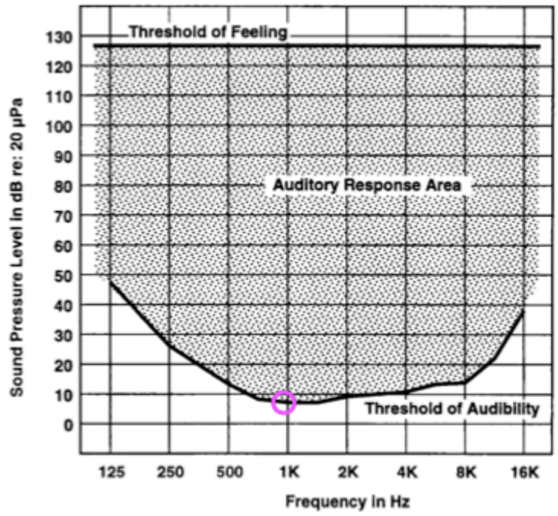
Frequency Range of Hearing Sensitivity:
Humans: 20 Hz to 20 kHz.

- Below 20 Hz, we feel a vibration rather than hear a sound.
- Most people have very diminished sensitivity for frequencies > 8000-10, 000 Hz.

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

Practically human ear hear from 250 kHz to 8000 kHz .

The Minimal Audible Pressure Curve (dB SPL)



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

Frequency axes:
In order to hear sounds out of our range from 250 to 8000 we need sounds of high pressure/intensity.

Intensity axes:
Hearing threshold: the lowest intensity, which can be detected by ...in 50% of trails. Just awareness of sound (no discrimination).

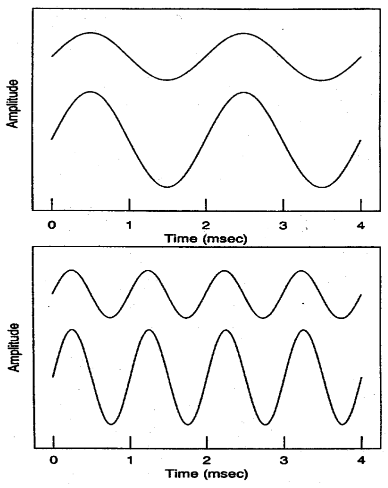
Comfortable level: discrimination 100%

Uncomfortable level: above the comfortable level by 40 dB

Hazardous: above 100 dB.

If we increase the intensity we will reach the sensation area and there will be tactile sensation.

Amplitude/ Intensity: (loudness)
The quantity or magnitude of sound.
Decibel (dB): Unit of amplitude used most frequently in clinical audiology.



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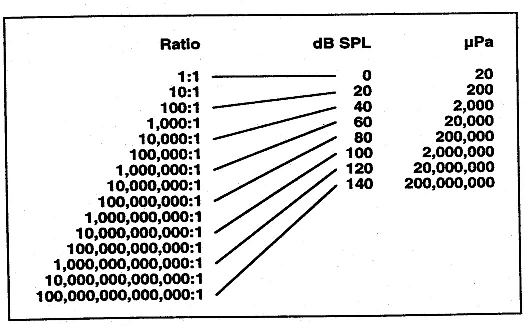


Figure 2-7. The relationship of the ratio of sound magnitude to the range of sound intensity expressed in sound pressure level. Sound ranges from barely audible at 20 μPa to painful at 200,000,000 μPa.

B. A. Stach (1998). Clinical Audiology: An Introduction. San Diego: Singular Publishing Group, Inc.

Hearing loss prevention:
Noise controls, hearing protectors
- Primary prevention ➔ reduction or elimination of HL

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

Hearing assessment

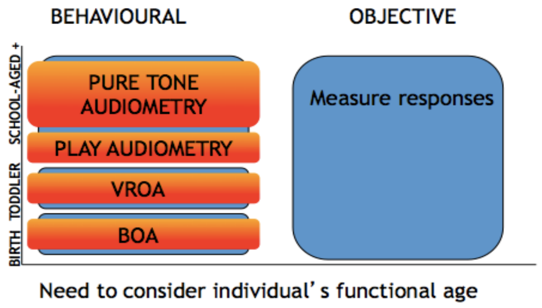
Types of Tests:
BEHAVIOURAL / subjective: patient listens to different sound at different frequency and at each frequency we raise and decrease the sound till it reaches the threshold.
- Reliable & consistent response to sound
- Developmental age
- Not used in newborn screening
- Not critically ill

In children below age of school we can assess hearing either by play audiometry or behavioral observation audiometry.

OBJECTIVE: record the biochemical/firing activity from the inner ear (cochlea or nerve)

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

Age based hearing assessment:



Overview
- Behavioral audiometry
- Tympanometry
- Acoustic reflex measurements
- ECochG
- Auditory Brainstem Response (ABR)
- Otoacoustic Emissions

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

Infants 7 months-3 years:

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

Visual Reinforcement Oreintation Audiometry (VROA):
Uses operant conditioned response and visual reinforcement

- Response typically head turn. Eye turn also possible
- Complex visual reinforcement usually lighted puppet theatre- colour movement and light are important

Play audiometry 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 with Play Audiometry

- use peg board, 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

Pure Tone Audiometry:

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

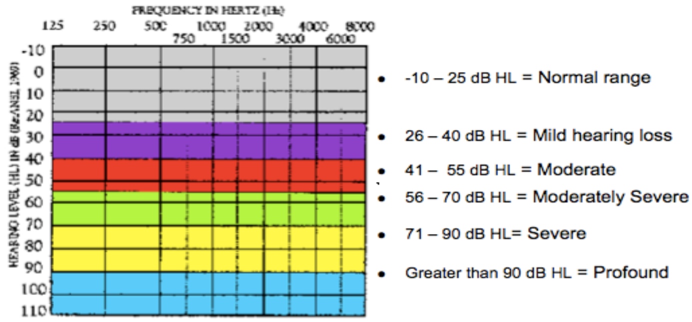
Pure Tones: important

- Auditory acuity

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

Pure tone audiometry:
Assessment of thresholds

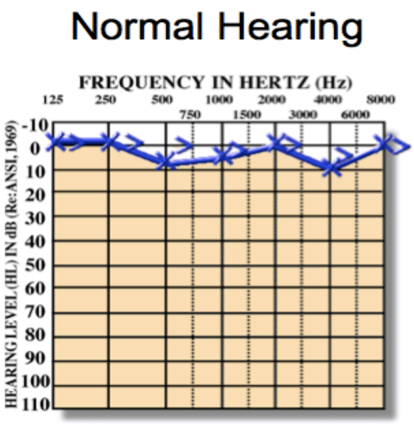
- Octave frequencies tested
- Bone conduction thresholds
- Mastoid or forehead used
- Mastoid preferred because less intensity required
- Occlusion effect
- Ascending series of tone presentations

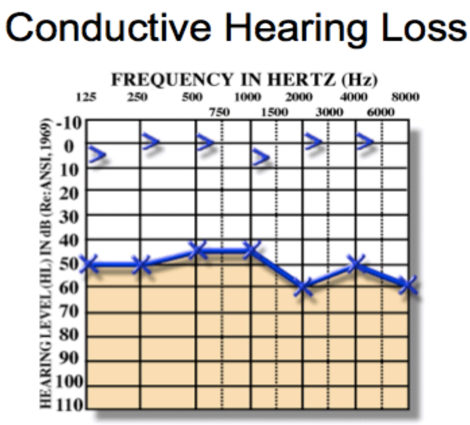


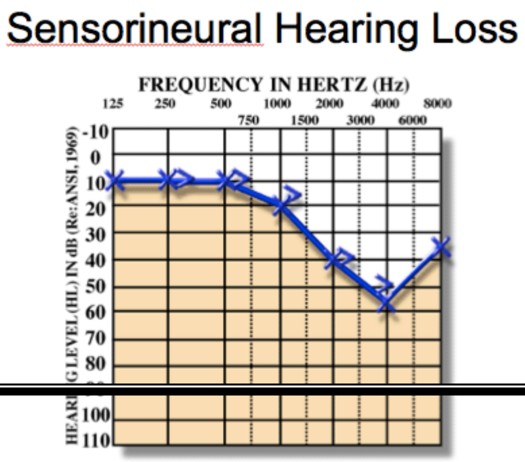
Air: medium between the sound source and ear is air we measure it using headphones or speakers
Bone: the medium is bone and measured by placing the vibrator over the skull.

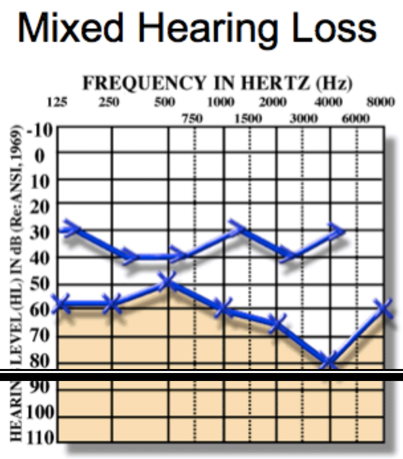
Types of hearing loss:
Conductive: air hearing loss: the problem either in the external or middle ear
Sensorineural: bone hearing loss: there is problem in the inner ear
Mixed: both conductive and sensorineural hearing loss

Ranges of Hearing Loss:
If the air line goes down that means it is a conductive hearing loss and it could be mild moderate, or sever according to the graph above. If both lines go down it is a sensorineural hearing loss, In mixed type both lines will go down however there is a gap between them and the bone is better.

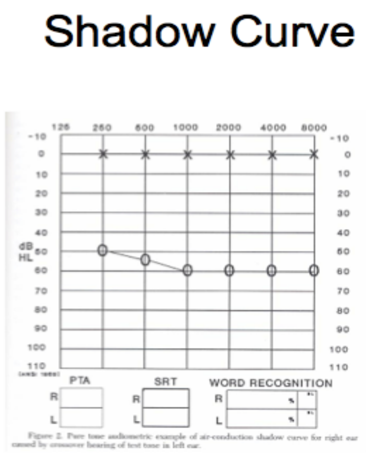








Speech Audiometry:
- Speech Reception Threshold using spondaic words
- Standardized word lists
- Familiarization with spondees
- Ascending series of presentation
- Excellent speech discrimination in conductive hearing loss patients
- Poor speech discrimination in cochlear hearing loss patients
- Poorest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



Clinical Masking:
- Nontest ear can influence thresholds of test ear
- Shadow curve apparent without masking / false hearing threshold taking from the nontest ear
- 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
-

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

Objective Audiological Tests:

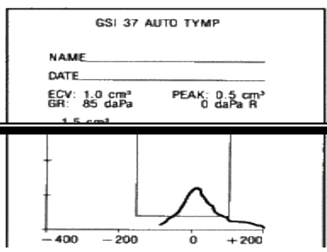
In short: for the external ear: otoscope
For the middle ear: immittance/tympanometry
For the inner ear: cochlea: otoacoustic emissions
Nerve: EBR (audiology brainstem response)

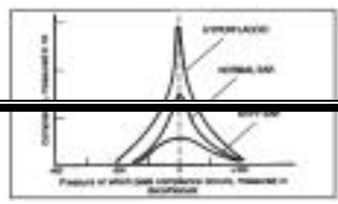
Electrophysiological Tests:
- Immittance
- Evoked Potential
- Otoacoustic Emissions

Immittance:
- Ear Canal Volume
- Tympanometry
- Static Compliance
- Acoustic Reflex, Decay, & Latency

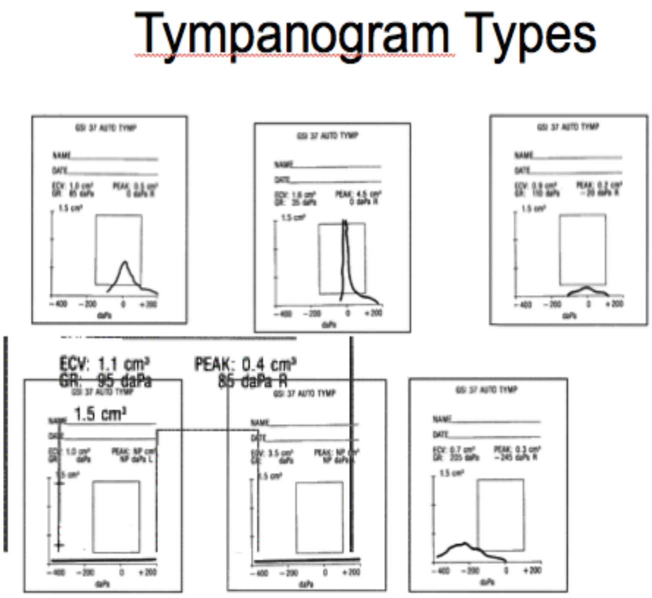
Ear Canal Volume:
- Measure at +200 mmH20
- Provides measure of volume of external ear canal
- Volumes based on age
- Volumes greater than 2.5 suggest:
  - Perforation or
  - Patent V. tube

Tympanometry:



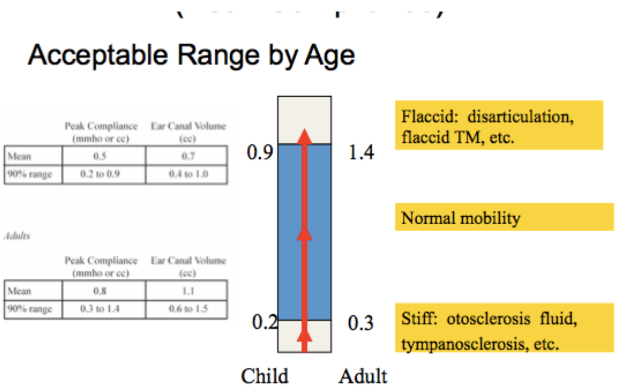


- Objective measure of the function of the TM and middle ear
- 5 or 6 basic shapes
- Tympanogram Types:



Type A/ normal curve:The peak more or less around zero (atmospheric pressure), and the amplitude from 0.3 to 1.7 and indicates normal middle ear function.
Type AD: very long curve indicates disarticulation
Type AS: very short curve indicates otosclerosis.
Type B: flat curve in case of middle ear effusion. If it's high that means there is perforation.
Type C: curve shifted to the negative and indicates eustachian tube dysfunction.

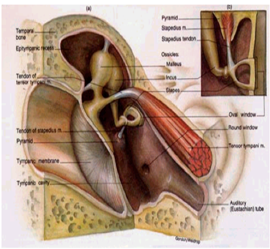
Static Compliance (Peak Compliance):

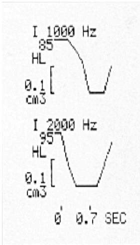


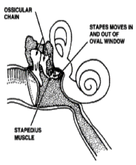
For the inner ear:
Otoacoustic emission: for the biochemical function of the outer hair cells of the cochlea
If I can record it that's mean we have normal cochlea
ABR: we test the nerve at the brainstem. We place 3 surface electrodes (forehead, right ear, and left ear) over the skull and deliver a sound through headphone to record the electric activity/firing of nerve. This is an evoked process meaning that we have to drive the auditory system into action by delivering a sound in order to be able to record the nerve activity. Normally there will be five waves. The most important one is wave 5 at 5 m. second which is time of onset of stimulus.

ART:

ART







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

Clinical application of ASR
- 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

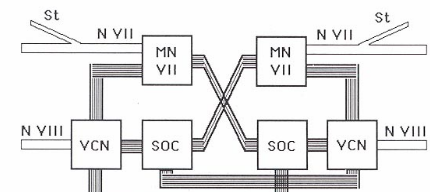
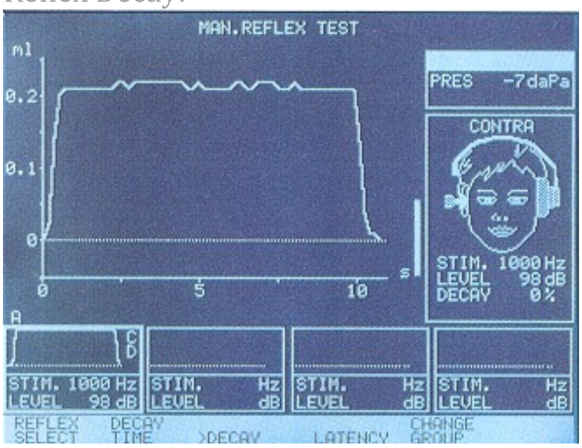


Figure 1. Acoustic-stapedius reflex (ASR) pathways. The afferent input to the ASR arc is the eighth cranial (auditory) nerve (N VIII). The central projections of N VIII synapse with dendrites in the ventral cochlear nucleus (VCN). The VCN sends projections to the ipsilateral and contralateral superior 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.

Reflex Decay:



otoacoustic emissions:

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.

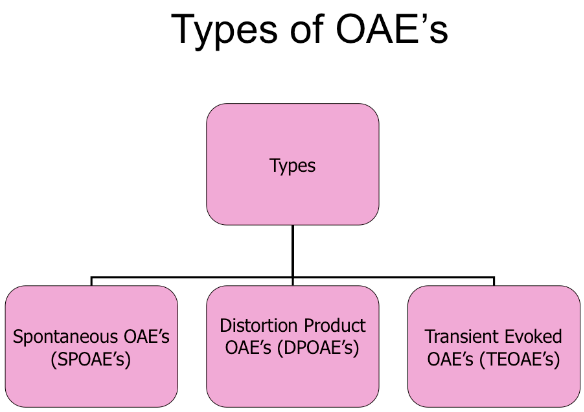
Otoacoustic Emissions:

- Otoacoustic emissions are sounds that are produced by healthy ears 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:

- The primary purpose of otoacoustic emission (OAE) tests is to determine cochlear status, specifically hair cell function. This information can be used to
- (1) screen hearing
- (2) partially estimate hearing sensitivity within a limited range
- (3) differentiate between the sensory and neural components of sensorineural hearing loss
- (4) 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.

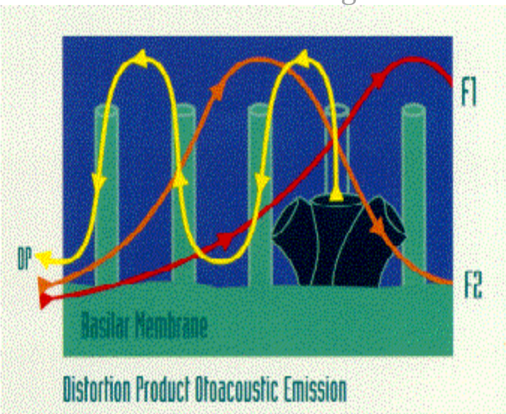
Distortion Product OAE's:

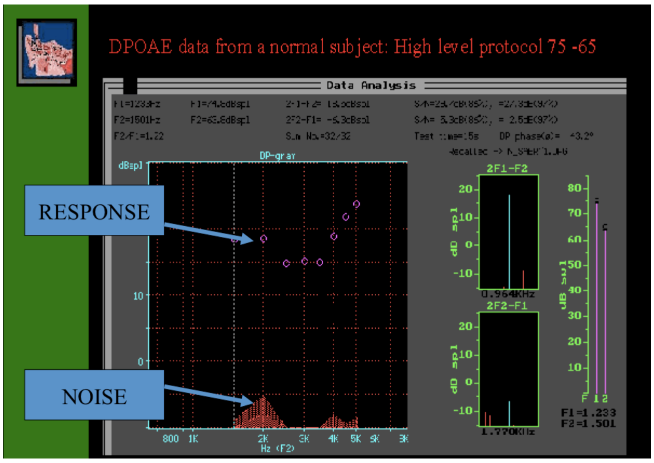
- Result from the interaction of two simultaneously presented pure tones.
- Stimuli consist of 2 pure tones at 2 frequencies (ie, f1, f2 [f2>f1]) and 2 intensity levels (ie, L1, L2). The relationship between L1-L2 and f1-f2 dictates the frequency response.

- DPOAEs allow for 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.
- 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

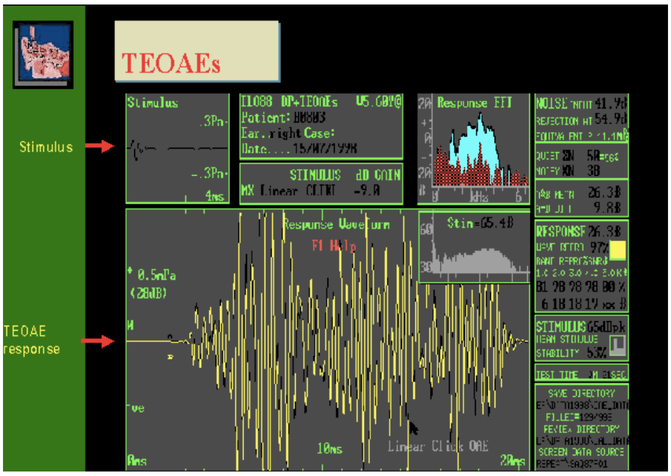




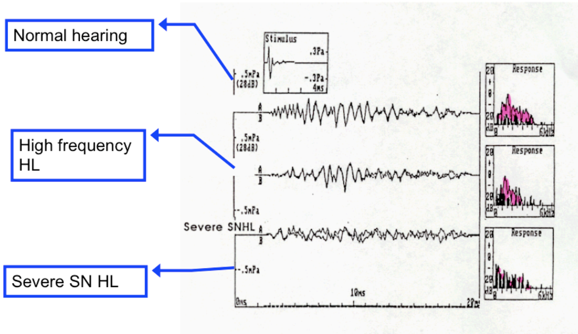
Transient Evoked OAE:

- 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.

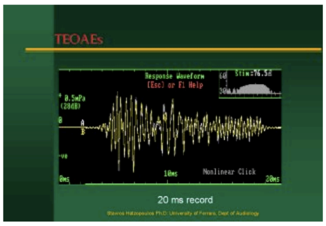
TEOAE results

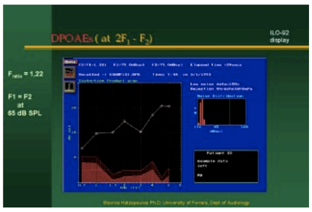


TEOAE results



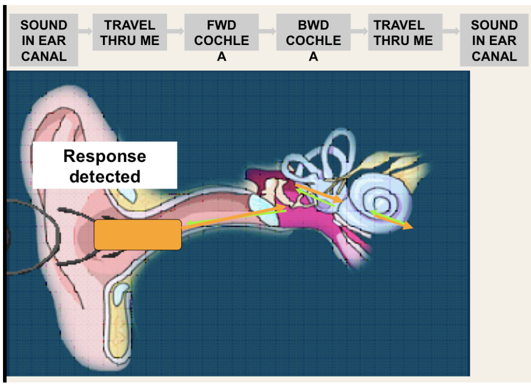
TEOAE & DPOAE





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.



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?

Evoked OAEs:

Types:

- Click (transient) evoked OAE- TEOAE : Absent for sensori neural loss greater than 20-30dB 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:

- Quick screening tool
- Good indicator of cochlear reserve- correlated with hearing
- Monitoring
- TEOAE present with hearing loss up to 30dBHL
- 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:

- 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:

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

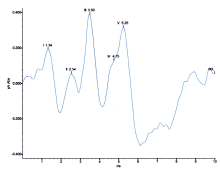
auditory brainstem response:

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?

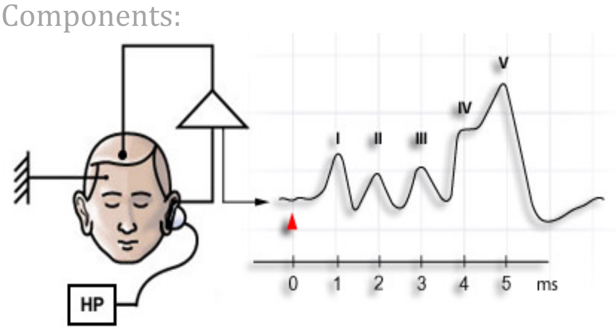
- The Auditory Brainstem Response is the representation of electrical activity generated by the eighth cranial nerve and brainstem in response to auditory stimulation

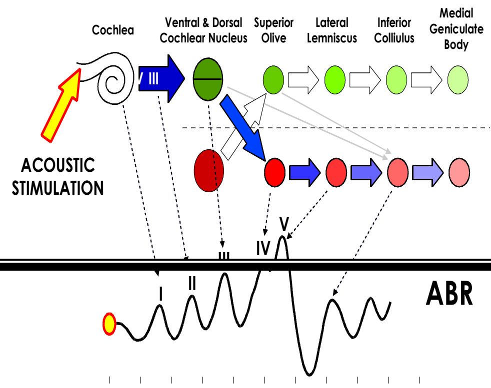


How is an ABR recorded?

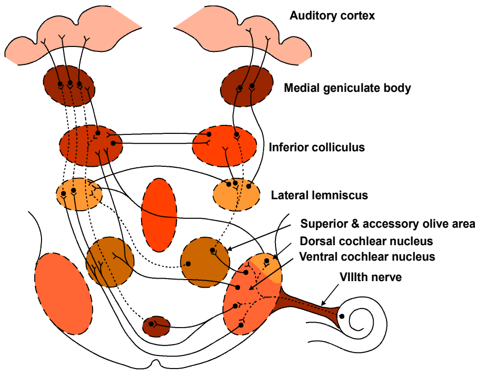
- Electrodes are placed on the scalp and coupled via leads to an amplifier and signal averager. EEG activity from the scalp is recorded while the ear(s) are stimulated via earphones with brief clicks or tones.
- A series of waveforms unique to the auditory neural structures is viewed after time-locking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

Components:

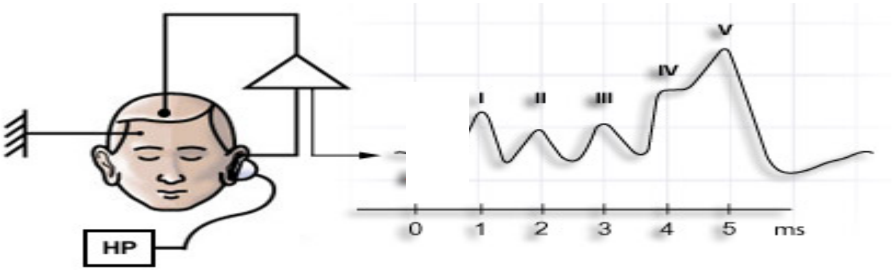




Generators of the ABR:

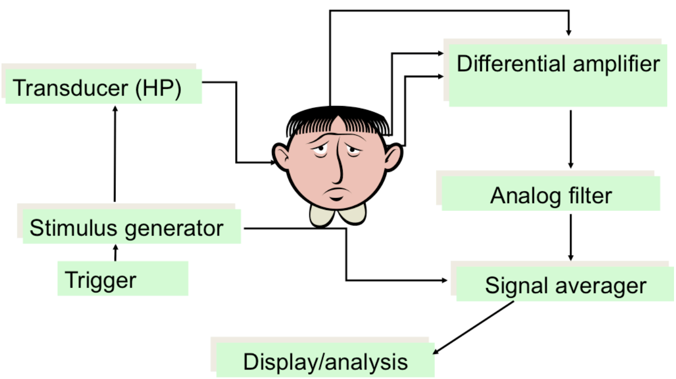


Anatomy:

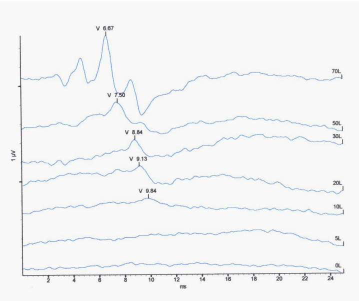


stimulus & acquisition:

- 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



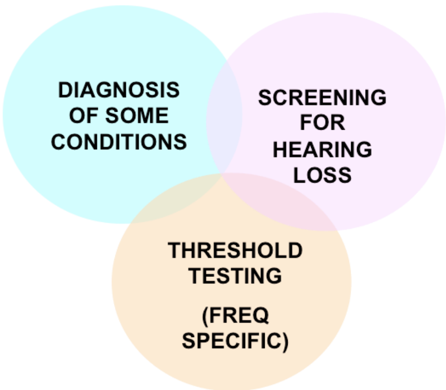
Example Normal Hearing:



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: