The Background Noise Issue

Why understandings speech in the presence of noise is so difficult

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Everyone has difficulty hearing in background noise!

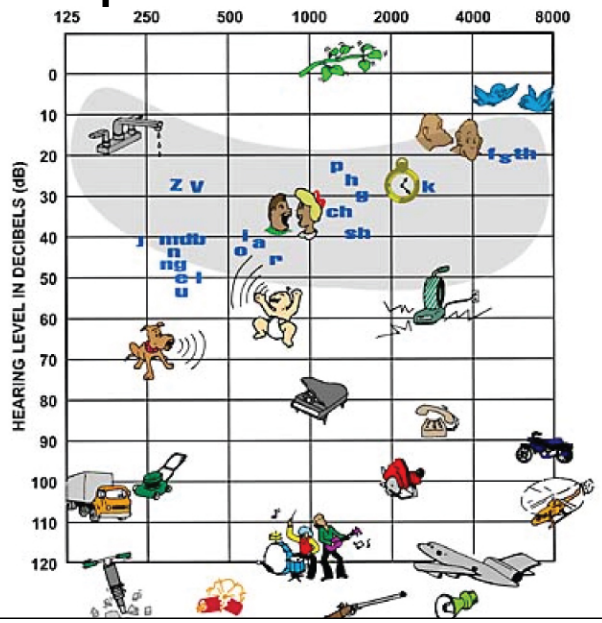
Outline

1. Why background noise is a problem
2. How and why hearing impairment effects speech understanding in noise
3. What hearing instruments and CIs do to combat these issues
4. What you can do to maximize speech understanding

Why is competing background noise a problem?

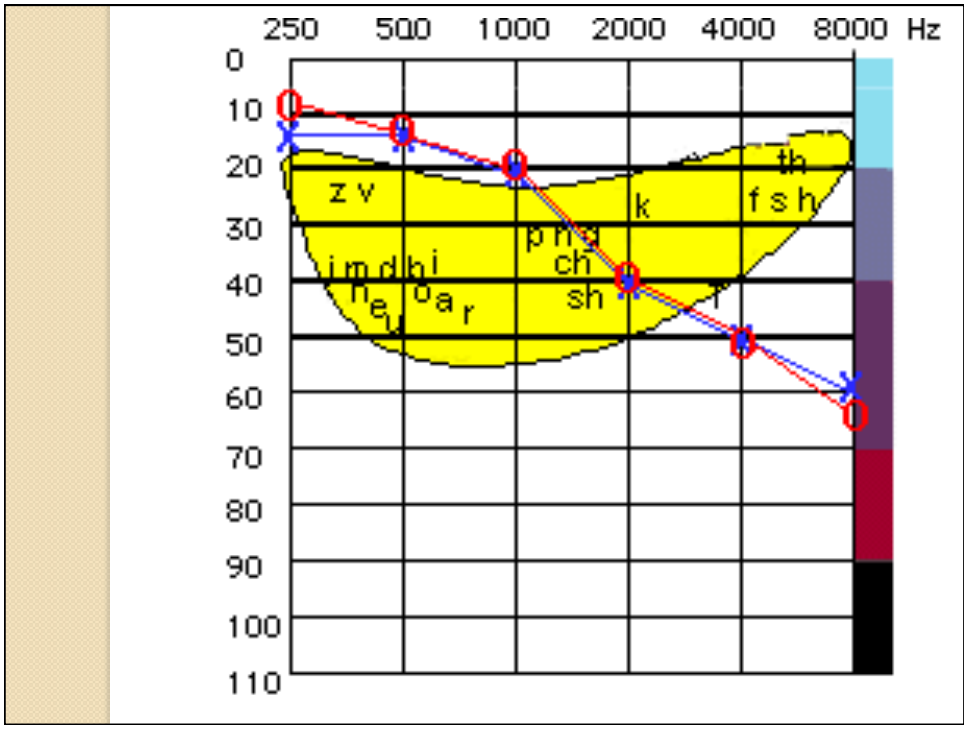
1. Speech and Noise contain energy at the same frequencies
2. Noise masks over soft sounds of speech
3. Noise effects amplitude and timing cues used to identify speech
4. Noise effects attention – It's Distracting!

Speech and Noise contain energy at the same frequencies



Noise masks over soft sounds of speech

- Most people who have hearing loss have more loss in the higher pitches than the lower ones.
- High-pitched sounds containing the consonants listeners need to hear to understands
- Unwanted low-pitch sounds cover the higher-pitched consonant sounds that contain critical information to understand speech.



Noise effects amplitude and timing cues used to identify speech

Waveform Graph of Speech:

"Middle of the night"

Speech in Quiet

Speech in Noise

Speech fluctuates in intensity…So does noise

Noise effects attention – It's Distracting!

Other Factors

- Room Acoustics
- Distance and loudness of the noise
- Distance and loudness of the speaker
- Number of people
- Type of sound
- Attention
- Mood
- Stress

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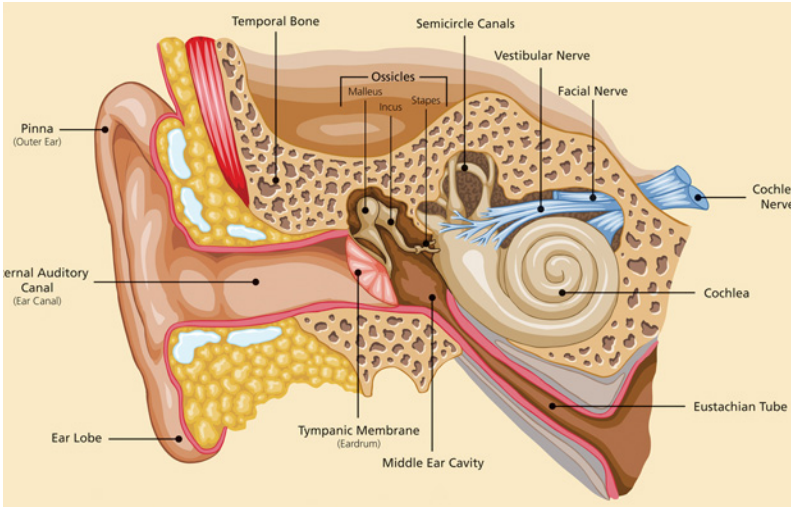
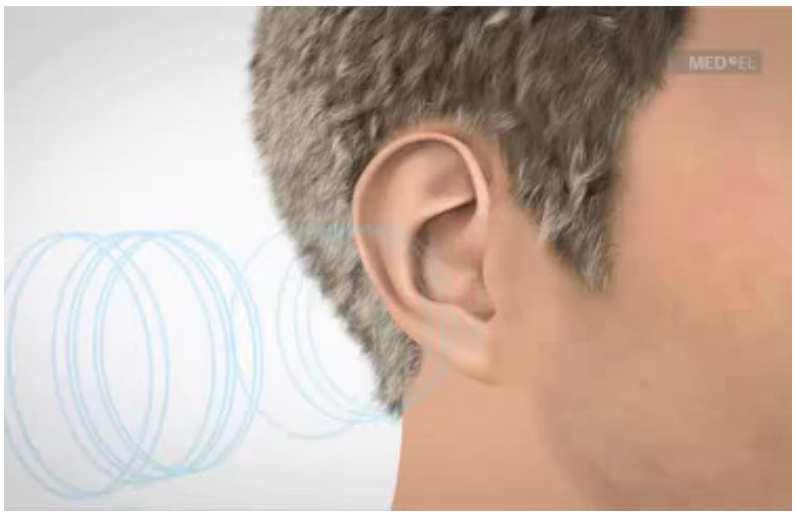
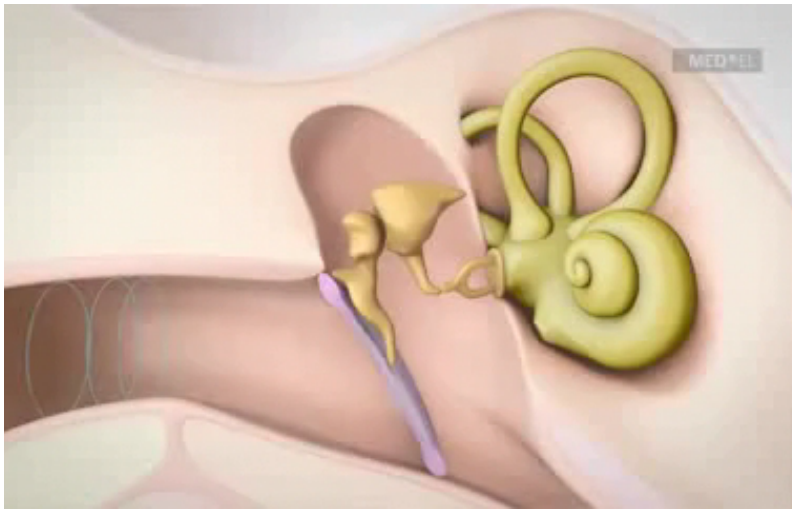
How we hear…



Outer Ear: Collects sound waves

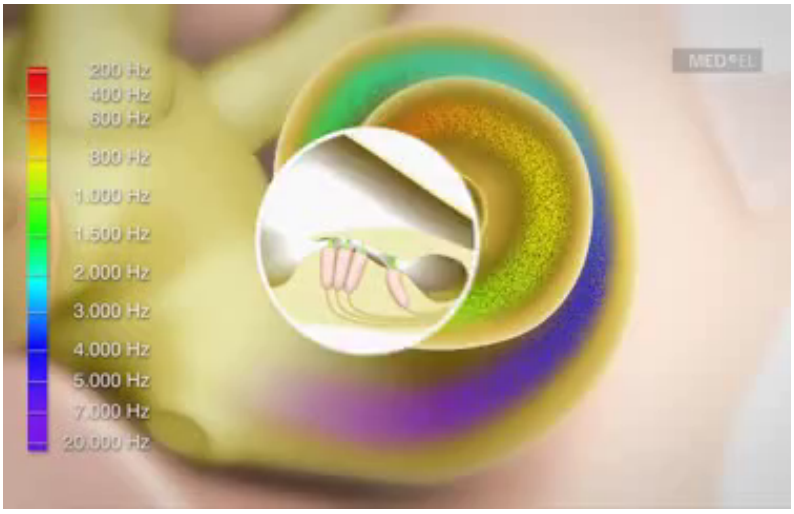


Middle Ear: pressure waves vibrate the eardrum and bones in the middle ear space

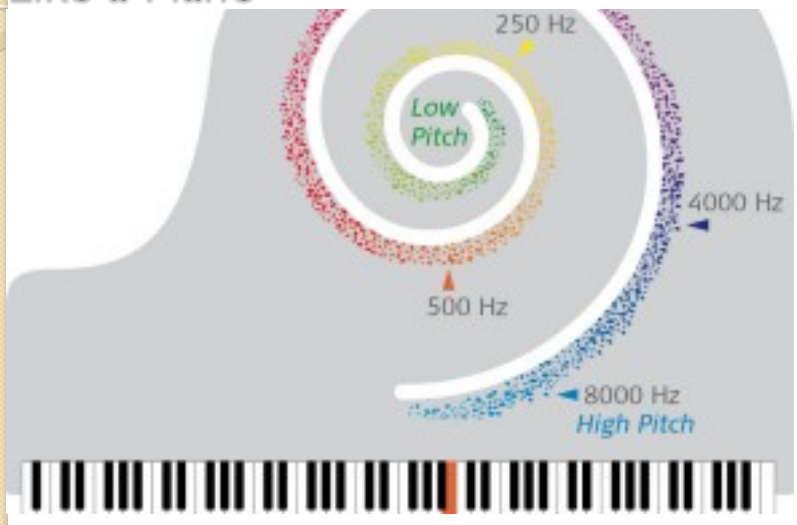


Inner Ear (Cochlea): Inside the cochlea, there are thousands of tiny hair cells. Hair cells change the vibrations into electrical signals that are sent to the brain through the hearing nerve.

Inner Ear – Inner and Outer Hair Cells

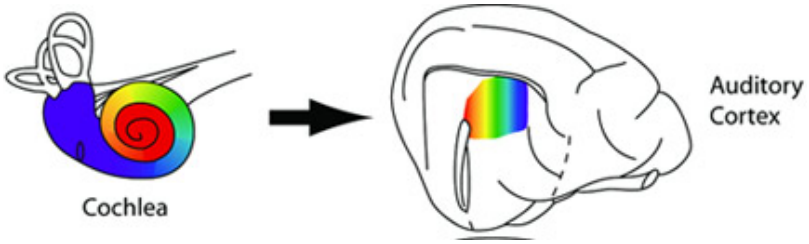


Cochlear Piano – Different areas in the inner ear represent different pitches – Like a Piano



Message interpreted by Brain: The brain tells you that you are hearing a sound and what that sound is.

Tonotopic Organization: This happens throughout the auditory system



How do we separate the speech from the noise?

How we separate speech from noise:

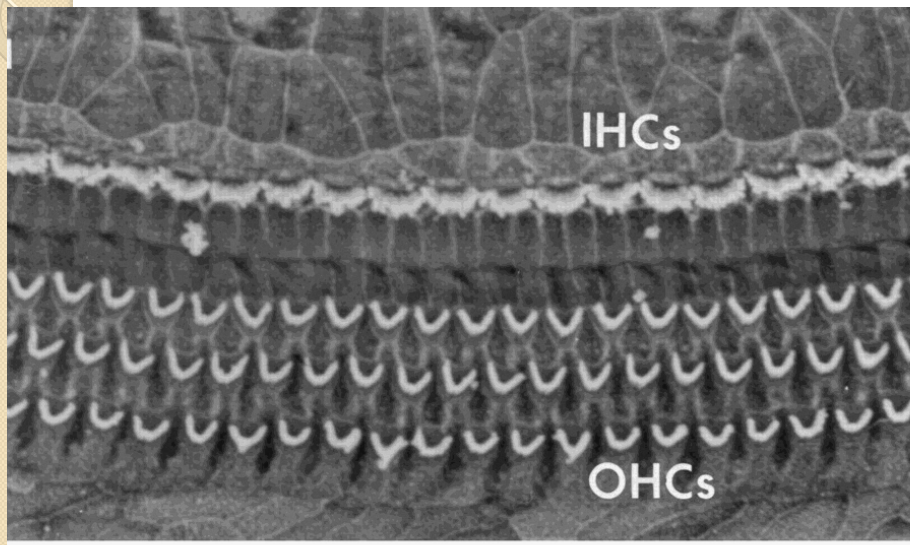
The Inner Ear!

- Outer hair cells
- Inner hair cells
- Cochlear synapses

  Connections between the hair cells and the auditory nerve

**New Research!

Normal Cochlear Hair Cells

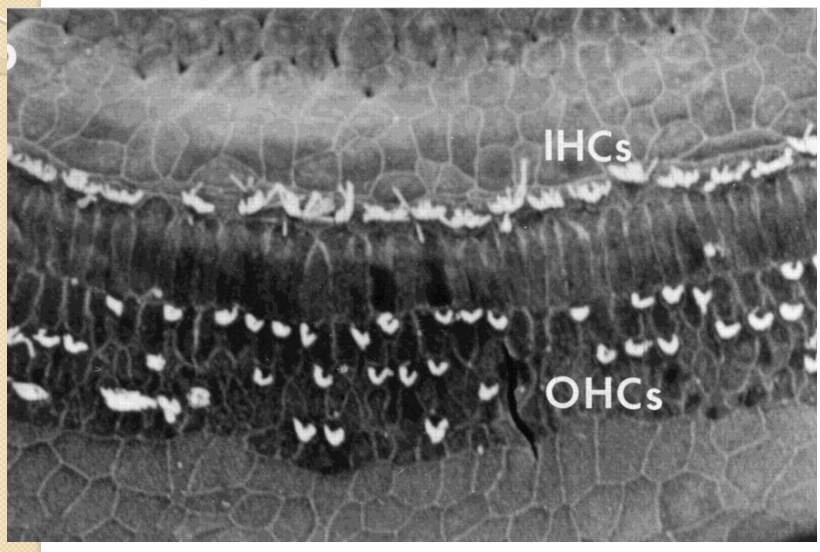


Outer Hair Cells

Two Main Functions:

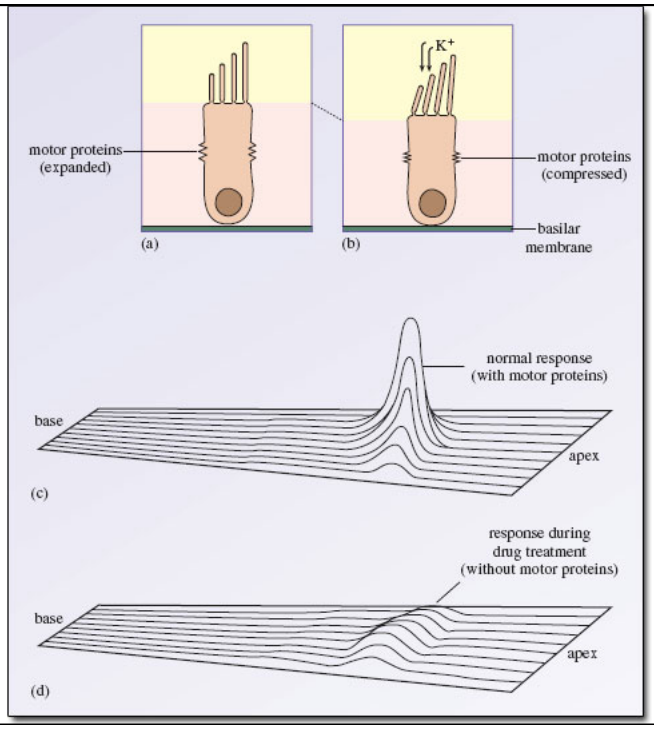
1. Turn up soft sounds
2. Sharpen the frequency response

Damaged Cochlear Hair Cells



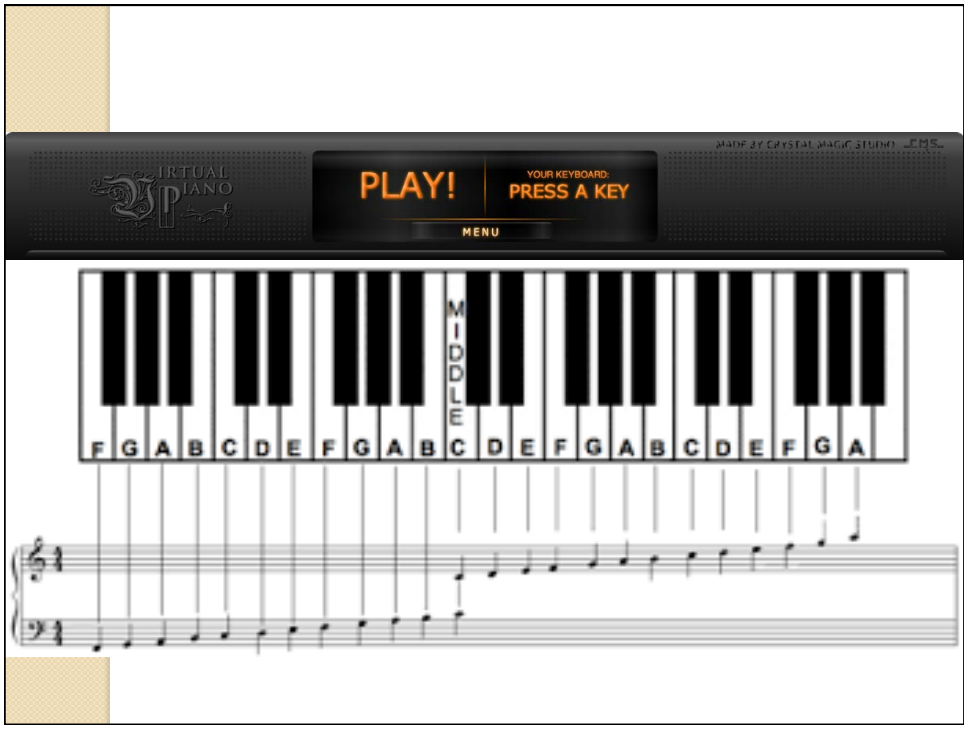
Frequency Selection

Not only do the outer hair cells amplify soft sounds, they also increase the sensitivity of the cochlea for frequencies to which the corresponding part of the cochlea is tuned



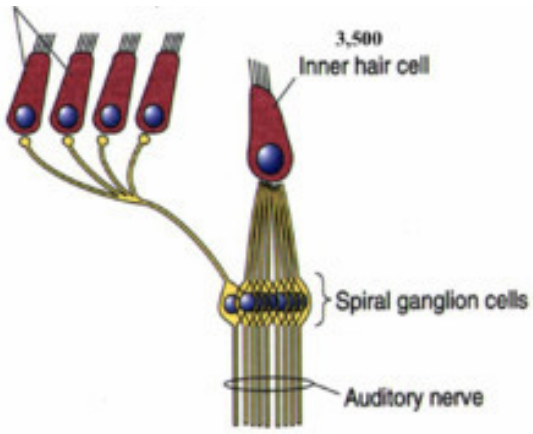
Damaged Outer Hair Cells

- Inability to turn up soft speech sounds
- Inability to separate differing speech frequencies
- Inability to separate the different frequencies contained in speech and noise
- Inability to send separate signals to the brain about what is speech and what is noise



Inner Hair Cells

Take information from outer hair cells to the brain



Damaged Inner Hair Cells

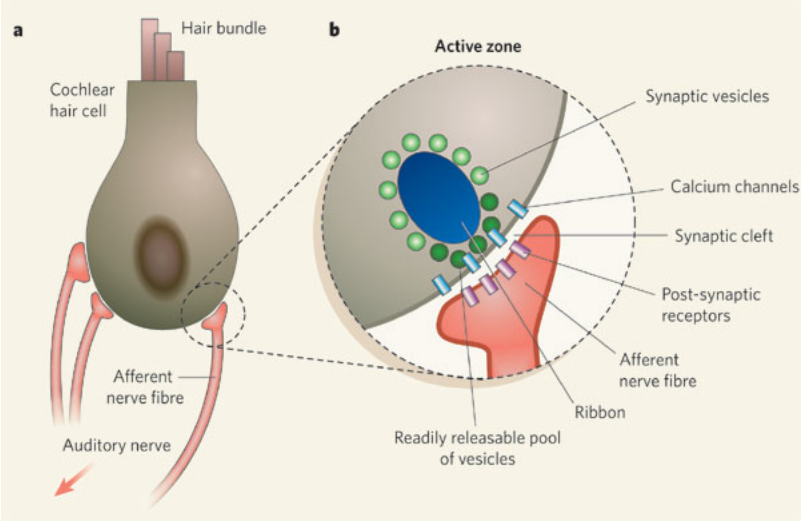
- Damage results in loss of sound and speech information, sending a garbled signal to the brain

New Research: **Cochlear synapses**

"Hidden Hearing Loss"

Effects Temporal Processing

New Research: **Cochlear synapses**



"Hidden Hearing Loss"

- Normal audiogram
- Problems understanding speech in background noise
- Damaged connections between hair cells and nerve terminals
- This effects information sent to the brain, particularly about the timing of speech information when noise is present

Other issues with hearing loss:

- **Frequency** ✔
- **Timing**
  - Diminished ability to hear a signal that rapidly follows or precedes a different signal
- **Spatial**
  - Diminished ability to separate sounds on the basis of the direction from which they arrive

I don't understand….

y □ h□d □ r□tt□n d□y
v□s c□m□ng □n fr□m pl□y.
□d□nt□lly st□bb□d my t□□s
□pp□d □nd f□ll □nd wh□ck□d my
pp□d □ t□□th. □ c□t my l□p.
□p□d my kn□□. □ h□rt my h□p.
□d my sh□□ld□r, tw□□k□d my □□r
□t □ br□□s□ □p□n my r□□r.

Processing and the Brain

Age-related changes:

- Cognitive processing
- Temporal processing
- Working Memory
- Attention/Distractions

Outline

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Main Goal of Hearing Instruments:

- Increase audibility and increased intelligibility
- **Improve the Signal-to-Noise Ratio**
- The speech has to be louder than the background noise to improve intelligibility

Hearing Instruments:

- Good at amplifying soft sounds
- Good at providing different amounts of volume at different frequencies regions

- **Cannot** replace frequency specific nature of the auditory system
- Microphones have many limitations in noisy and reverberant environments

Main Features to help in noise:

- Directional Microphones
- Digital Noise Reduction
- Microphone at the Sound Source

Directional Microphones

- Sense sound at two locations in space
- Emphasize wanted sounds coming from one direction
- Partially suppress unwanted sounds coming from other directions

- Only proven feature to improve the SNR

Directional Microphones

Directional Mic Limitations

- **Reverberation!!!**
  - Room Acoustics
- Distance and Intensity of Noise
- Distance and Intensity of Speaker

- Insensitivity from sounds from the back and sides

Digital Noise Reduction

- Attempts to provide less amplification to noise than to speech
- Tries to make ambient and background sounds more tolerable
- Tries to recognize speech vs. noise based on the pattern, intensity and frequency of the signal

Limitations to Noise Reduction

- Does not improve speech intelligibility
- Improves listening comfort and reduces listening effort
- Reduces low frequency soft level gain
- May take away from needed low frequency amplification

Best Communication Solution:

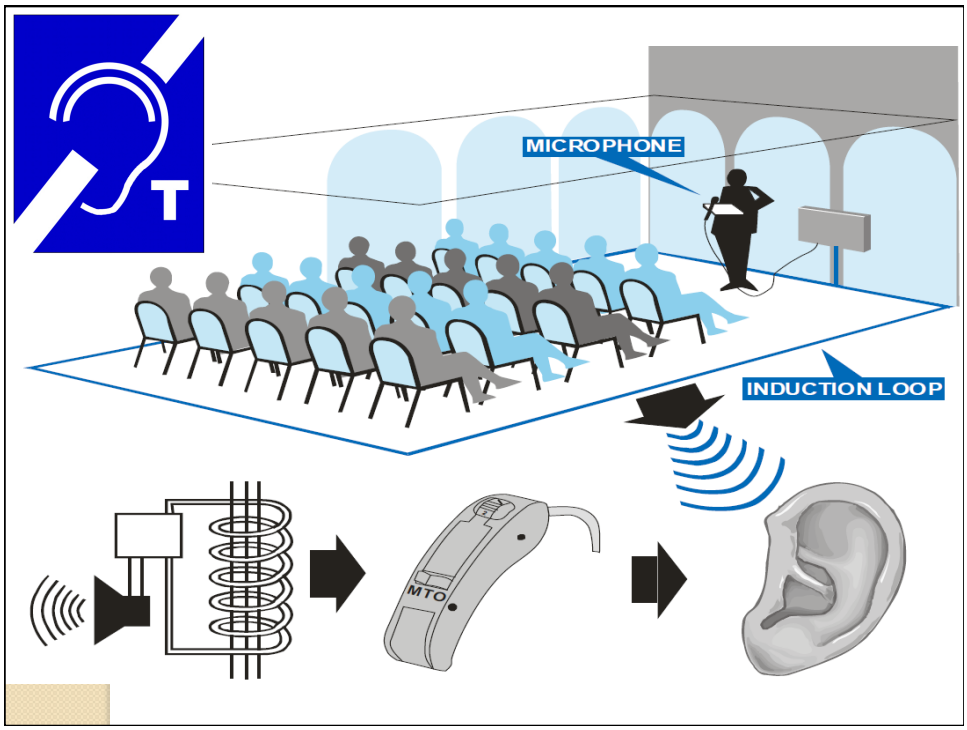
- **Microphone at the Sound Source**

Microphone at the Sound Source

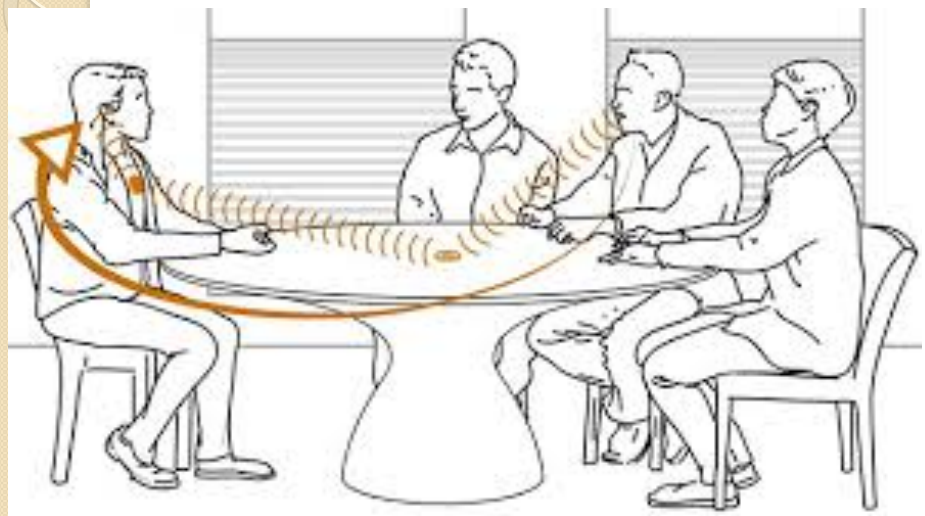
Best Solution!

Direct Audio Input Technology

- T-coils and neckloops
- FM receivers
- Companion Bluetooth Microphones



Best Signal-to-Noise Ratio



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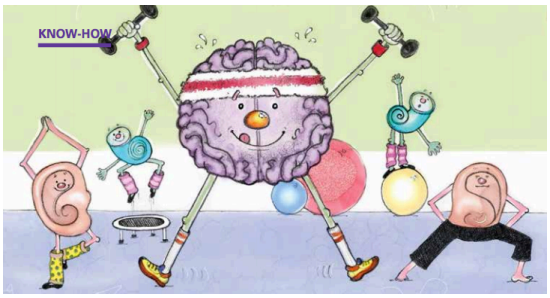
Tips

- Two Devices vs. One
- Appropriate fitting for audibility based on verification testing
- Acoustics - What's in your ear!
- *Proper placement of device in and on ear*
- Program Options
- Education and Realistic Expectations

Auditory Training

- Lip-reading Classes
- Memory Games
- Auditory Rehabilitation



Communication Strategies

- Plan ahead
- Ask for accommodations
- Enhance lighting
- Obtain attention first
- Use visual cues
- **Advocate for yourself**

Final Points

- Newer does not always mean better
  - Be weary of the "Research"
- Hearing Instruments and Microphones have limitations

Final Points

- Selection, programing and verification should to tailed to you
- Regular maintenance is important
- Educate yourself on hearing device accessories and technologies
- Take the time to ensure the devices are inserted correctly
- Wear them consistently everyday for best results

Thank you!

Questions?