2010 청각학회 보청기 W/S

Selection and Fitting

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*HA Selection

Factors to Consider in Selection of HA

General Considerations

- Age
- Configuration and Degree of hearing loss
- Auditory environment
  - Educational environment
  - Special needs
- Style
  - Body
  - BTE
  - ITE/ITC
  - CIC
  - Open Canal

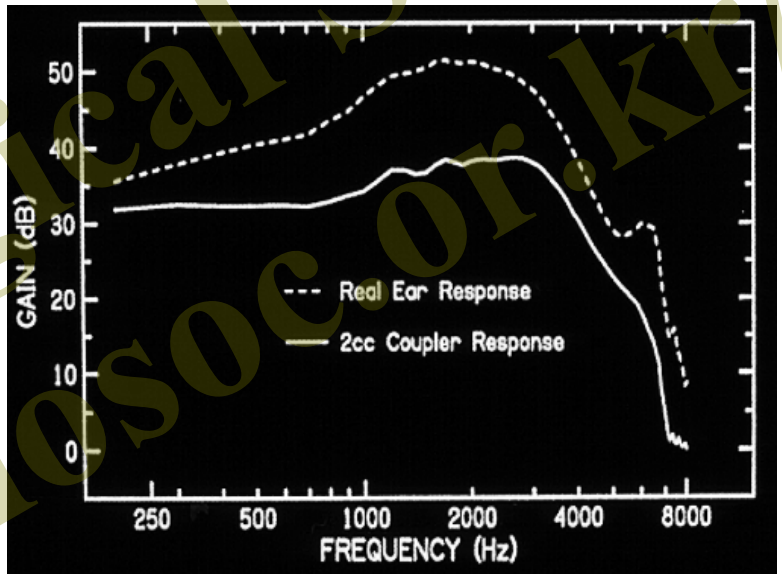
Optional Functions

- Channels
  - Multichannel
- Feedback cancellation
- Digital noise reduction
- Directional microphone
- Automatic program
- Data Logging
- Extended high frequency gain
- FM/Remote Control

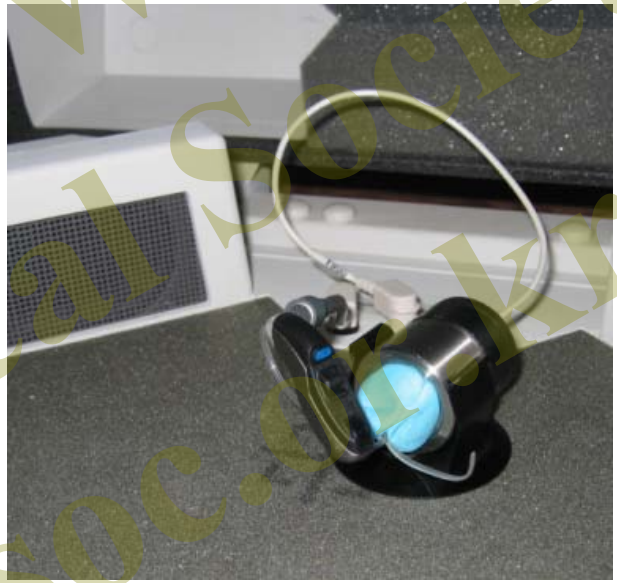
HA Selection in Children

Characteristics of Young Hearing Aid Candidate

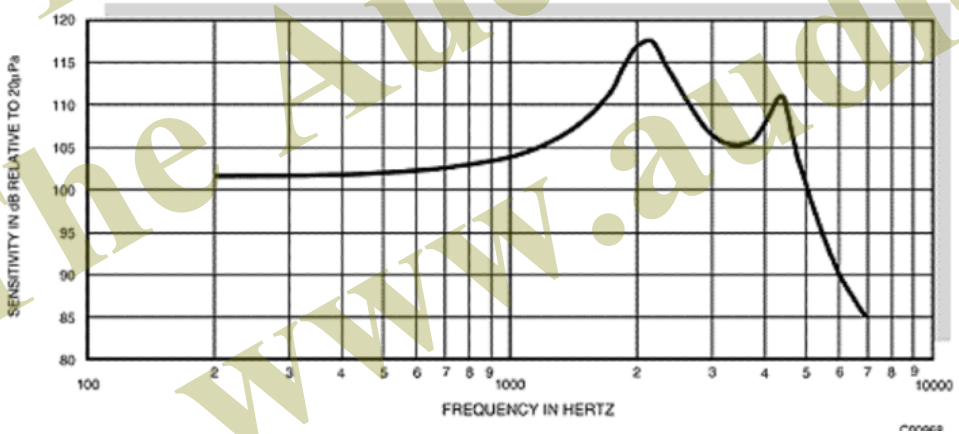
- Small Ear Canal
  - RECD
  - Limited Earmold Options
- Practical Issues
  - Size of baby's ear
  - Hearing Aid Size
  - Retention



2cc Coupler Response

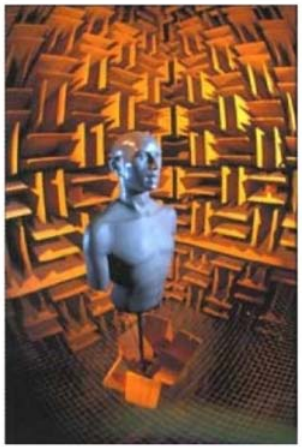


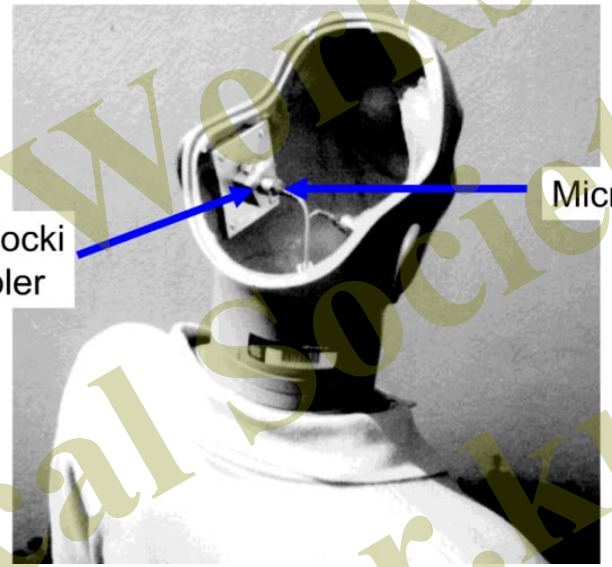
- on a 2cc coupler

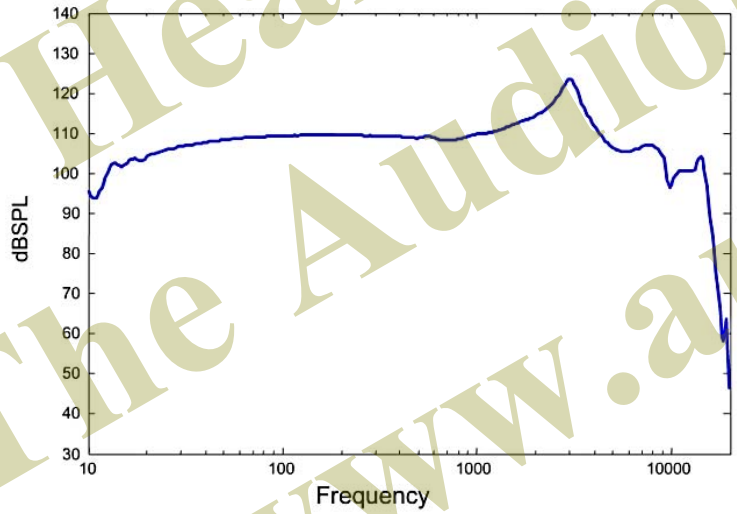


- Any and all venting is closed off
- Minimal risk of Feedback
- Stable and repeatable measurements

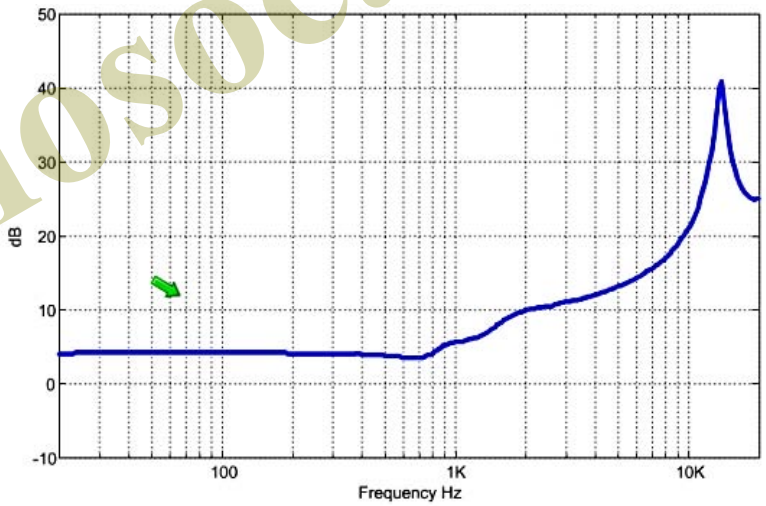
KEMAR







Receiver Bandwidth - on KEMAR

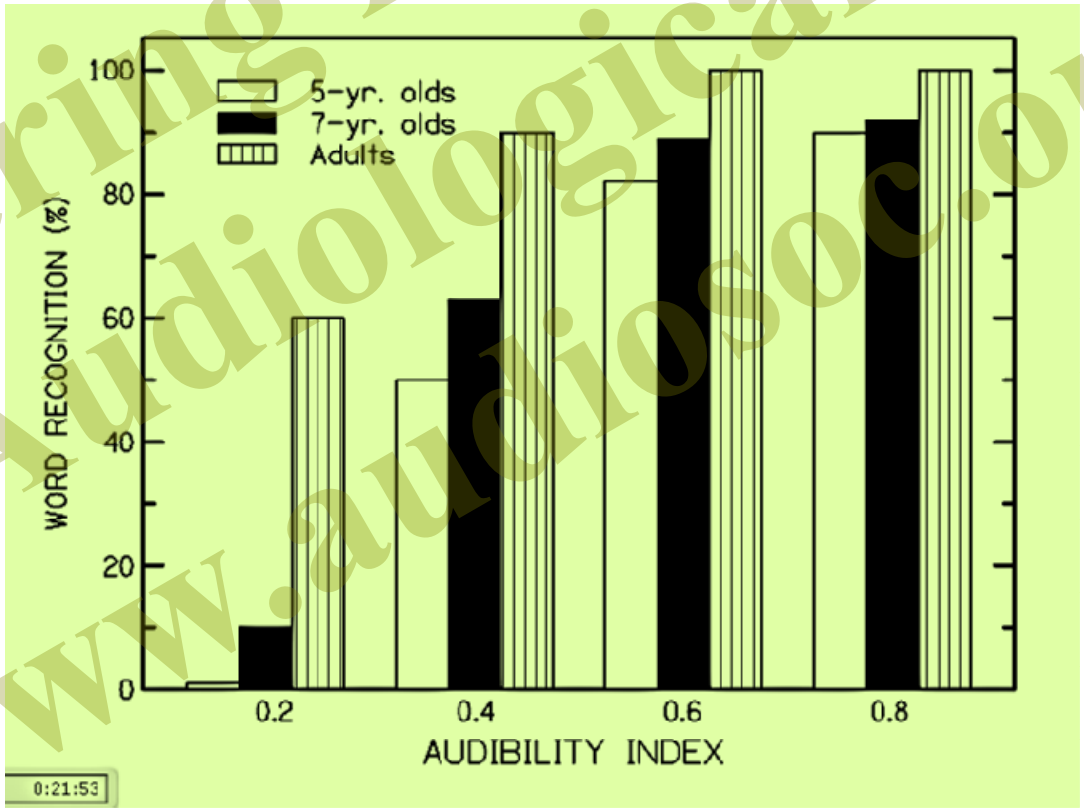


RECD of Zwislocki coupler

Children Require

Higher SPLs for equivalent word recognition in 4-word sentences

(Stelmachowicz, Hoover, Lewis, Kortekaas, & Pittman, 2000)



Effects of Distance and Noise Children with Normal Hearing

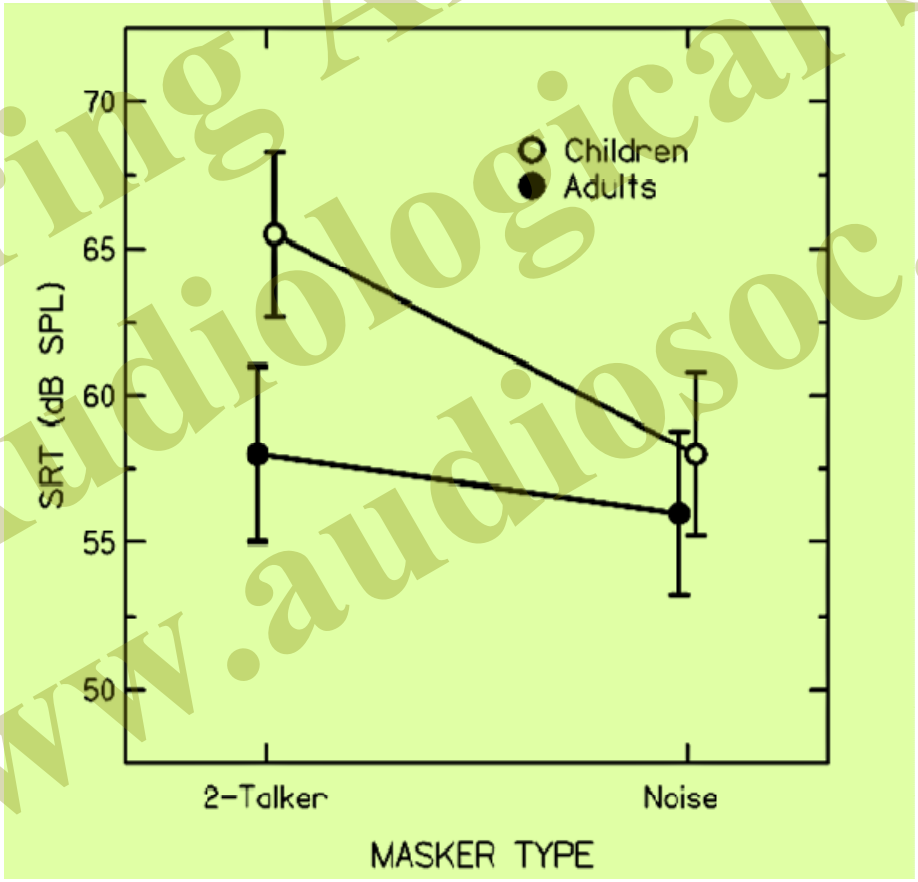
AGE group	Word Rec. Quiet/Close (1.8 meters)	Word Rec. Noise/Far (7 meters)
4 years	88.3%	67%
5 years	94.3%	84%
6 years	98%	87.6%
Adult	99.3%	97%

(Johnson, 1999)

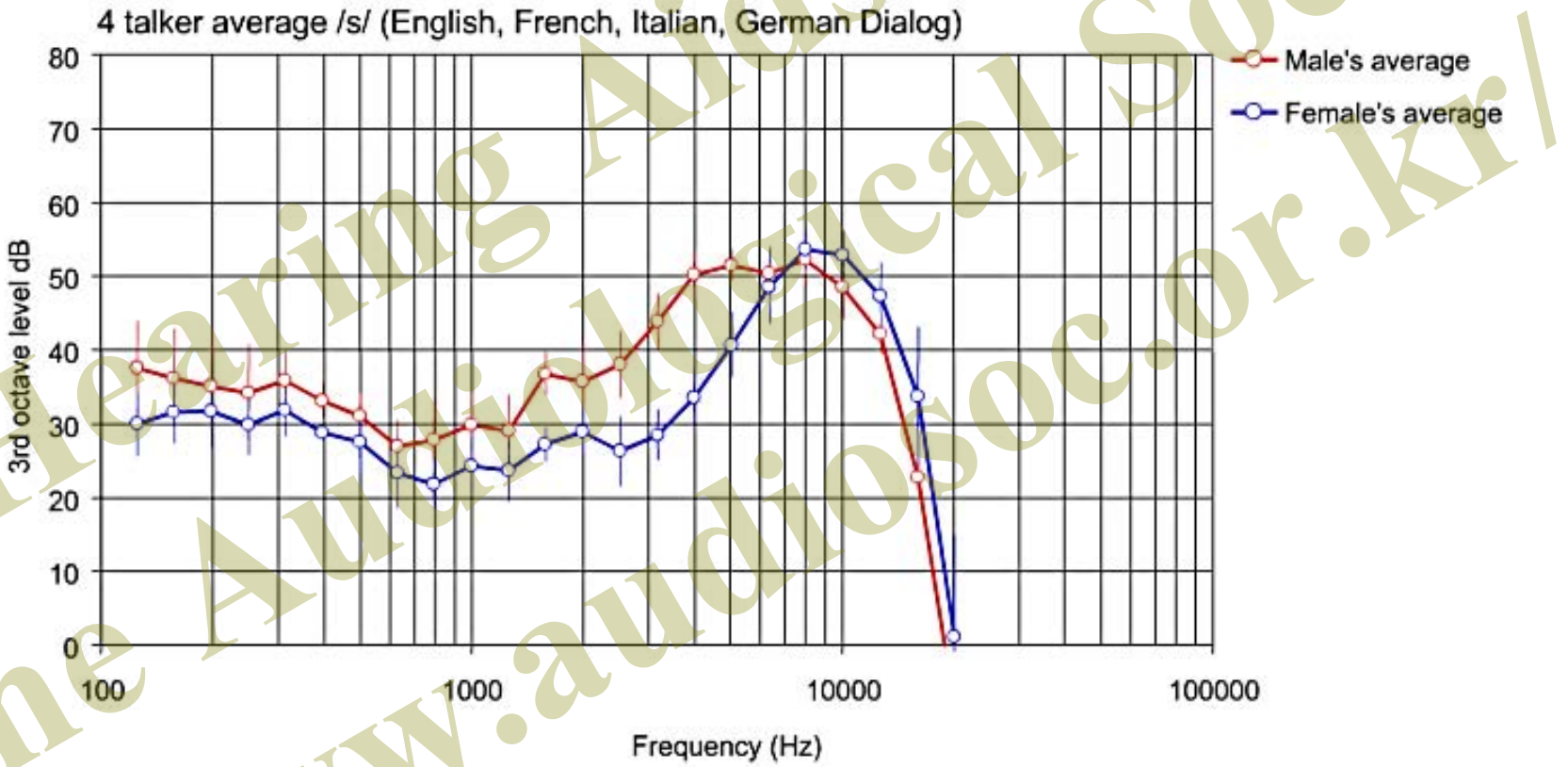
Children Require

Higher SNRs for equivalent spondee recognition

(Hall, Grose, Buss, & Dev, 2002)



Average /s/



Children Need

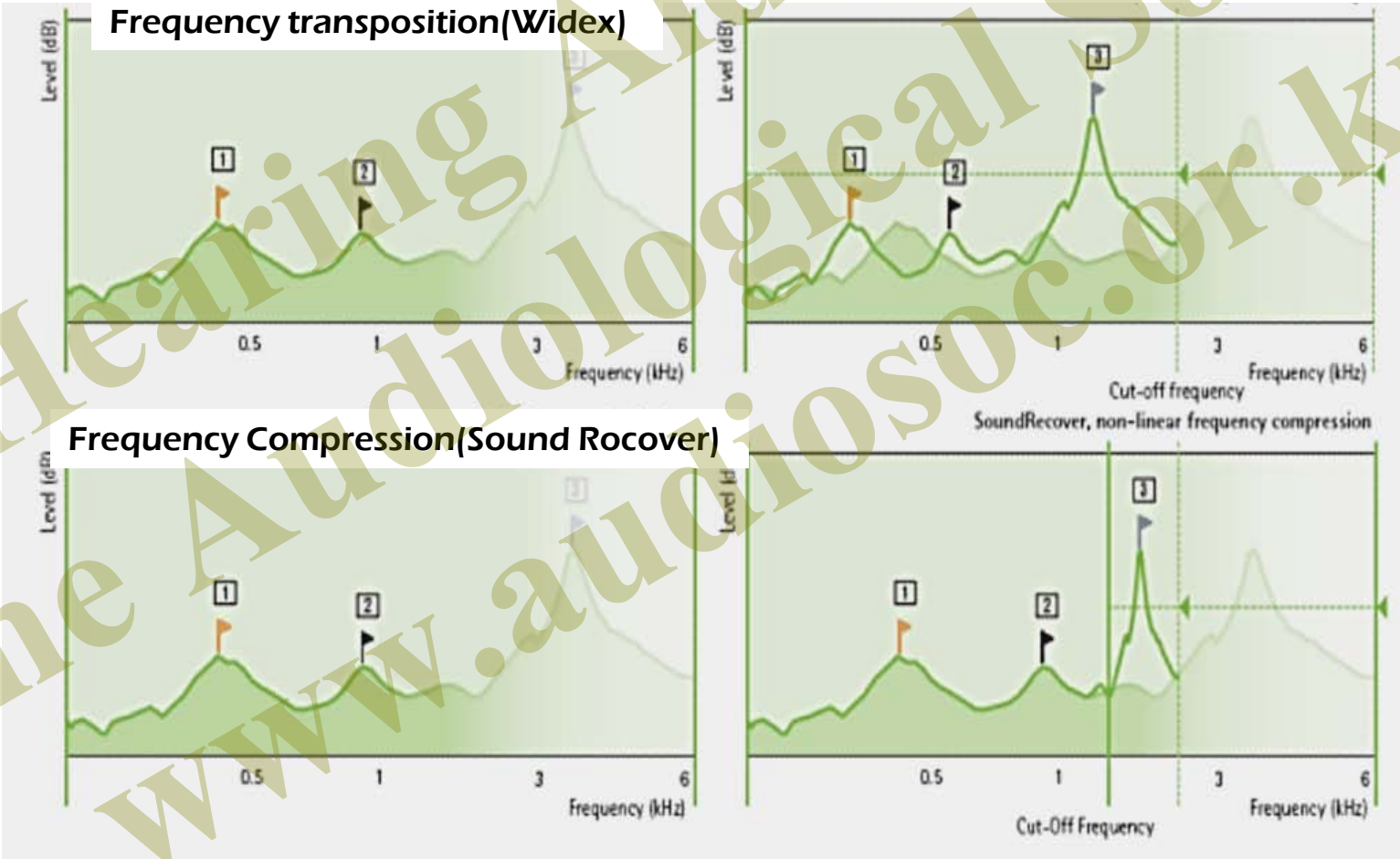
- Higher signal-to-noise ratio (Hall et al, 2002)
- Lower reverberation times (Neuman et al, 1983)
- Less able to make use of context (Nittrouer & Boothroyd, 1990)
- Depend more on audibility of high frequency amplification
- High frequency audibility to develop proper speech and language skills (Stelmachowicz et al, 2002)

HA in Children: Circuitry Options

- Access to high frequencies
- FM/Remote control
- Feedback cancellation
- Digital noise reduction
- Multiple bands for flexible gain response

Frequency Compression and Transposition

"Shift" or "compress" high frequency sounds to lower frequencies



Frequency Lowering Devices
The Evidence Based Bottom Line

- Review of 10 studies employing modern frequency lowering in adult populations:
- 8 of 10 studies
  - Majority of patients find little appreciable benefit to frequency lowering hearing aids when compared to properly fitted conventional devices.
  - For the small % of patients who do report benefit it comes at a significant price – poor sound quality and a long adaptation period.
- 2 of 10 studies
  - Significant improvement in speech intelligibility associated with training (5 weeks, 4 hours/day, 6 days per week).

- Frequency Lowering devices show promise but no evidence supports their effectiveness in everyday listening situations.

Additional Options

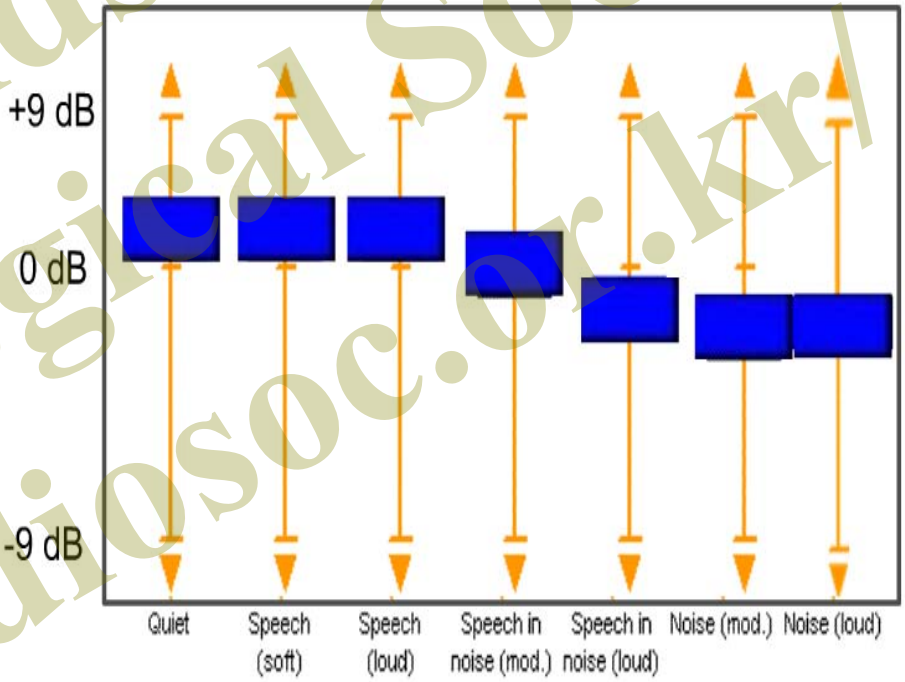
- Directional microphones
- Telephone programs
- Automatic switching of programs
- DataLogging
- Bluetooth

Data Logging

Automatic Program Switching

Classify Setting and Apply Pre-Set Gain

Classify the Environment



User Preferences

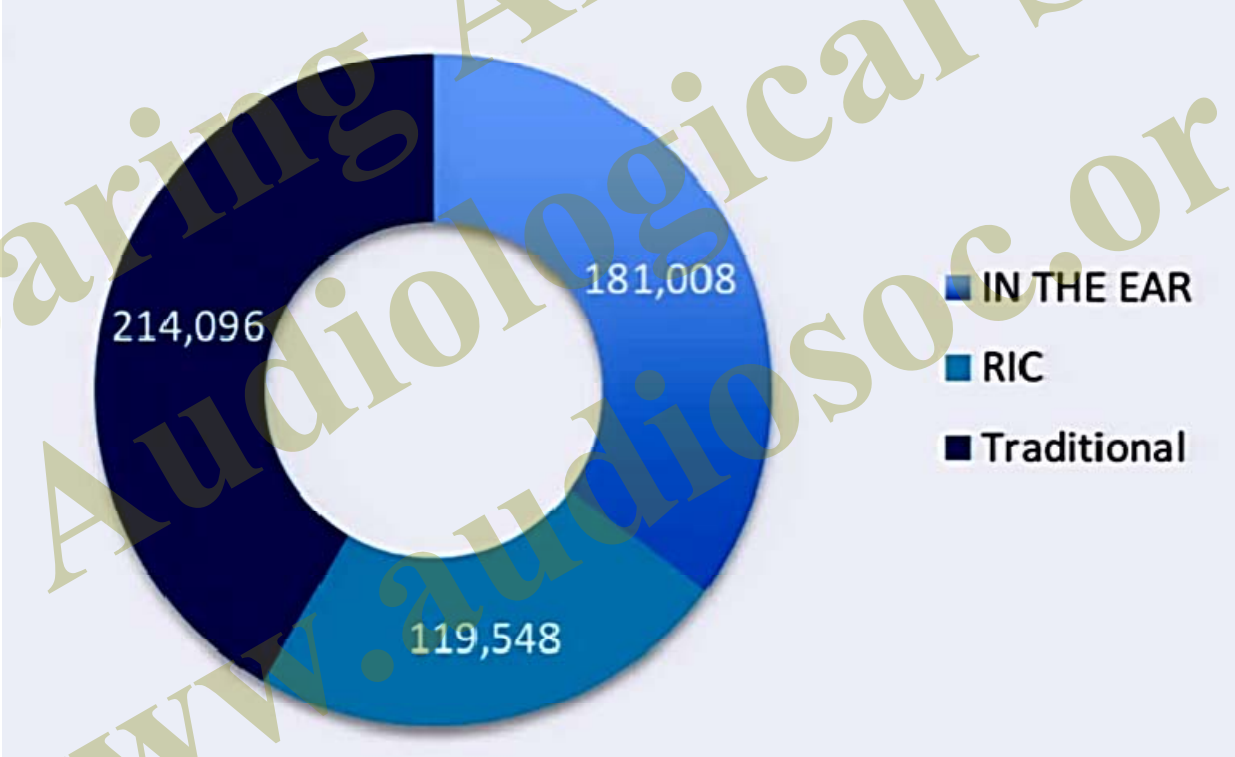
Bluetooth Latency

- TV speaker to ear : 10ms
- Bluetooth(A2DP transmitter) to streamer (3.83 Mhz) to HA: 250 ms
- Today's Bluetooth codec is inefficient and would result in delays of 100 ms or more
- Consumer electronics industry will introduce a more efficient codec for TV transmission

HA Selection in Adults

Which technologies make the biggest difference?

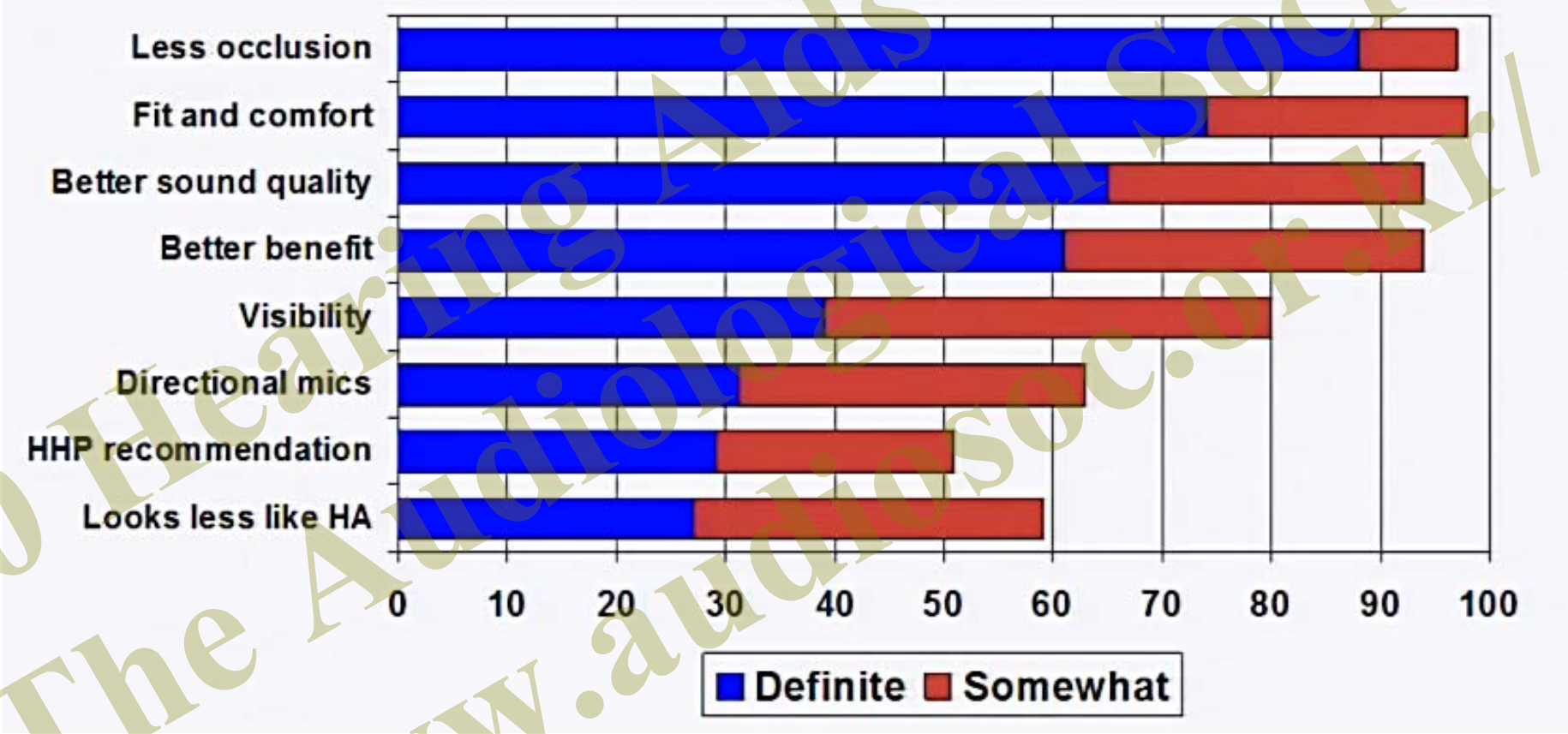
- Open fit "receiver in the canal(RIC)" BTE device



2009 US commercial trends

Receivers in the Canal (RIC)
= Open Canal (OC) Fitting
= Open Fitting

Reasons for RIC



2008 Dispenser Survey, Hearing Journal— AudiologyOnline

Open Fitting Candidacy

- Typical users complain that own voice is too loud or like they are speaking in a barrel
- Occlusion has been cited by as many as 30% of hearing aid users as a reason for their dissatisfaction or discontinued used

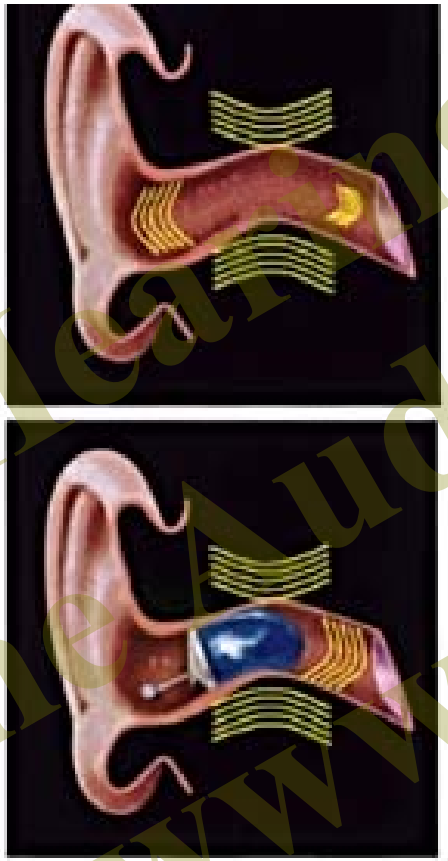
(French-Saint George & Barr-Hamilton, 1978; MacKenzie et al., 1989;Brügel et al., 1992)

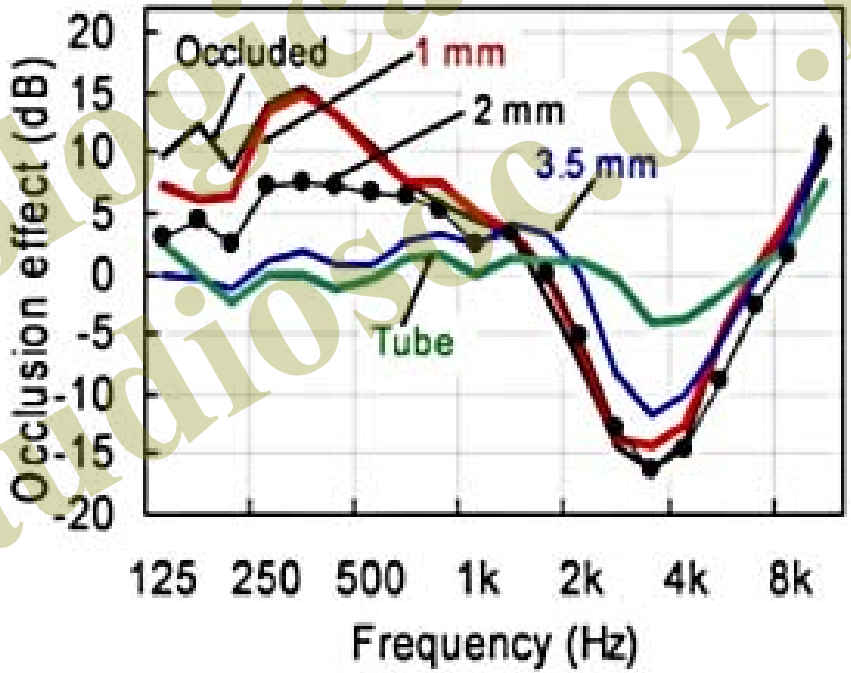
- Occlusion effect is most common problem for HA users with low-frequency thresholds better than 40 dB HL

(Dillon, 2001; May & Dillon, 1992)

Open Fitting Candidacy

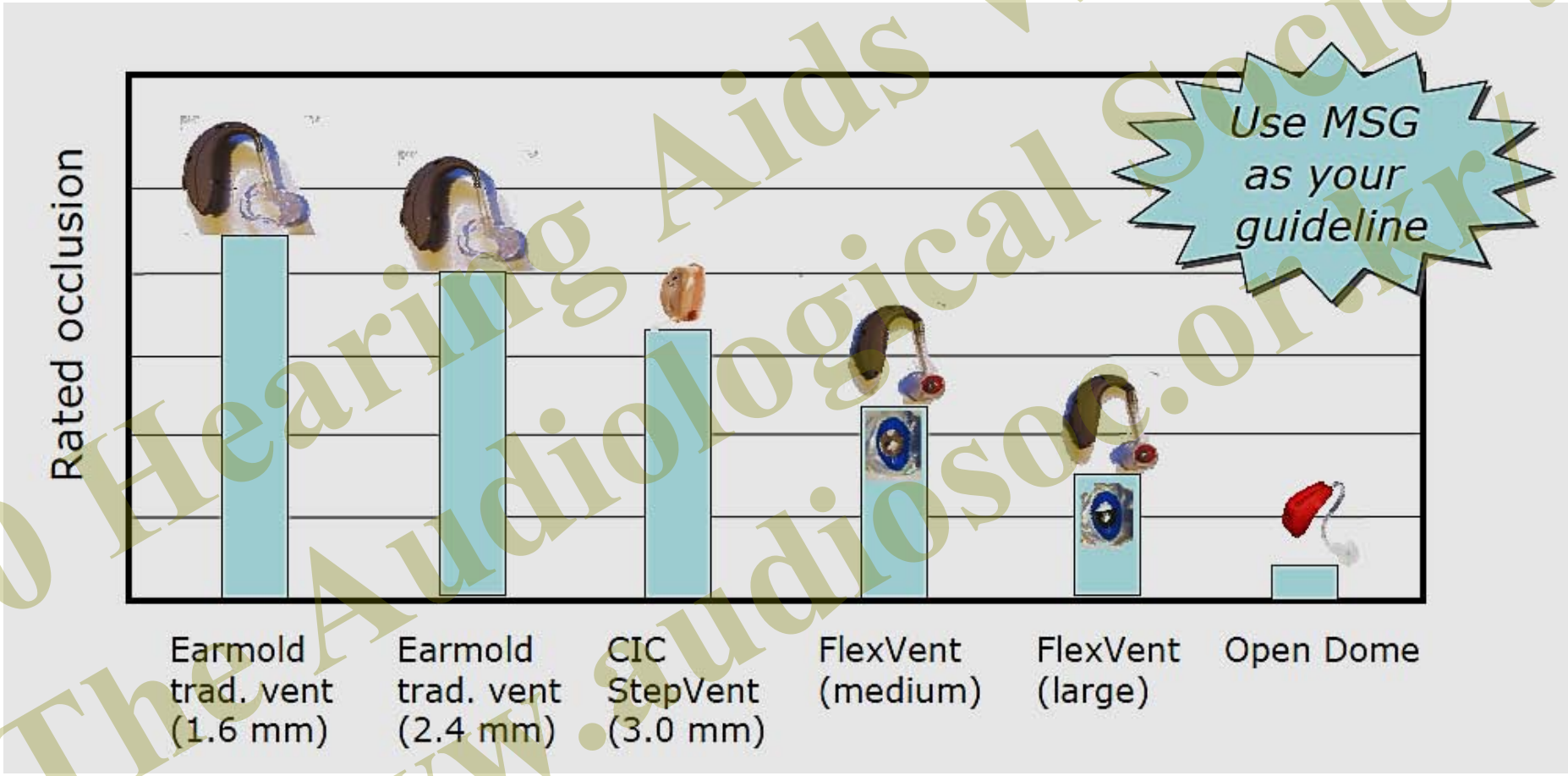
- Many investigators demonstrated acoustic relationship between earmold venting and occlusion effect as well as subjective correlates
  - Grover & Martin (1979); Wimmer (1986); Killion et al (1988); McKenzie et al (1989)....



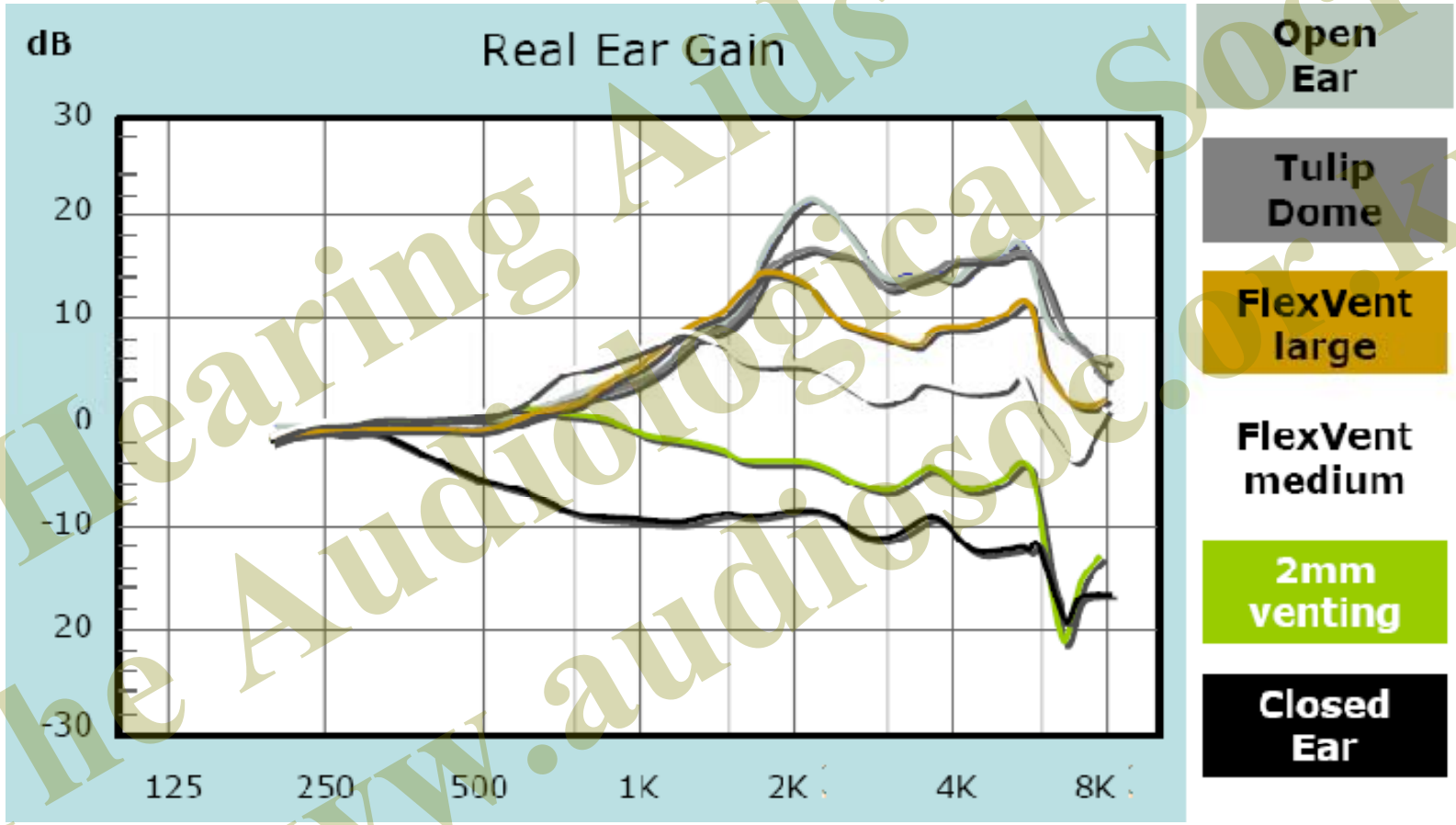


May & Dillon, 1992

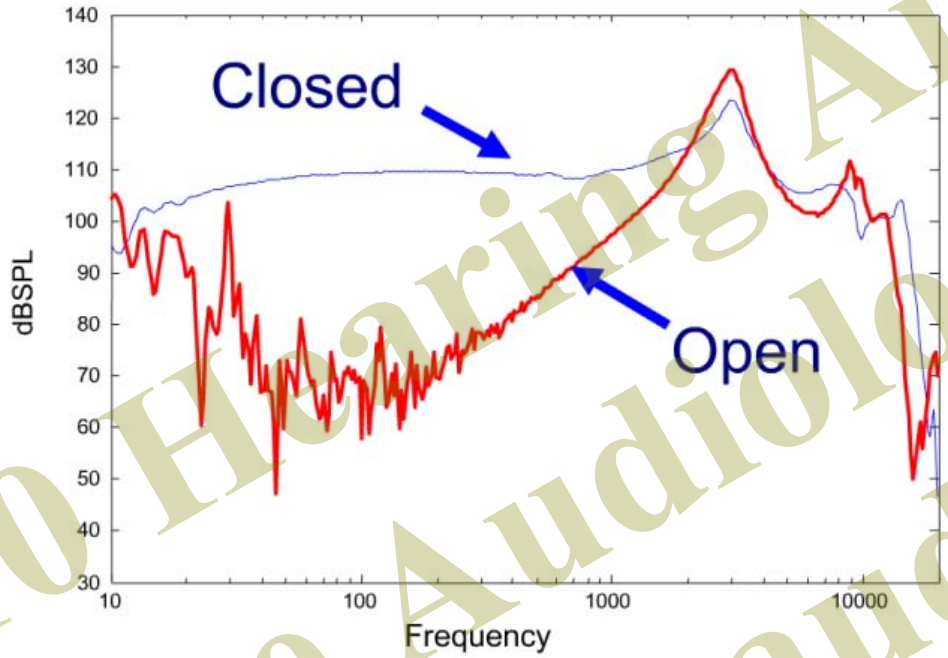
Occlusion Decreases with Open Solutions

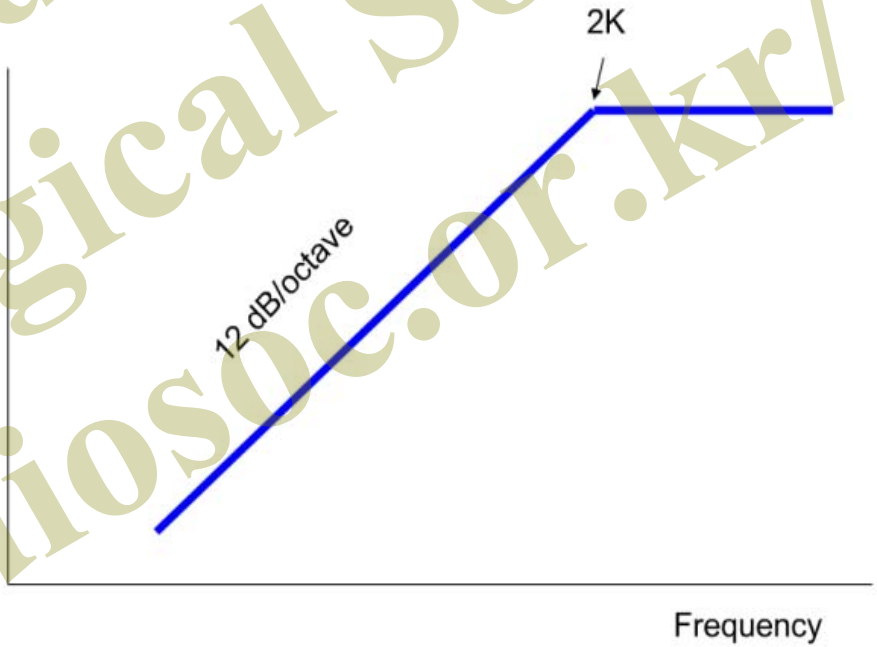


Open Ear Resonse



Output – Open vs Closed





Open Fitting Candidacy

Audiometric criteria

- Low frequency thresholds better than 40 dB HL
- Unusual audiometric configurations with areas of normal hearing (e.g. reverse slope, cookie bite)

Otologic considerations

- TM perforations, chronic EOM, outer ear malformation, etc

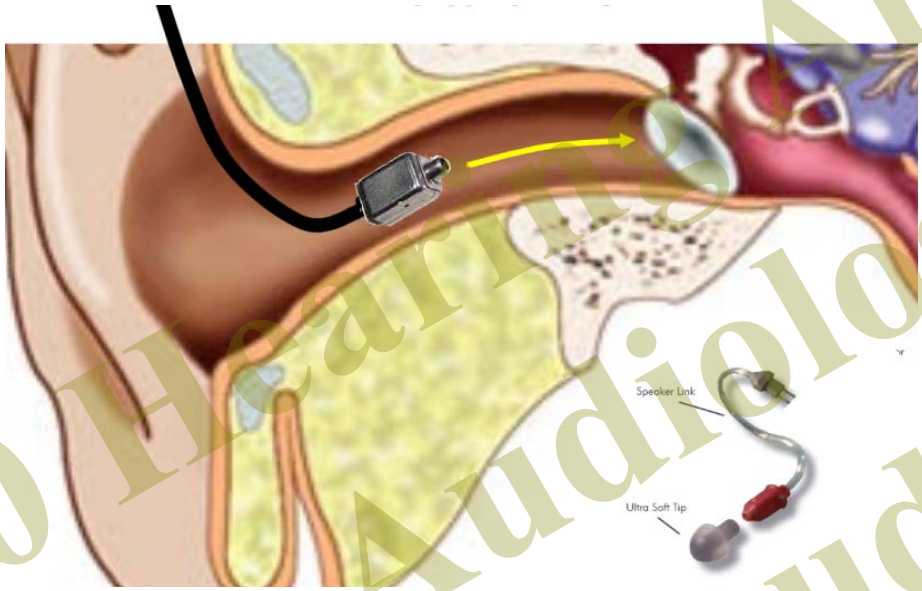
Other considerations

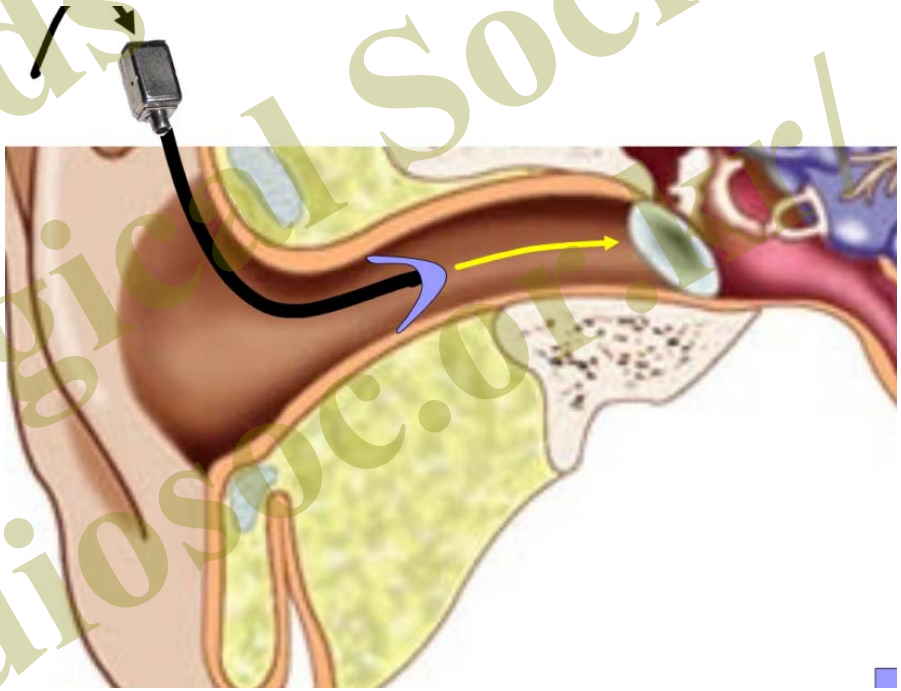
- Preference related to comfort and occlusion
- Sound quality preference
- Cosmetics

OC Fittings: Benefits

- Alleviate occlusion
- Improved sound quality due to use of natural low frequency signal
- Comfortable fit
- Improved cosmetics compared to many styles

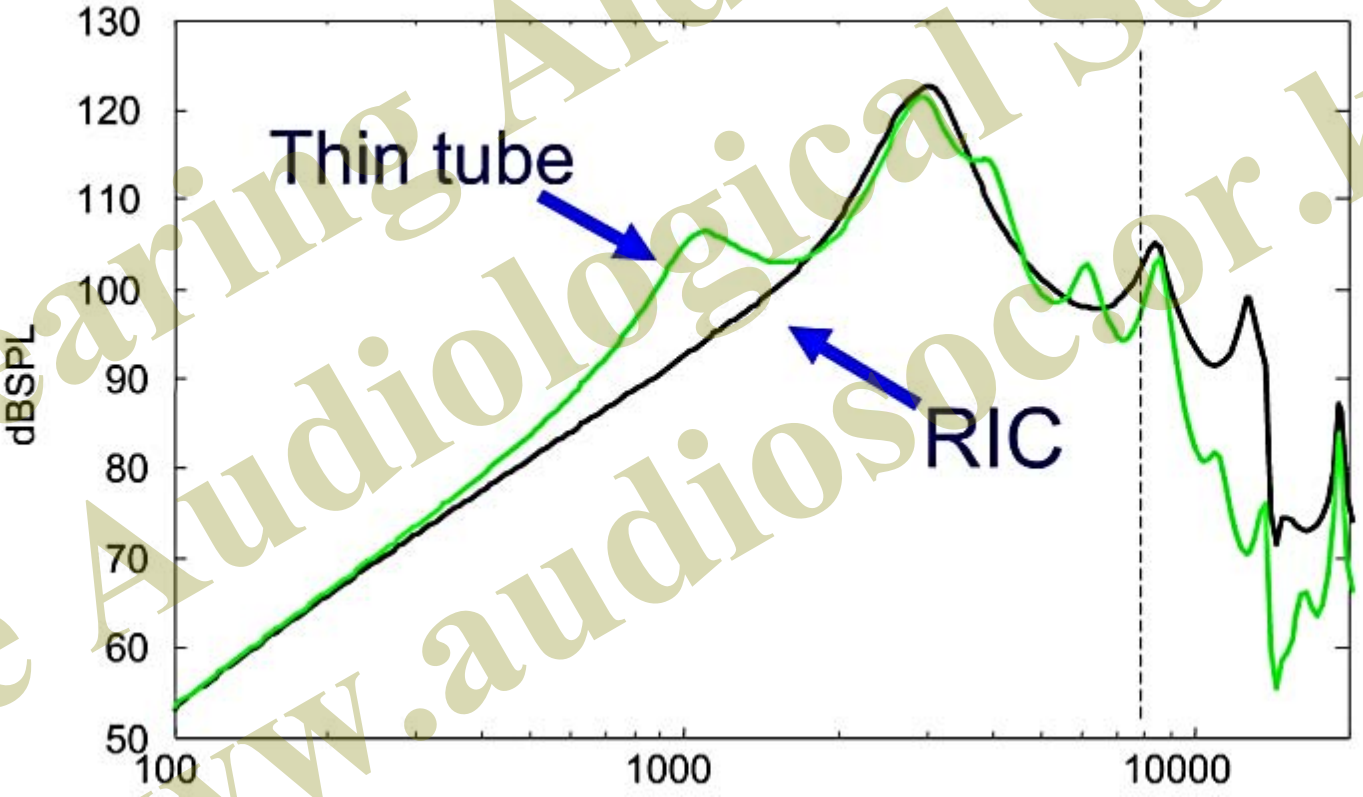
RIC vs Thin Tube





Trivia: Thin tube is 0.8mm diameter, and a #13 tube is 1.98mm

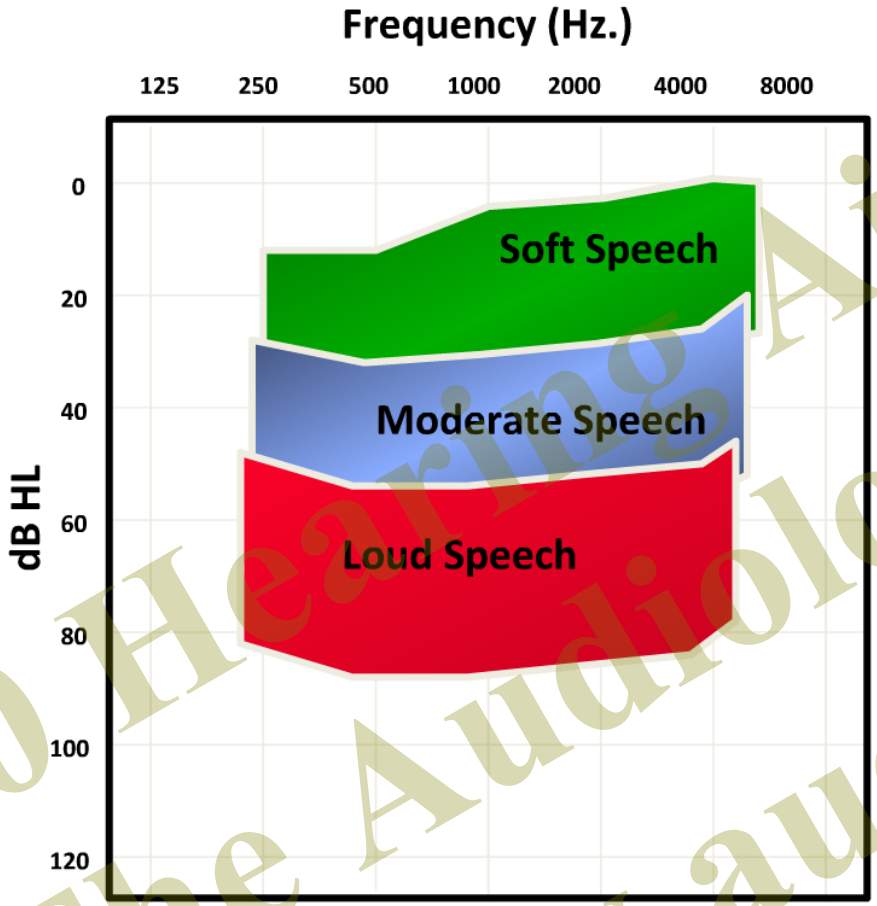
Thin Tube vs RIC

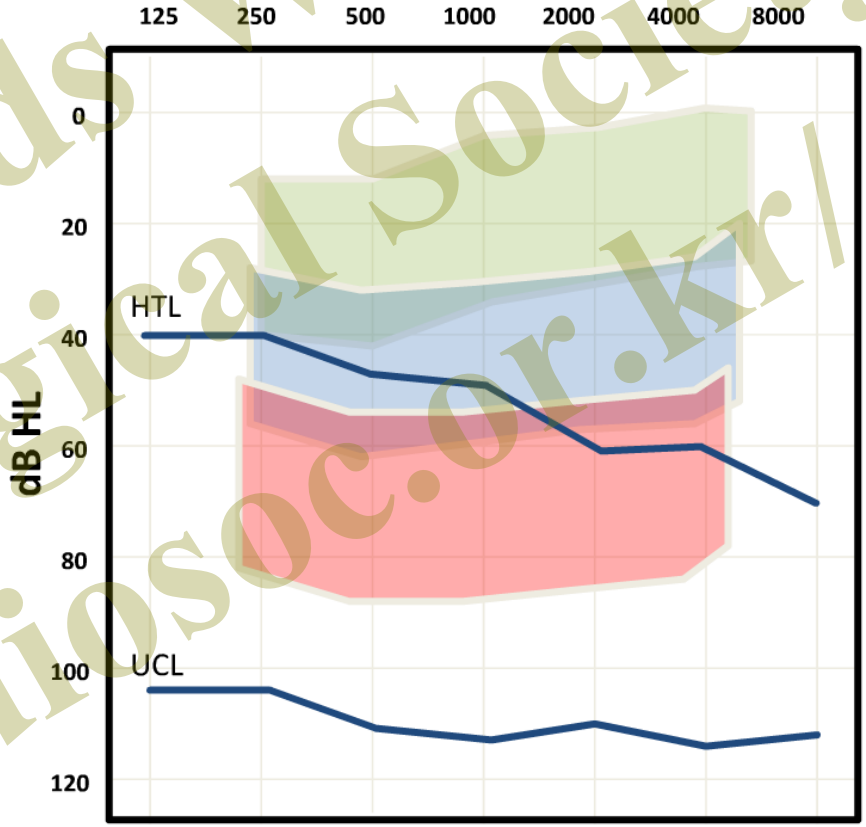


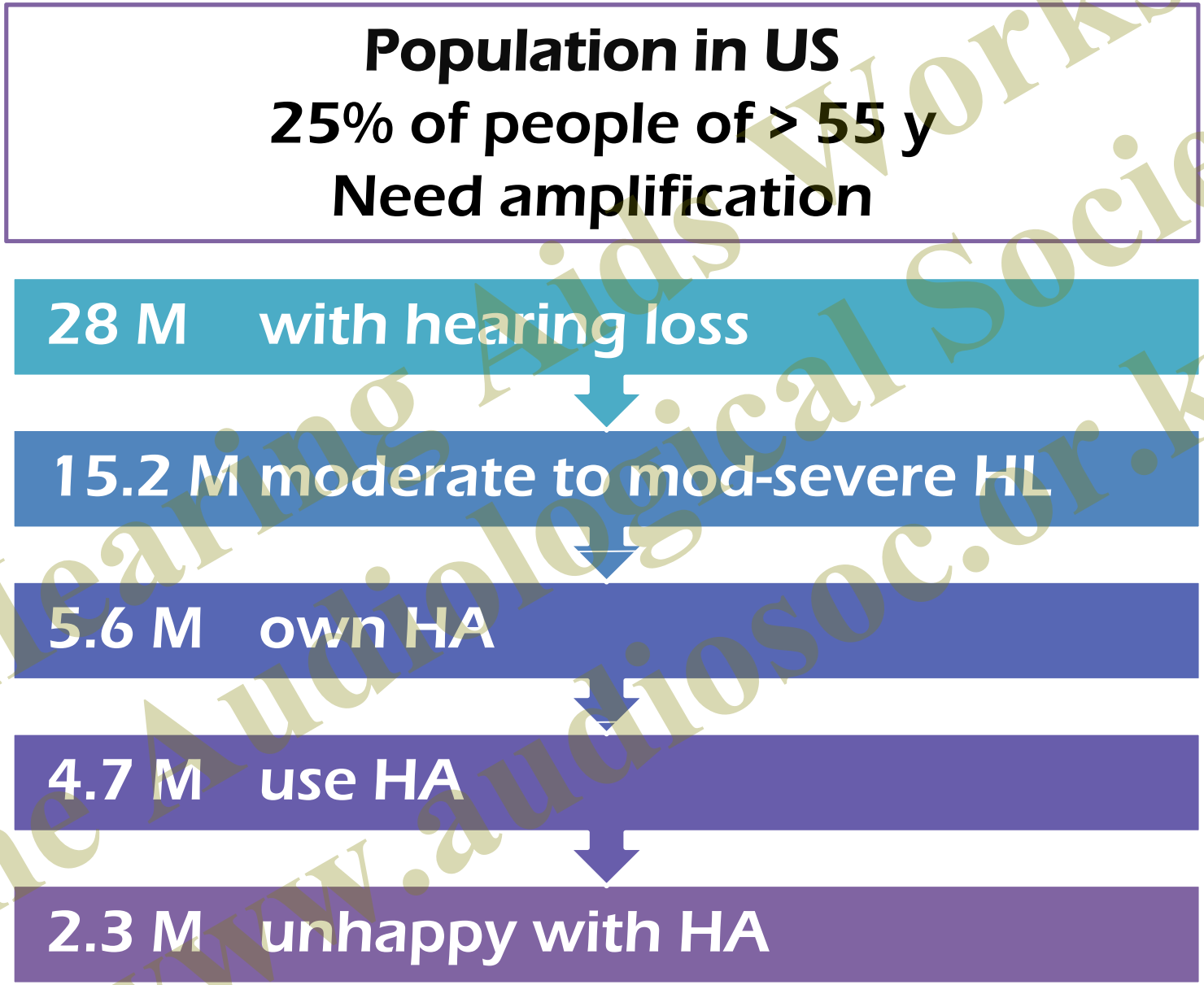
OC Fittings: Limitations

- Most models mainly appropriate for HF hearing loss (normal or near normal lows)
  - Adults may accept less benefit because of fewer negatives?
  - "Echo effect" when fitted with high amounts of gain.
- Additional care must be taken when fitting with Probe Mic equipment
- Directional benefit limited to about ½ of a good performing closed.
- More cerumen and debris issues

* Fitting Hearing Aids



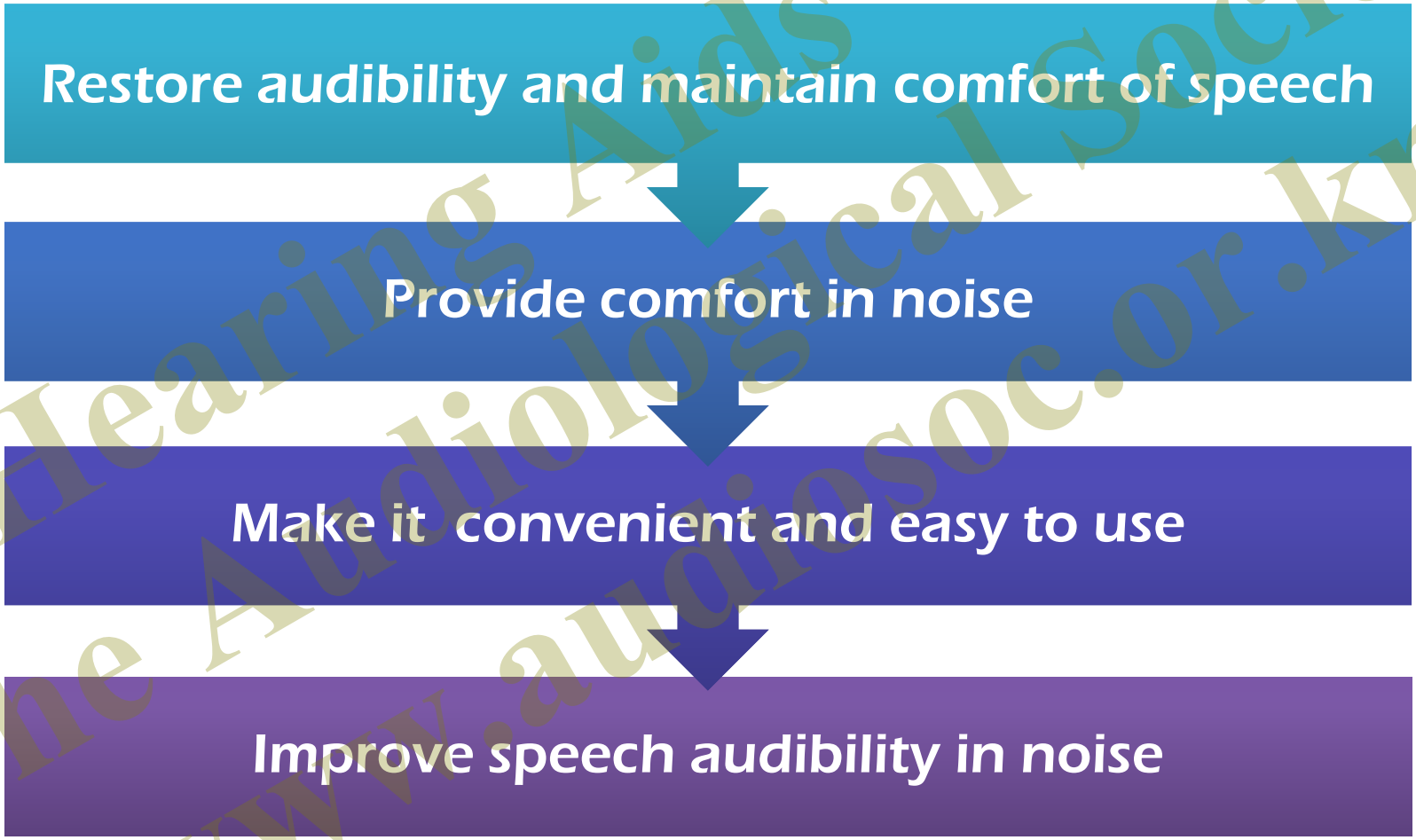




Absolute Expectations

- Functional on a daily basis
- Feedback free under normal use conditions
- Physically comfortable to wear
- Ability to hear soft and conversational levels of speech in quiet environments.
- Comfortable to wear in louder, noisier environments.

What we do on the day of fitting

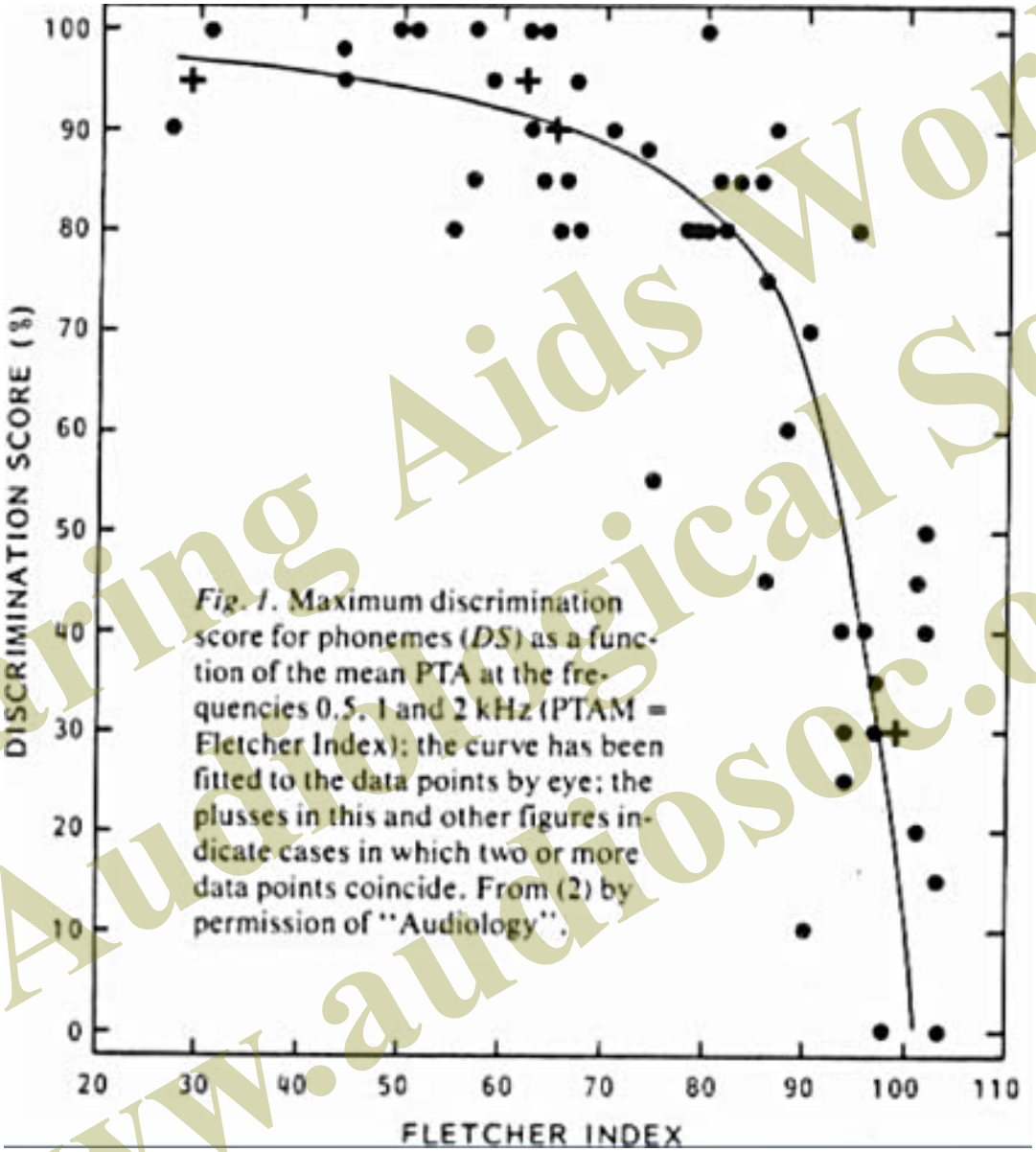


Basic Goal of Fitting

- Amplify soft sounds to compensate for hearing loss
  - 1/3 gain for mild to moderate
  - ½ gain for moderate to severe
- Prevent loud sounds from becoming uncomfortable
  - Too loud will prevent someone from being able to wear devices
- Need to verify through
  - Direct measurement: Real-ear is direct
  - Indirect measurement: Performance or questionnaire is indirect

Fitting Rationales

- Why would someone want something different?



Maximum speech discrimination as a function of average hearing loss (Lamore,Verweij & Brocaar, 1990)

Individual Differences in . . .

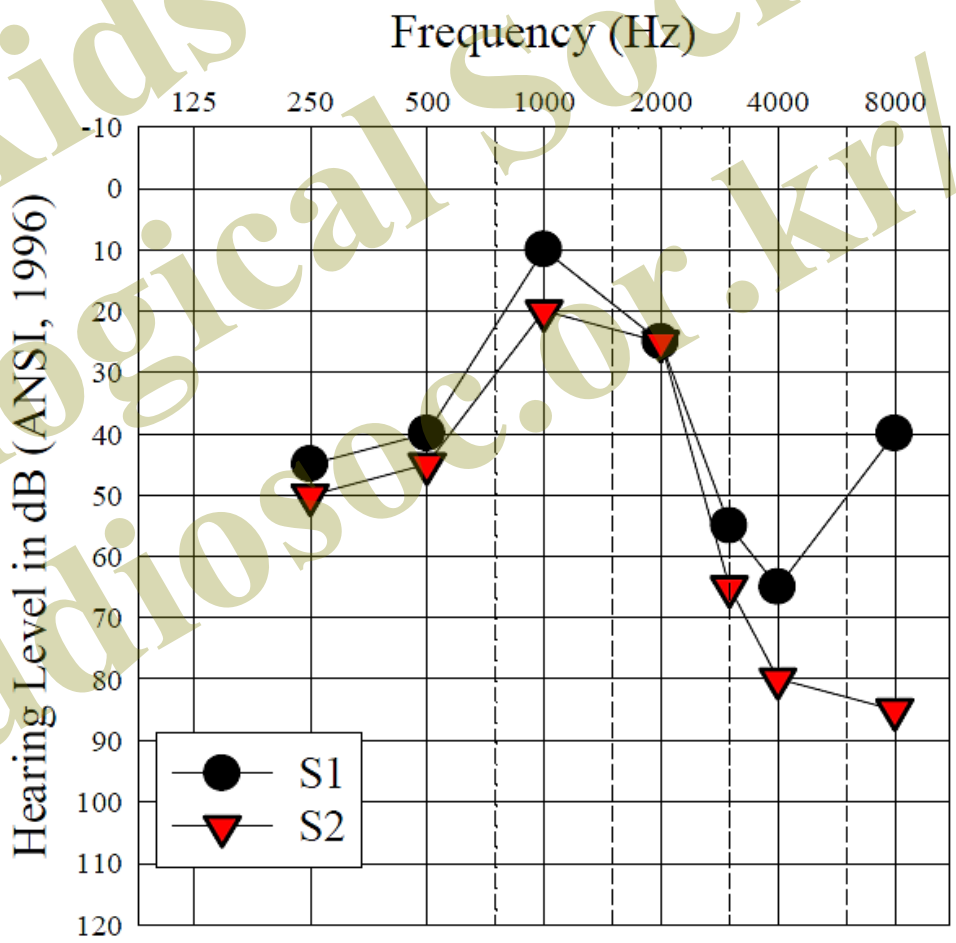
- Spectral Preference
- Loudness/Audibility Trade Off
- Loudness Perception
- Adaptation Process
- Signal of Interest
- Psychoacoustic Integrity
- Cognitive Processing

Things Know before HA Fitting

- Hearing thresholds for pure tones
- Ability to understand speech in quiet and noise
- Patient's "acceptance" of background noise
- Loudness discomfort levels
- Cognitive function
- Expectations
- Motivation to use hearing aids

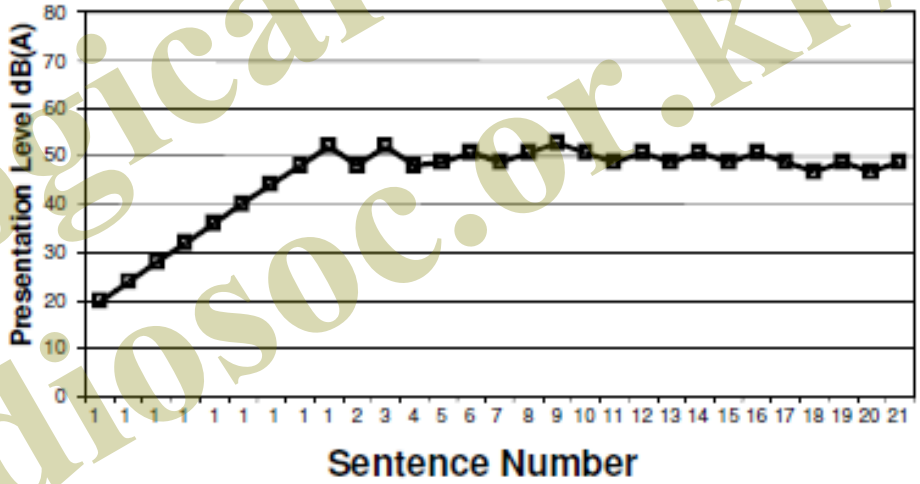
Similar audios don't always mean similar cochlear function (or understanding)

- S1 (circles) word rec = 92%
- S2 (triangles) word rec = 42%



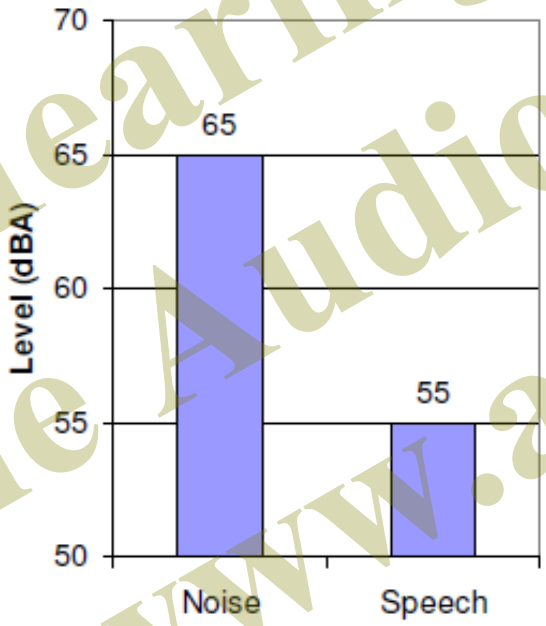
HINT Threshold

- There are 12, 20-sentence lists of short simple sentences.
- Step-size for 1st 4 sentences is 4 dB
- Step-size for the rest of sentences is 2 dB
- Reception Threshold for Sentences (RTS) is computed for sentences 5 to 21

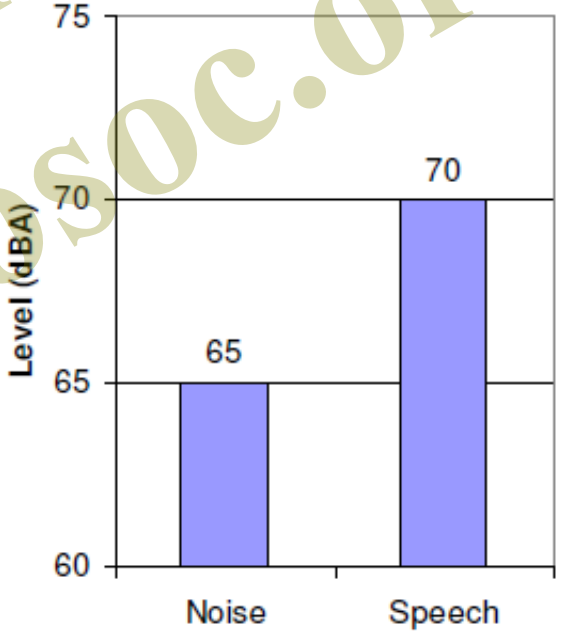


Calculating SNR in HINT

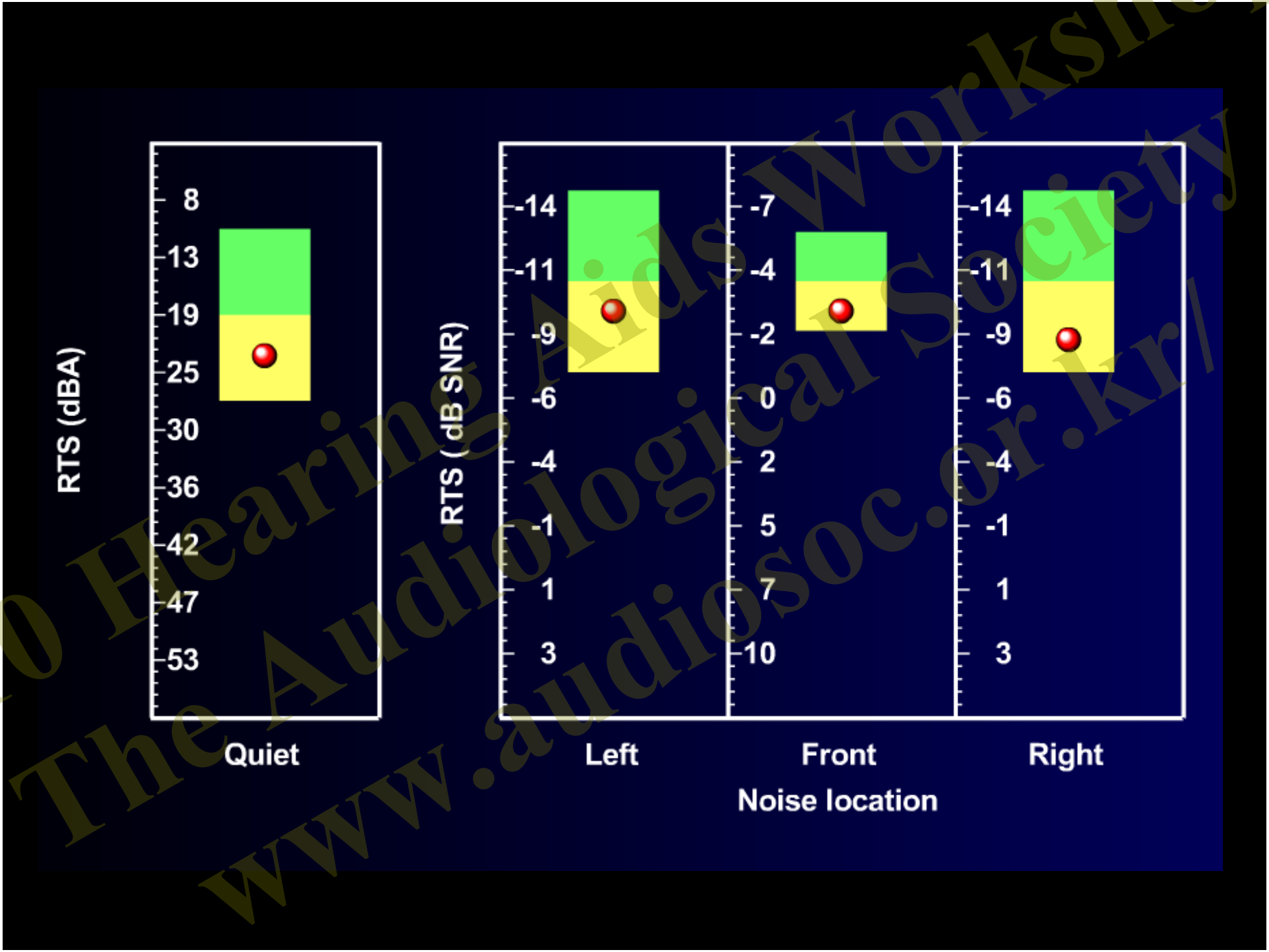
$$\frac{\text{Level of Speech} - \text{Level of Noise}}{\text{Signal-to-Noise Ratio}}$$

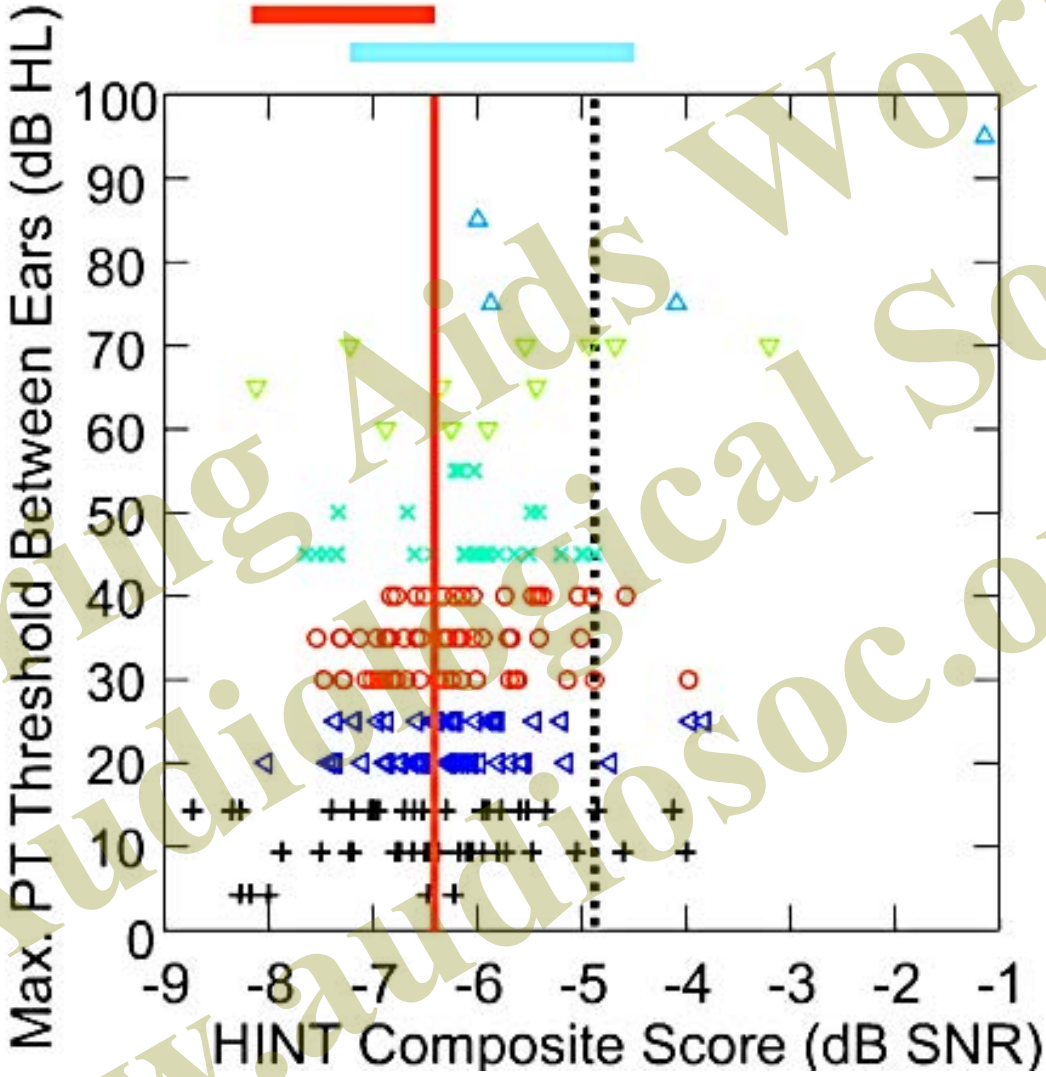


-10 dB SNR



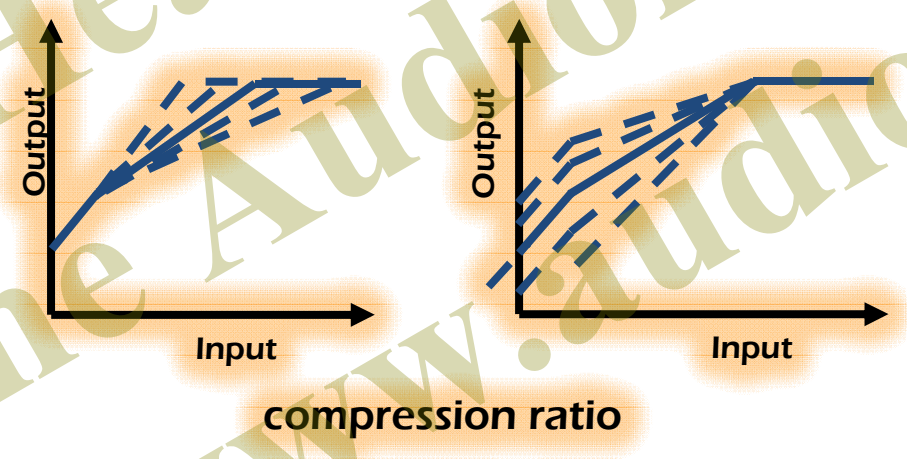
5 dB SNR

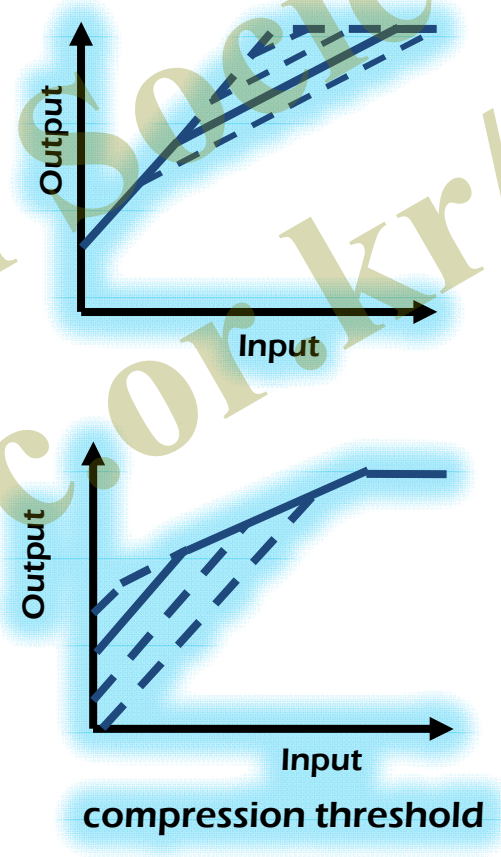




- HINT composite noise scores (n=215). Groups sorted by maximum pure tone thresholds for illustration.

- Overall gain (VCW)
- Channel gain
- Time constants
- Frequency response shape
- Amount of compression



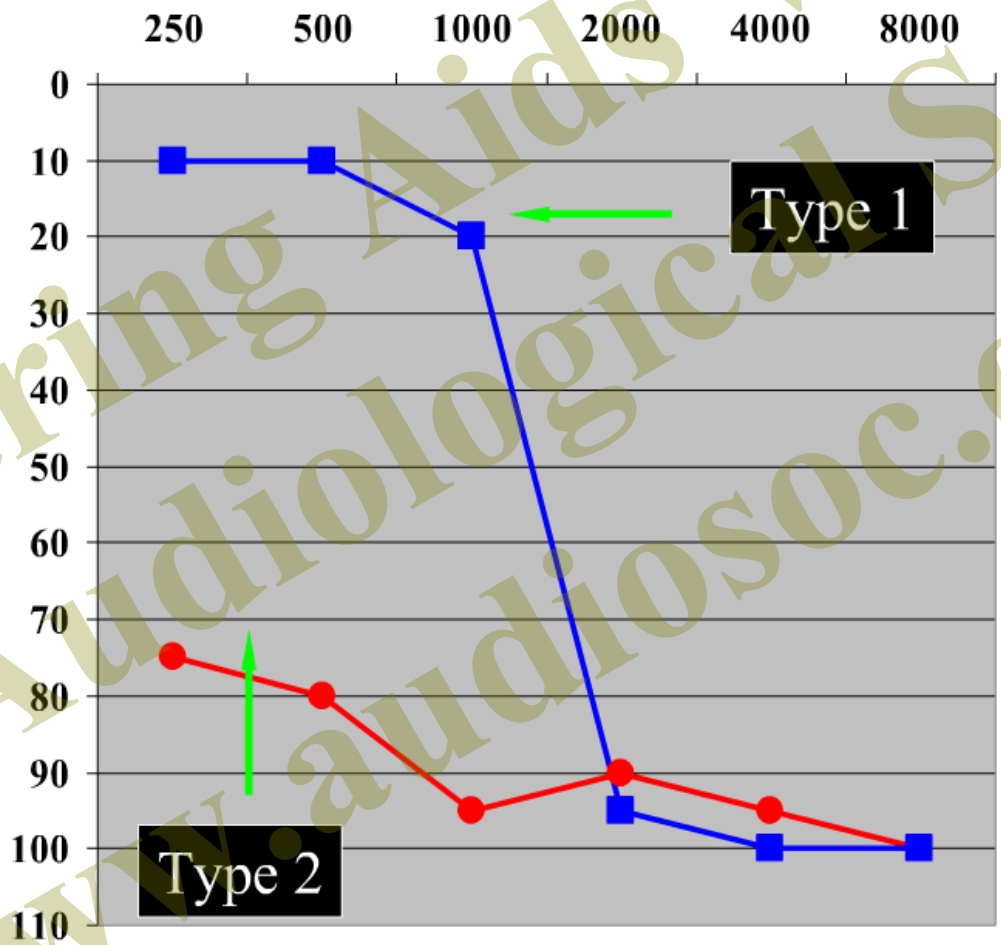


Special Fitting Populations

- Ski Slope Hearing Loss
- Severe SNHL
- Low Frequency SNHL

*Special Fitting Populations

What Do We Mean by Severe/Profound SNHL?



Nature of Severe/Profound SNHL

- Inter-patient variability goes up for greater hearing losses
- The greater the damage, the more variable
  - Not just Outer Hair Cell loss, but
    - Inner Hair Cell loss ("Dead Zones")
    - Membrane disruptions
    - Neural cell death
    - Mechanical & metabolic disruptions
    - Disrupted coordination

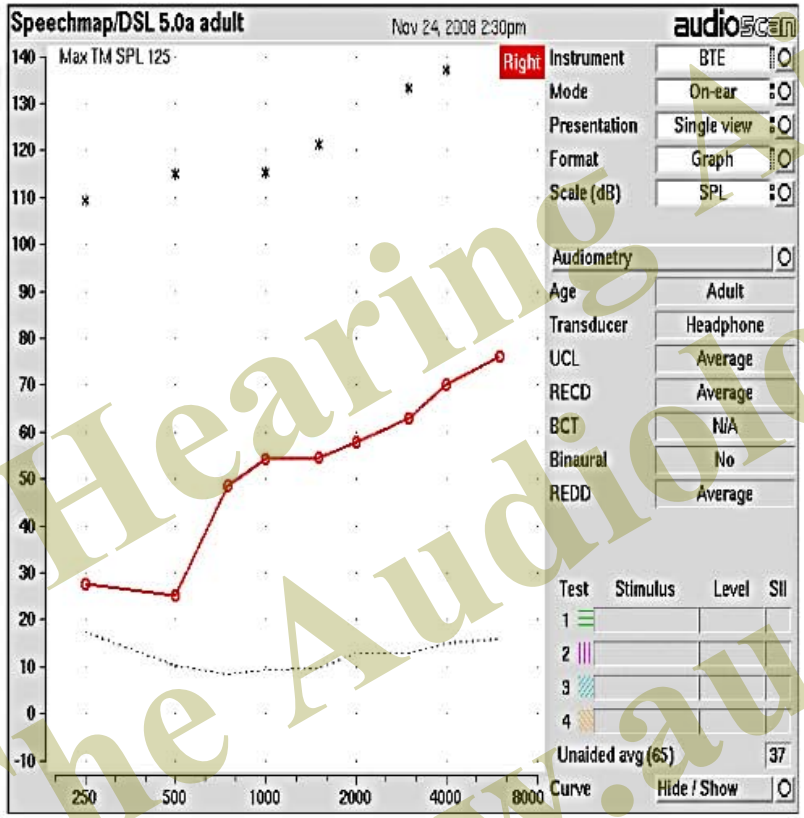
In severe SNHL, what need to consider?

- Is a hearing aid effective?
- What are the optimal CRs and frequency response?
- What about frequency transposition devices?
- Do they have a cochlear dead region?
- Will the dead region effect the fitting?

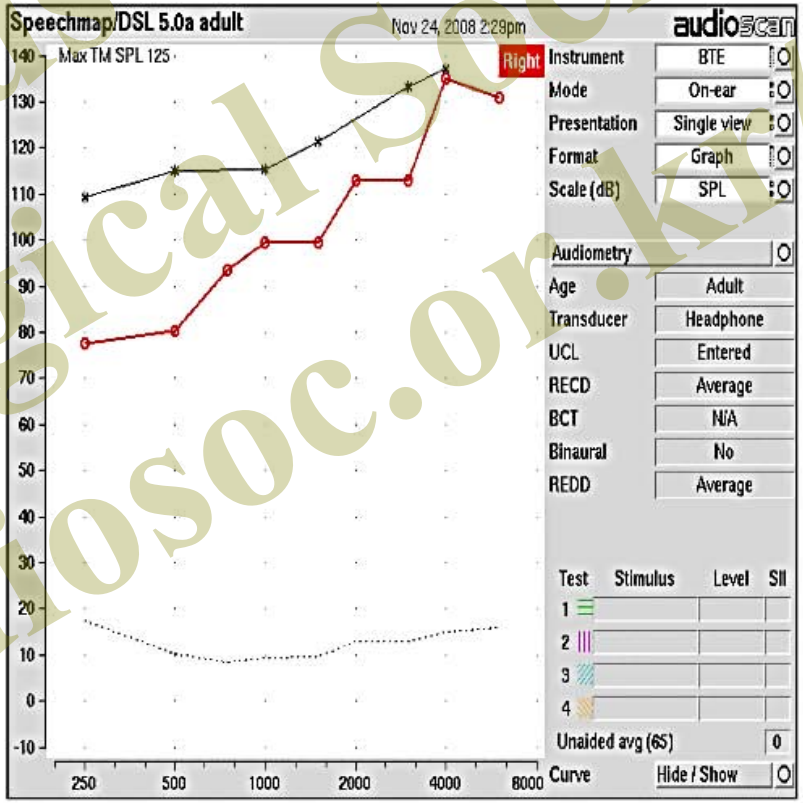
Unique Characteristics of Profound/Severe HL

- Elevated thresholds
- Very restricted dynamic range
- Distortion – poor scores on speech in noise testing (poor frequency resolution)

Restricted Dynamic Range



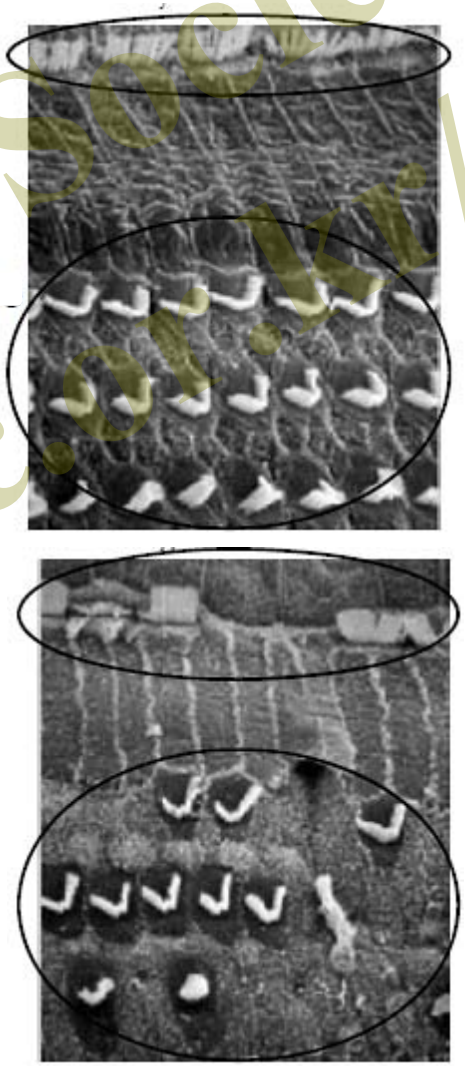
Mild Hearing Loss



Severe Hearing Loss

What are "Dead Regions"?

- A dead region is present "when the IHCs are nonfunctioning over a certain region of the cochlea." (Moore, 2001)
- IHCs are "transducers" converting basilar membrane motion into neural signals
- Acoustic information from dead regions may not be transmitted accurately to higher auditory centers.



- Audiogram "thresholds" in these regions may be from spread into other regions
- Limited Dynamic Range
- Amplification in these regions usually provides little benefit
- Sometimes, amplification in these regions introduces distortions

- "No audibility" is better than "audibility"

Cochlea Dead Regions

- Can occur at any frequency, but are more likely in the highs (4KHz)
- More likely to occur when the audiogram drops by 30/40 dB octave
- May be a concern when hearing loss is greater than 80 dB below 2000 Hz.
- When a high frequency HL is 90dB

Dead Regions - Prevalence

- For losses greater than 70 dB HL, there is 59% chance that the patient has a dead region.

  Vinay and Moore. (2006). Ear and Hearing

- 70% of teenagers with severe-profound SNHL had a Dead Region.

  Moore, et. al (2003). IJA

- 87% of adults with a steeply sloping, moderate to severe SNHL met the criteria for a Dead Region for at least one frequency.

  Markessis, et al (2006). IJA.

- For moderate to severe loss (thresholds between 50 and 80dB HL) 29% of subjects had a dead region.

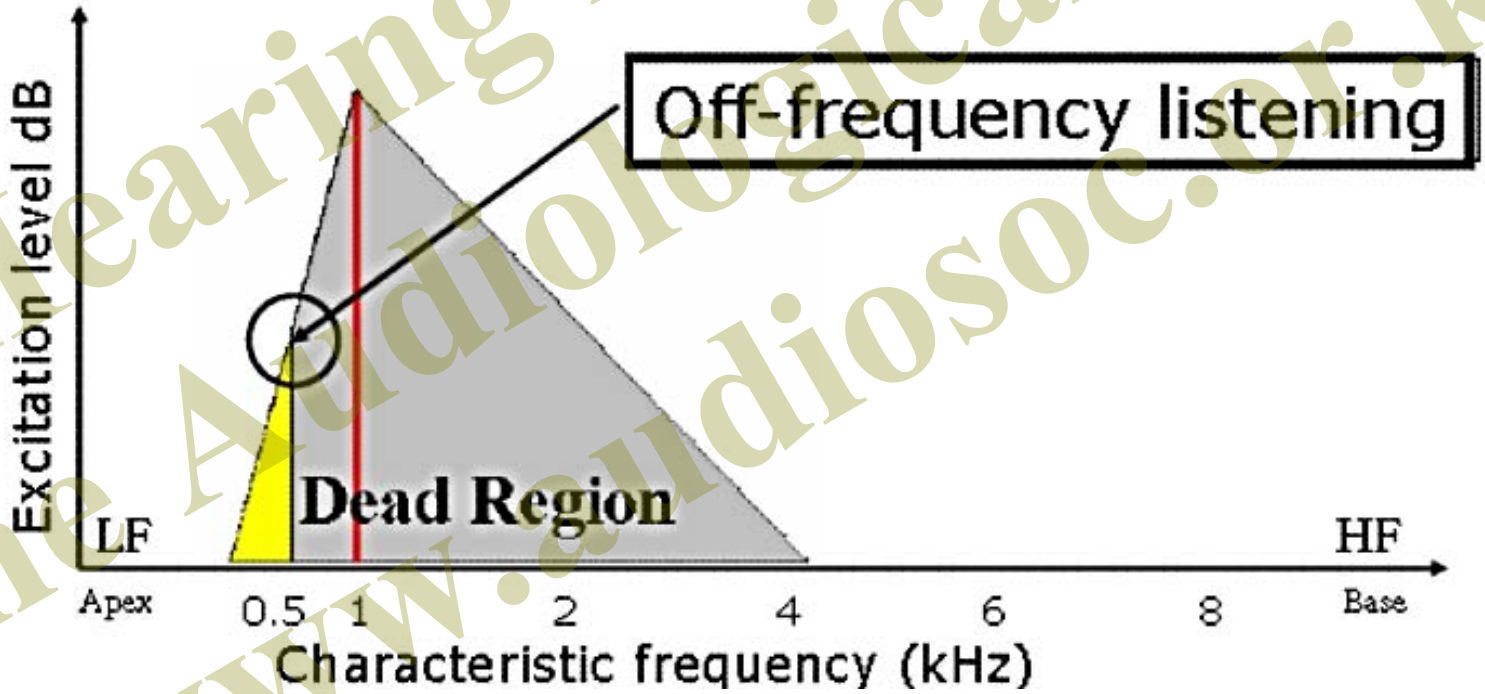
  Preminger, et al (2005). JAAA.

- Lower prevalence compared to Moore's work is likely due to stricter criteria on the TEN test (masked threshold 15 dB above absolute threshold, rather than 10dB.)

- Bottom Line: Somewhere between a 1/3 and 2/3 of patients with severe-profound HL have a dead region

Off-frequency listening

- *IHCs within a dead zone do not detect tone, but other regions along the basilar membrane are stimulated at high intensity levels.*



Kluk & Moore, 2007

Dead Regions and Hearing Aids

- Sounds arriving at Dead Region are not audible
- Amplification in DR may sound distorted
- Limited Dynamic Range

- Ski Slope Hearing Loss
- Severe SNHL
- Low Frequency SNHL

*Special Fitting Populations

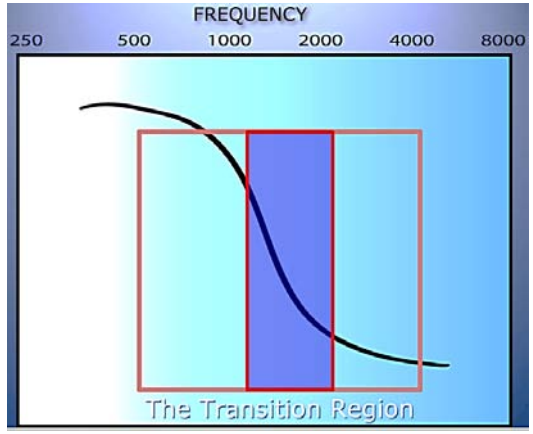
Ski Slope Hearing Loss

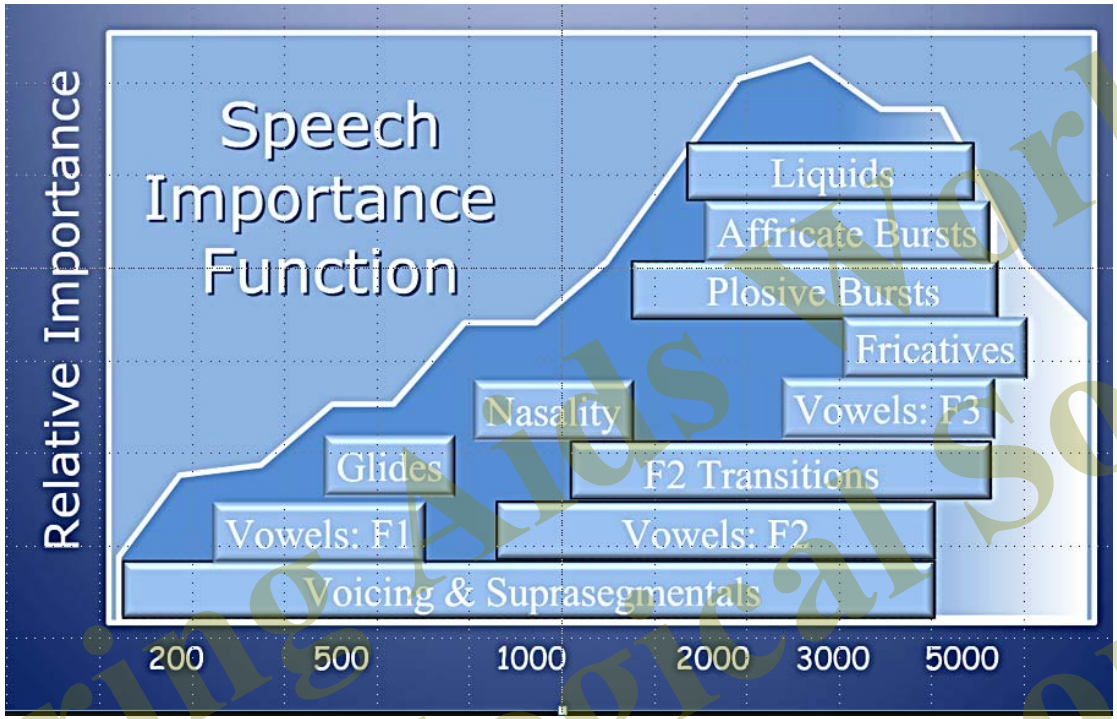
- Key Research Findings
  - Beyond moderate SNHL in HF, improved audibility may not always improve speech understanding
  - At times, attempts at full audibility may decrease speech understanding

Ching et al. (1998)/Hogan & Turner (1998)

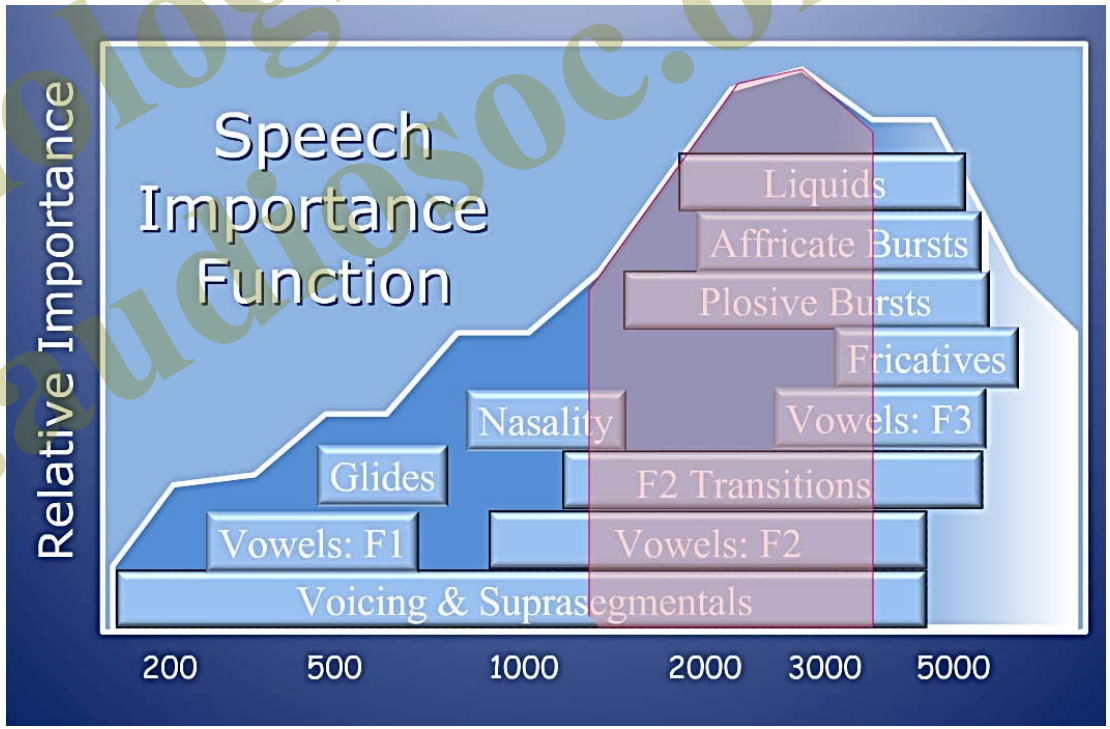
Goal of SKI fittings

- Maintain comfort
- Maintain acceptable sound quality in quiet
  - no dramatic frequency responses
  - vented fitting
- Modest audibility enhancement
  - focused on transition region
  - will be appreciated in quiet
  - may be quite helpful in noise



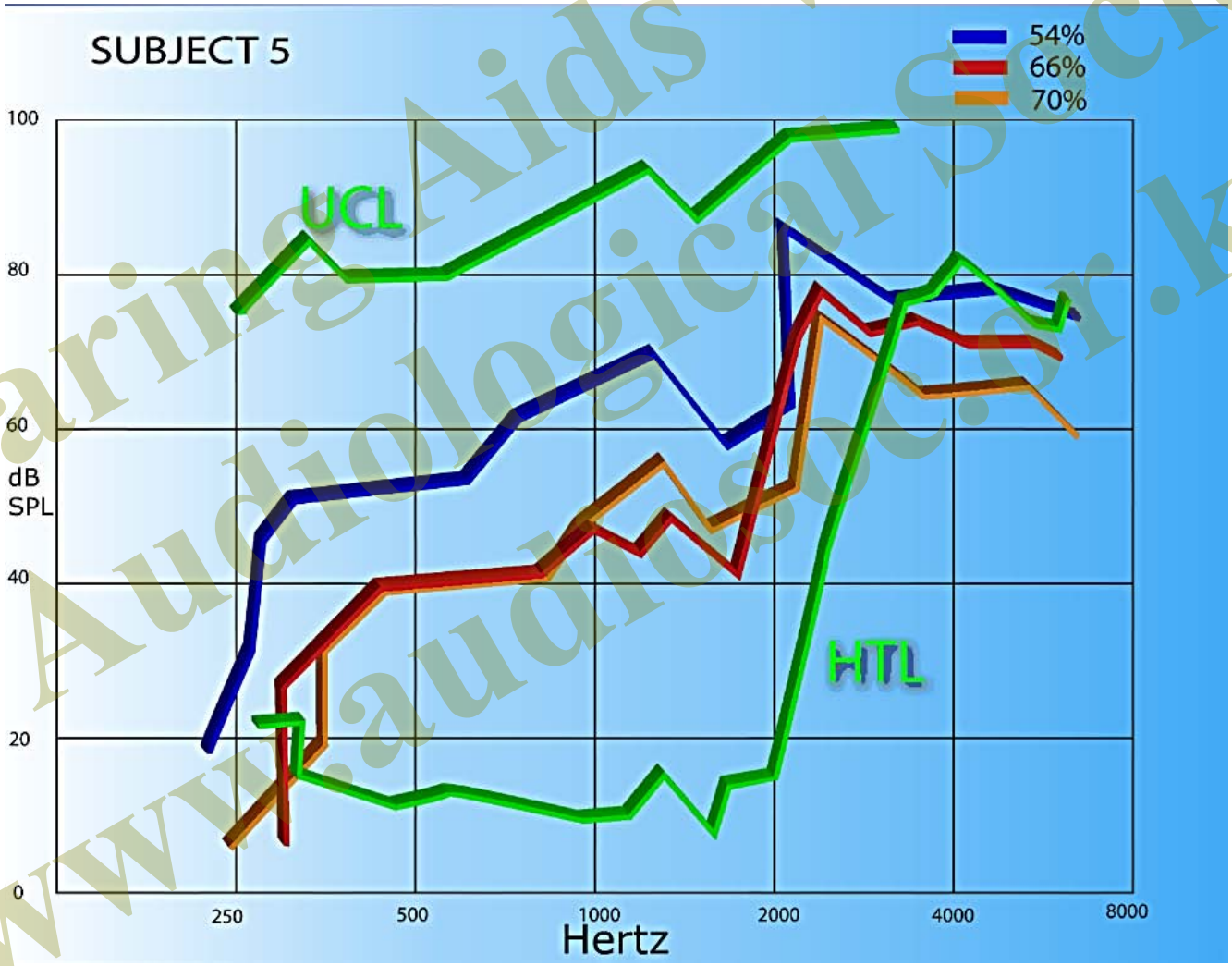


Transition Region



Aided Speech Spectra

(Skinner, 1980)



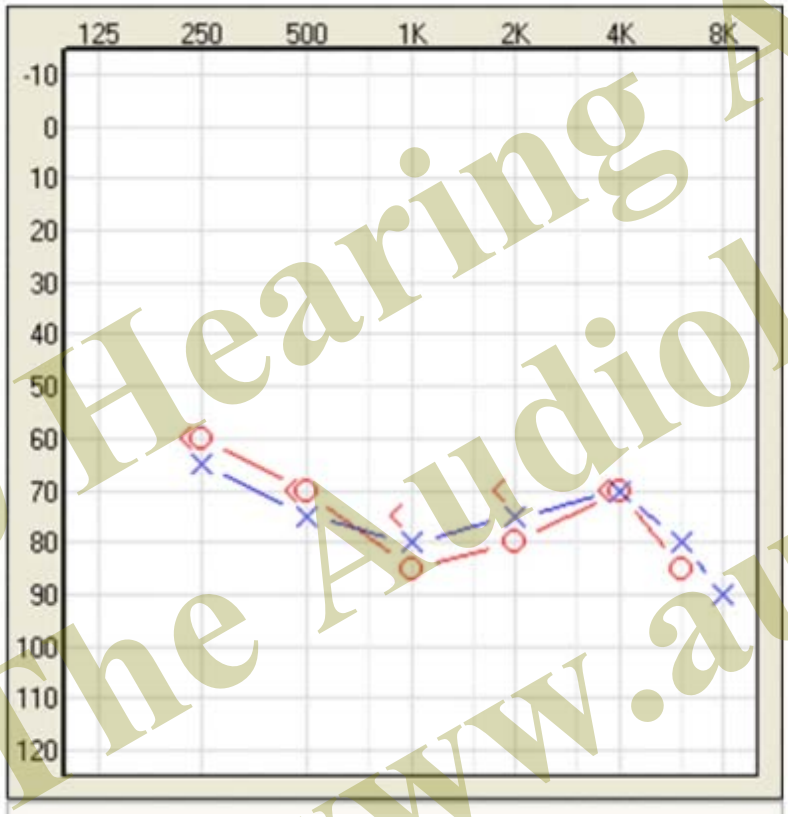
Hearing Aids in Ski

- Even the most aggressive prescriptive fitting formula do not recommend more than 25 dB gain in HFs.
- Improving HF audibility from 10 to 20 dB increased speech intelligibility by 30% on average. (Ching, et al, 2001).
- Listeners with severe hearing loss have tremendous variability on speech intelligibility scores

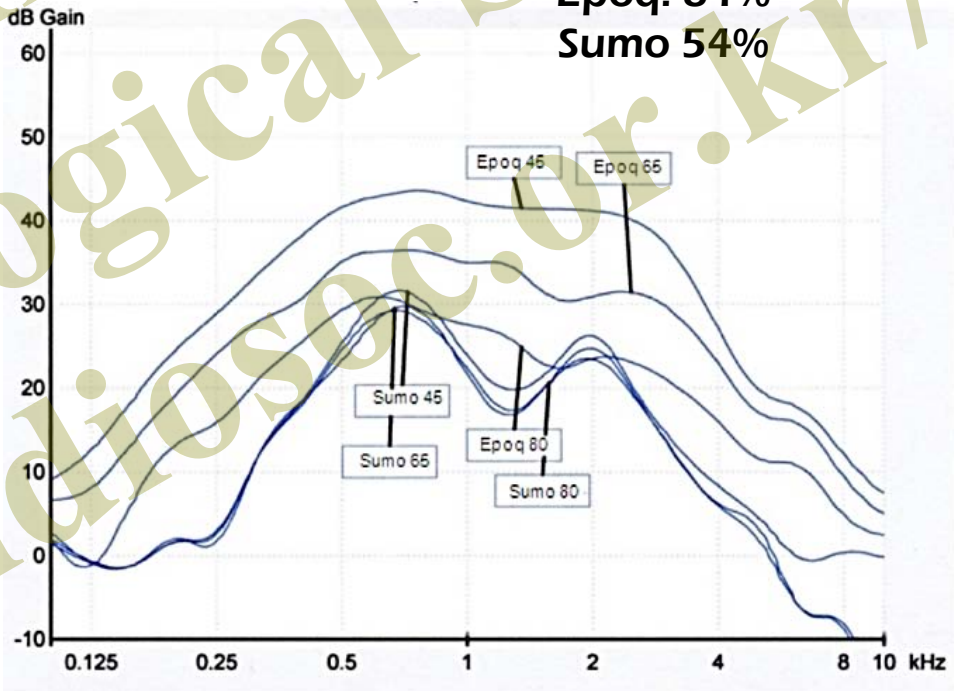
- Ski Slope Hearing Loss
- Severe SNHL
- Low Frequency SNHL

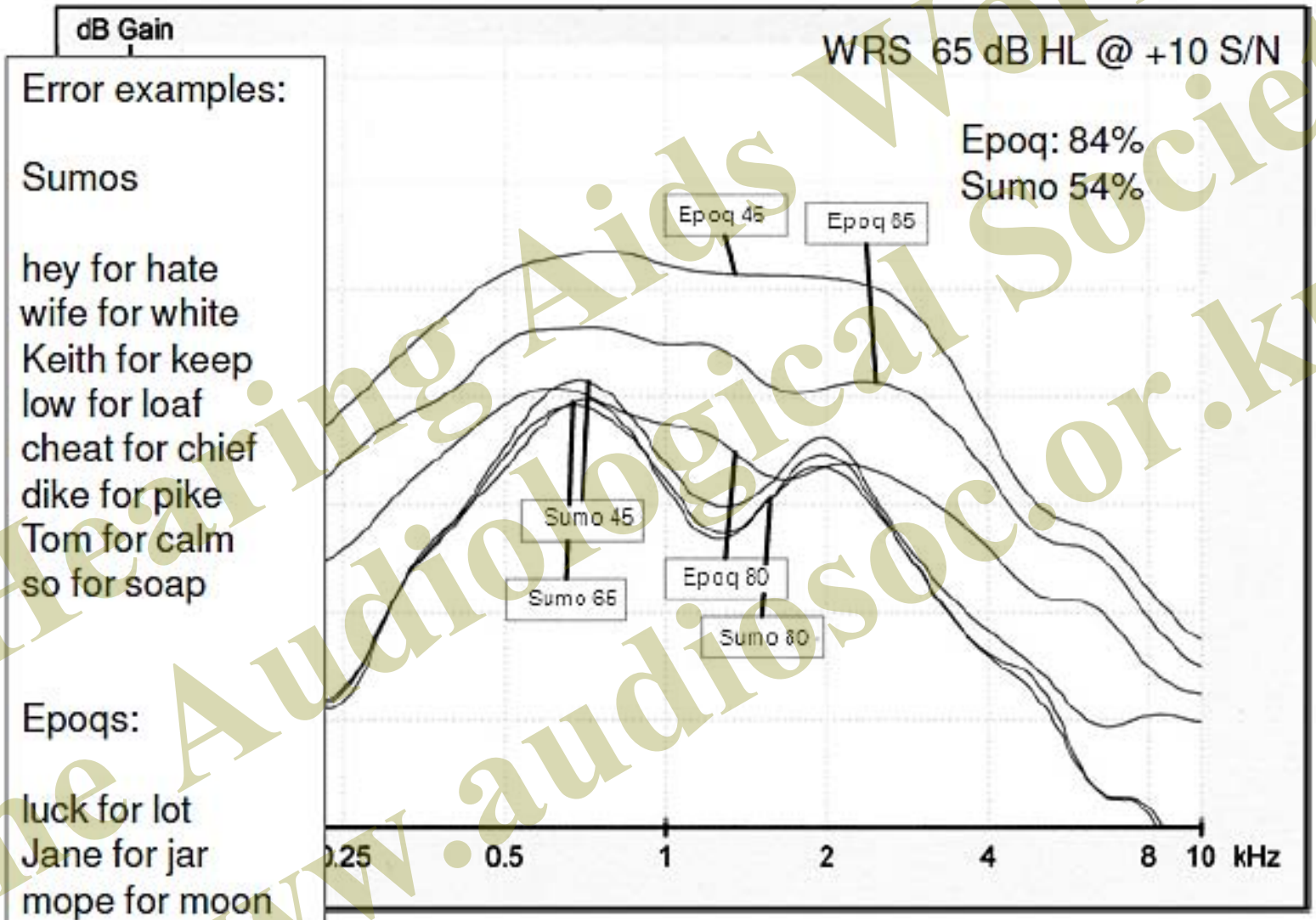
*Special Fitting Populations

- if there is hearing above 1 kHz.
- . . .must be “power MCNL” approach



WRS 65 dB HL @ +10 S/N
Epoq: 84%
Sumo 54%





Error examples:

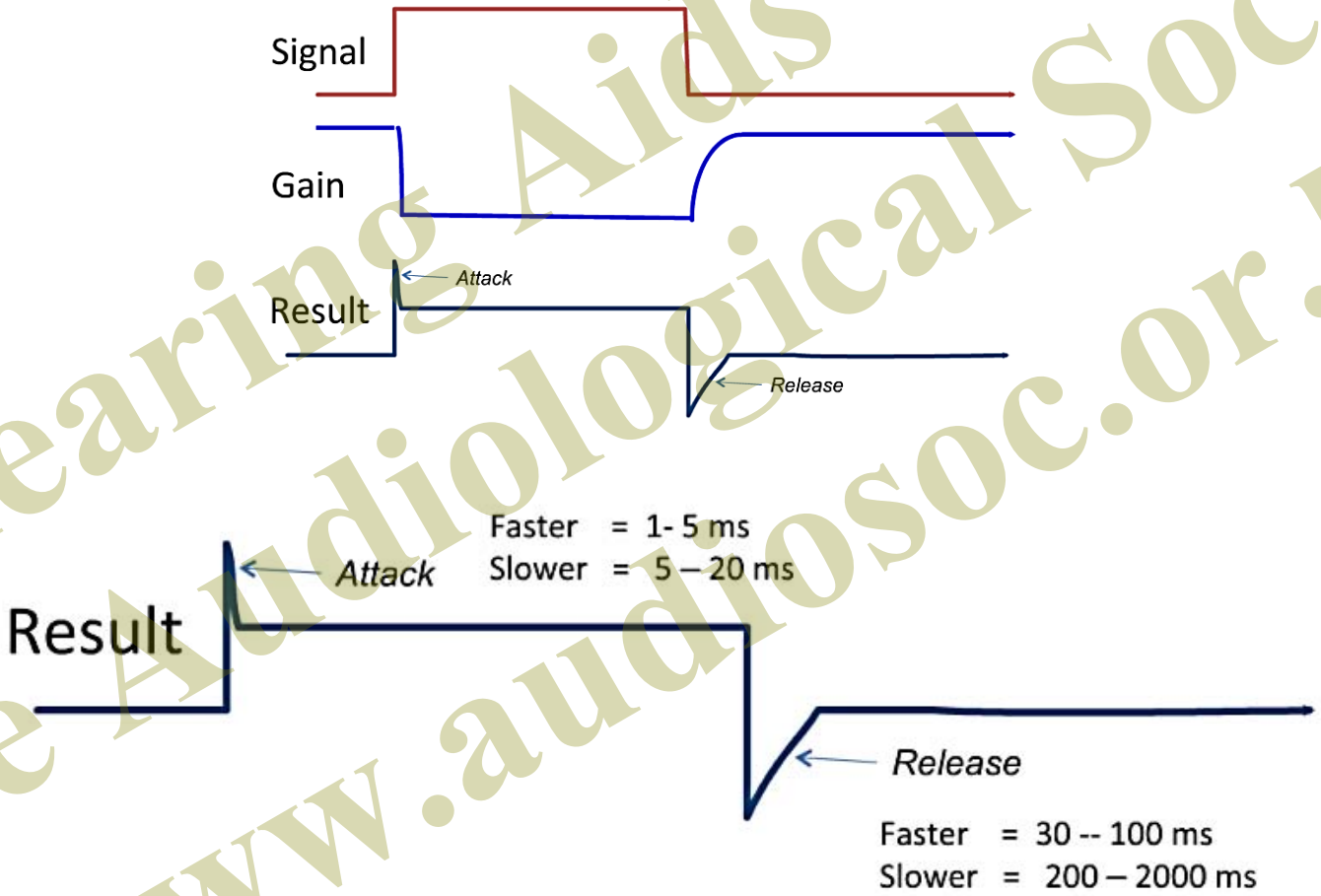
Sumos

hey for hate
wife for white
Keith for keep
low for loaf
cheat for chief
dike for pike
Tom for calm
so for soap

Epoqs:

luck for lot
Jane for jar
mope for moon

True effects of WDRC



Stressed vowels occur 2-4 times per second

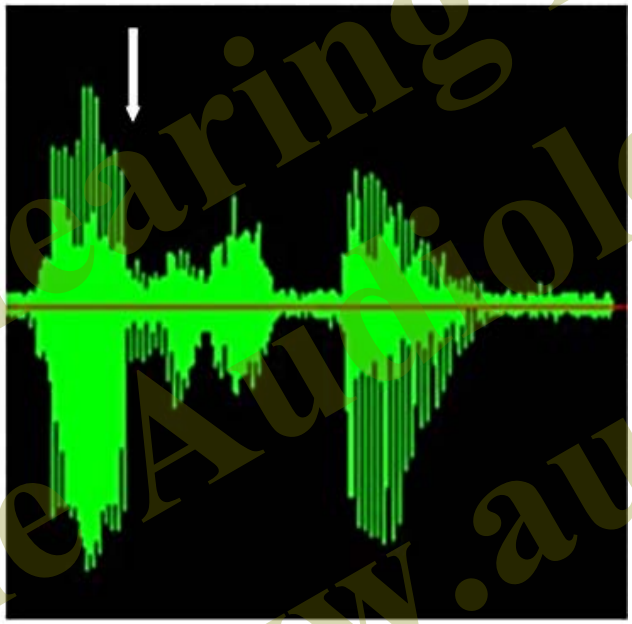
Effect of Compression

Fast Compression: Short Release Time

Effect of Compression

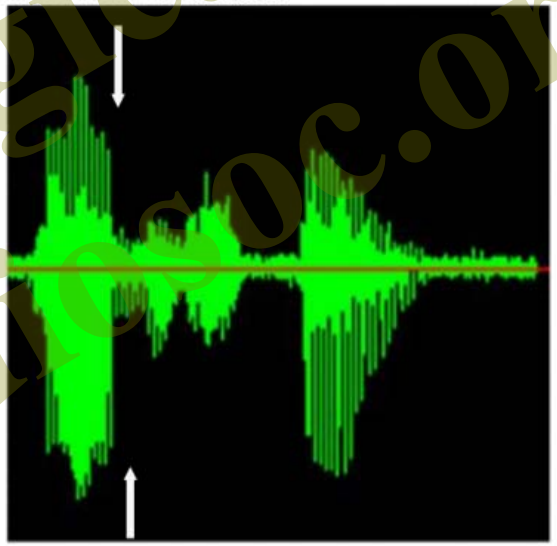
Long release time

Signal Level Drops



"Da-nish beer"

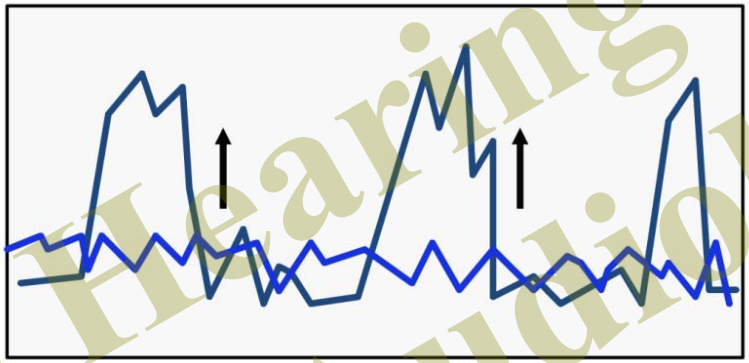
Compression does not release

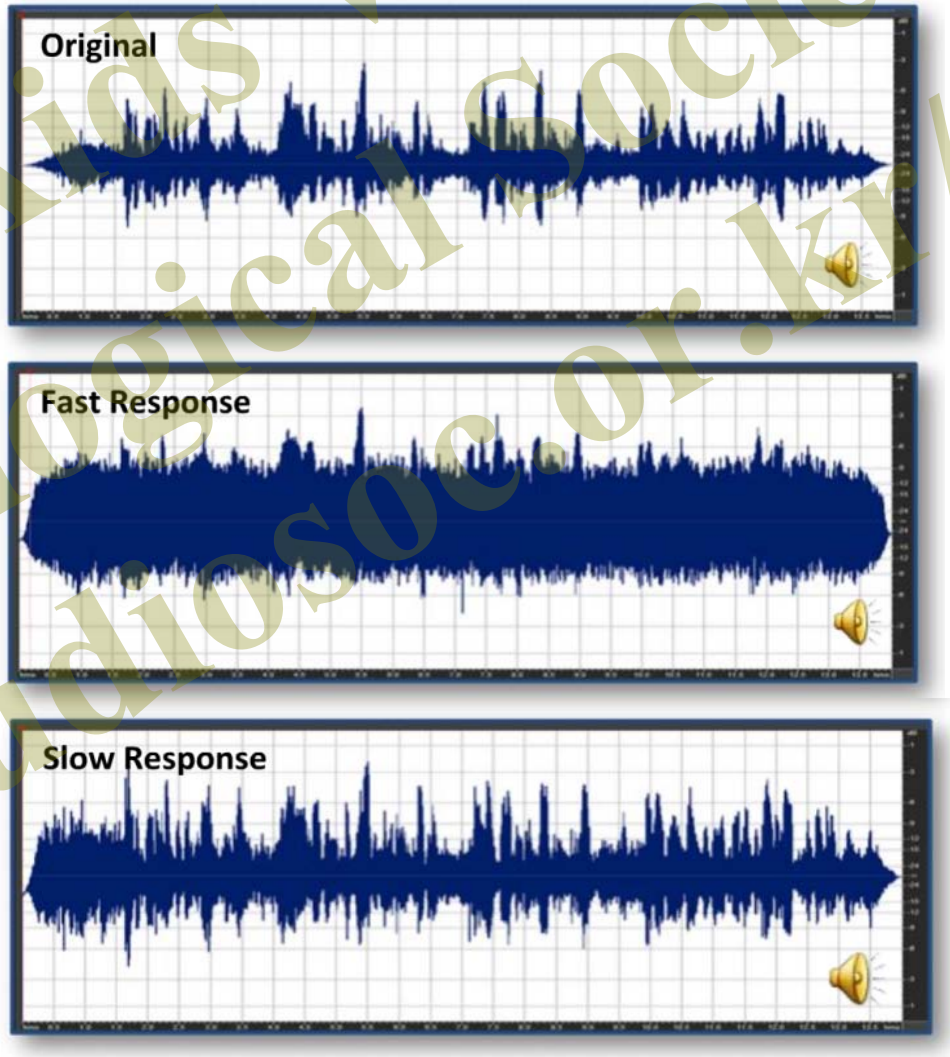


Gain remains stable

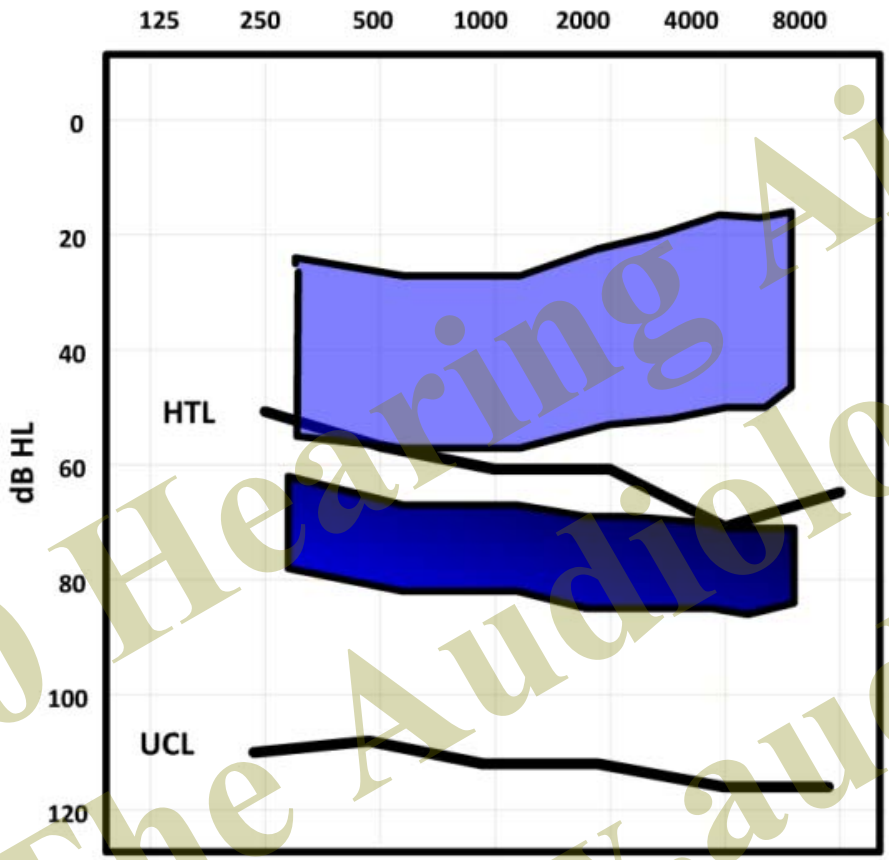
Effect is even more apparent in background noise

Speech in Noise

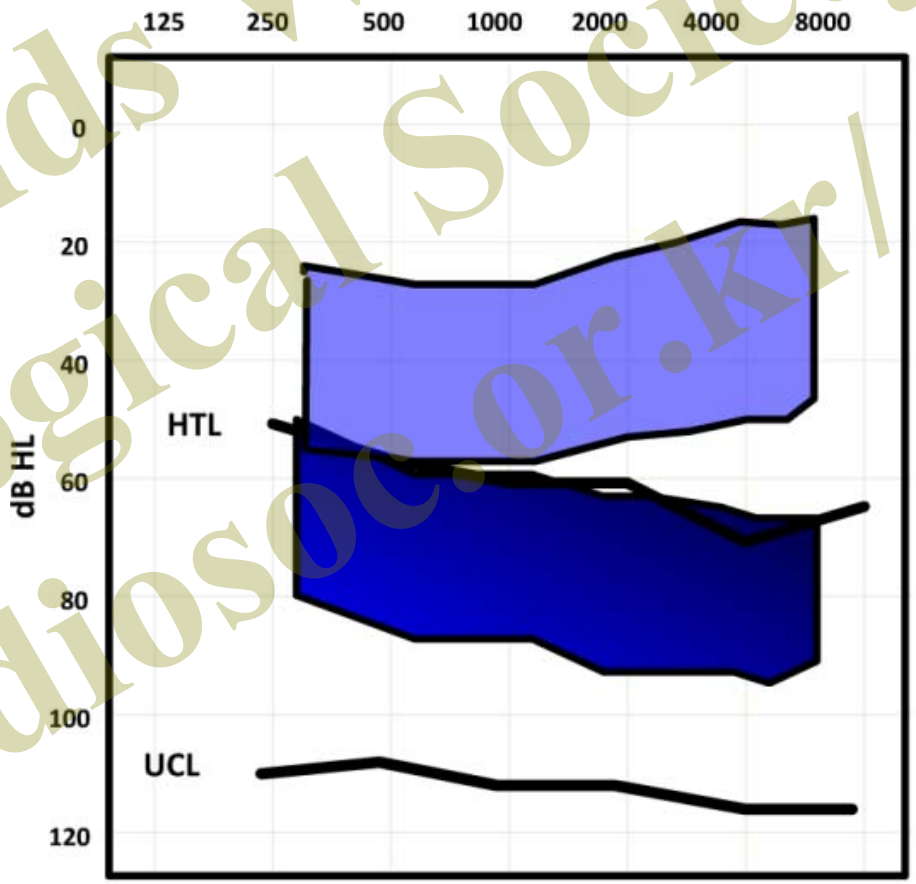




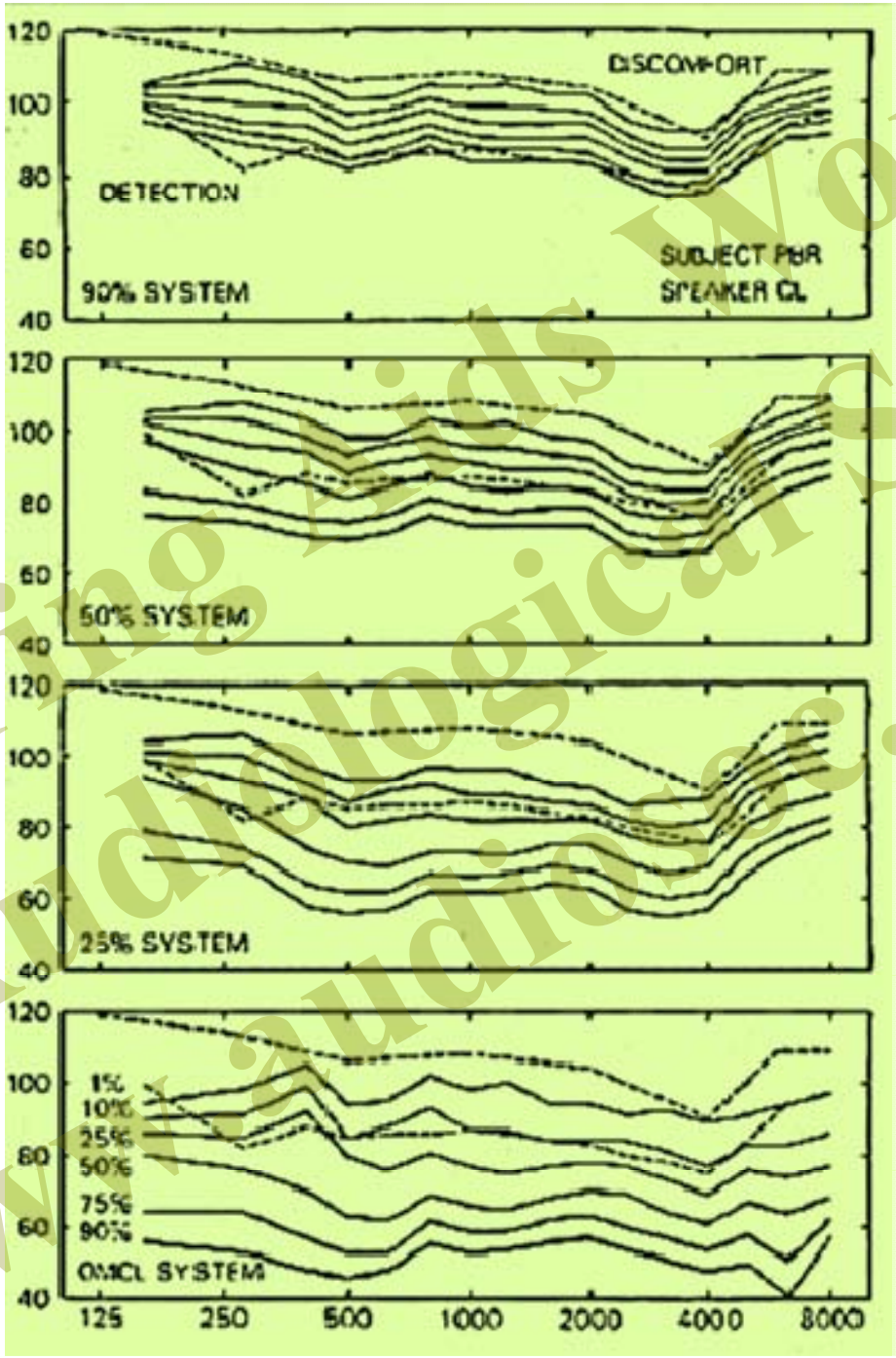
Short Release Time



Long Release Time

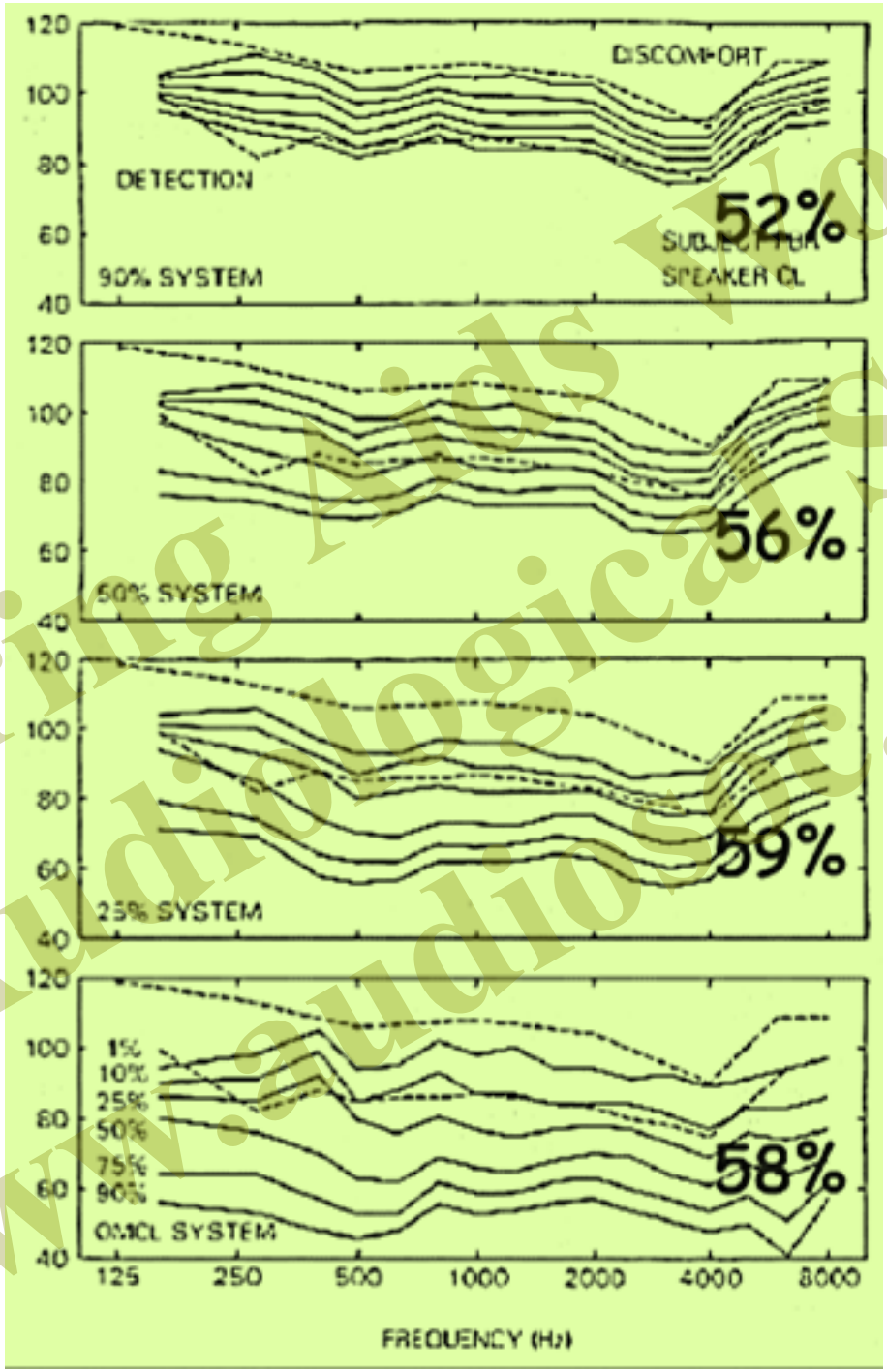


Fast acting compression



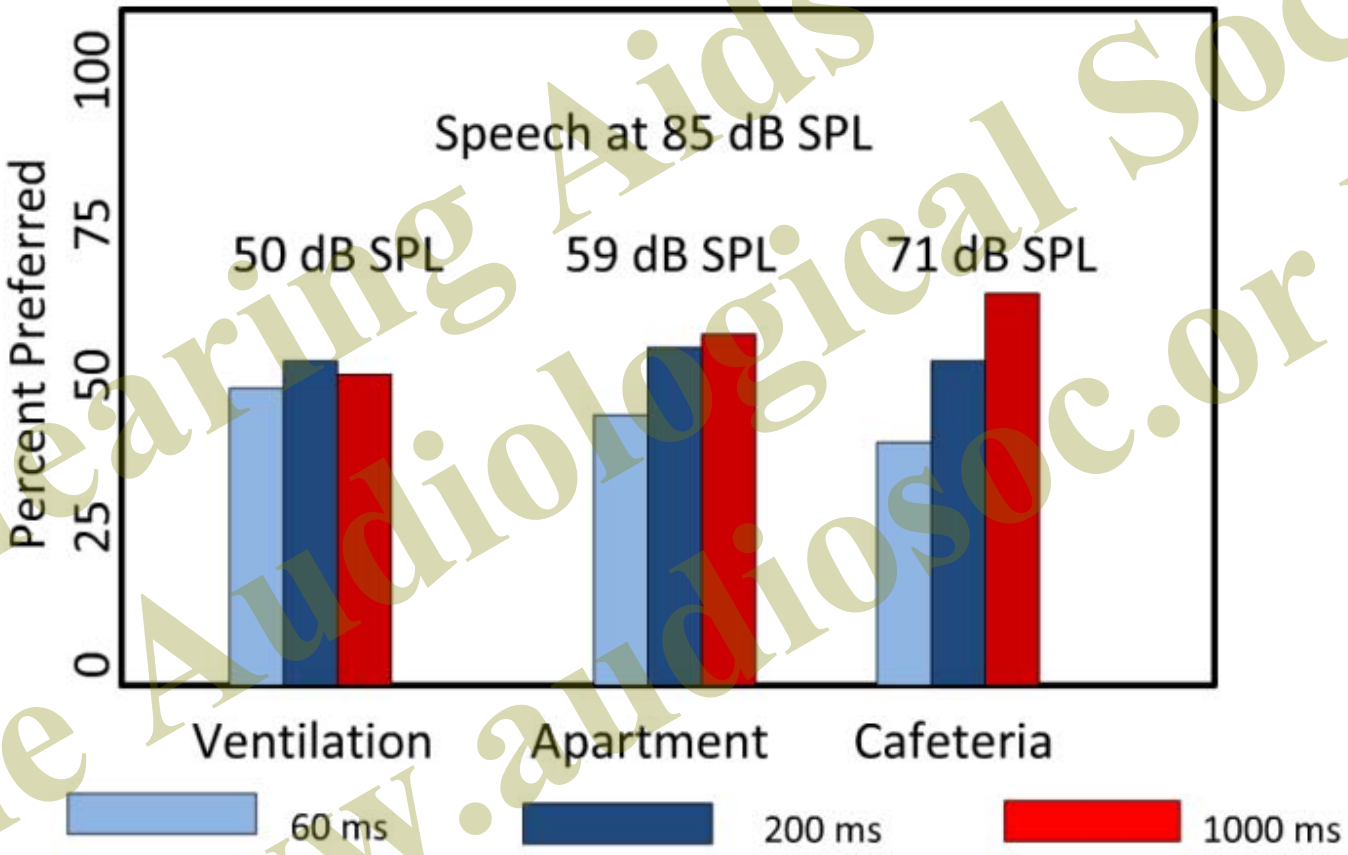
(De Gennaro, Braida, Durlach, 1986)

Fast acting compression



(De Gennaro, Braida, Durlach, 1986)

Release Time Preferences



Neuman et al., 1995

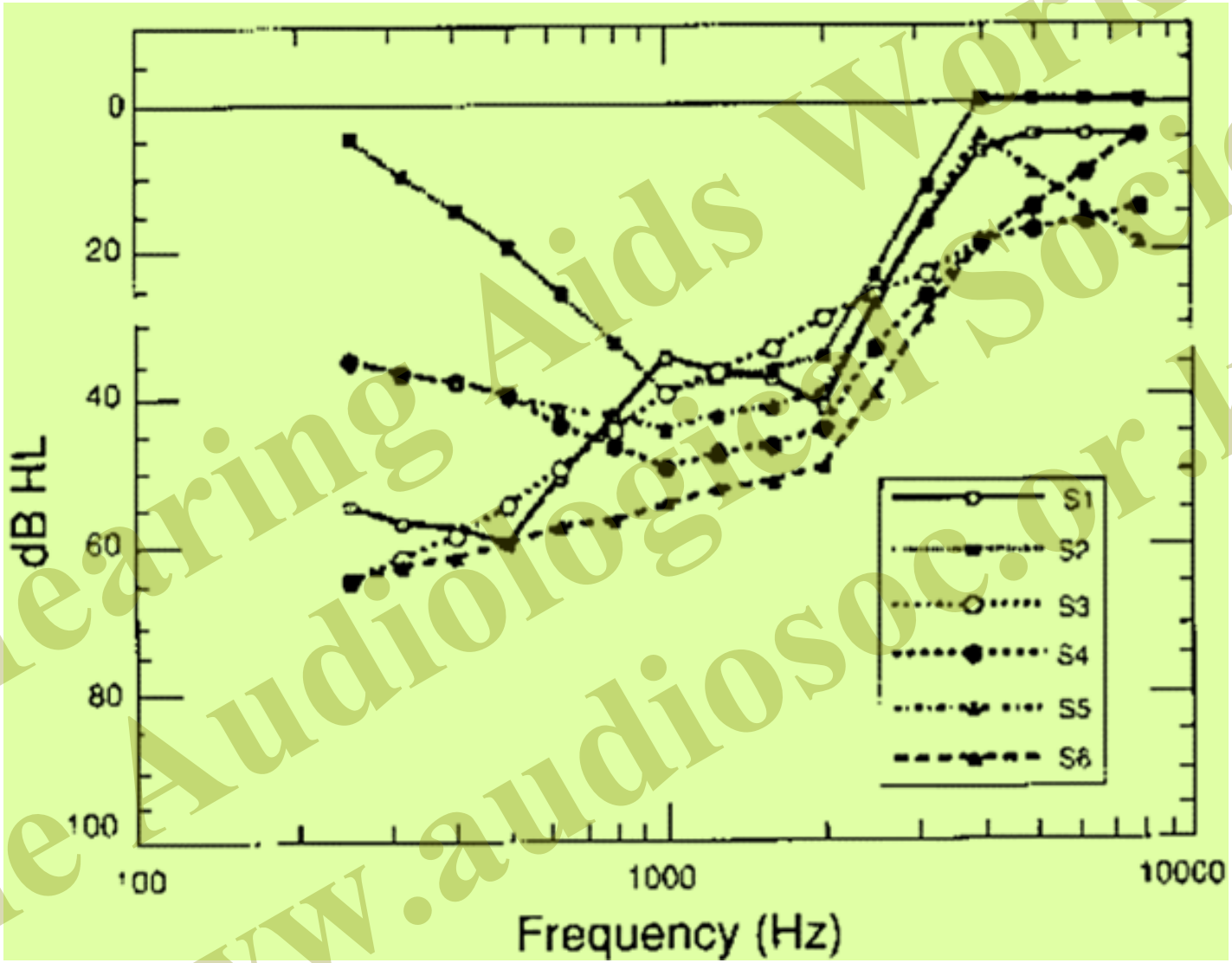
Managing Severe Losses

1. Fit modern "WDRC" hearing aids
2. Employ frequency lowering scheme:
   - Frequency compression (non-linear frequency lowering) – Phonak Sound Recover
   - Frequency shifting (linear frequency lowering) – Widex Auto Extender
3. Cochlear Implant

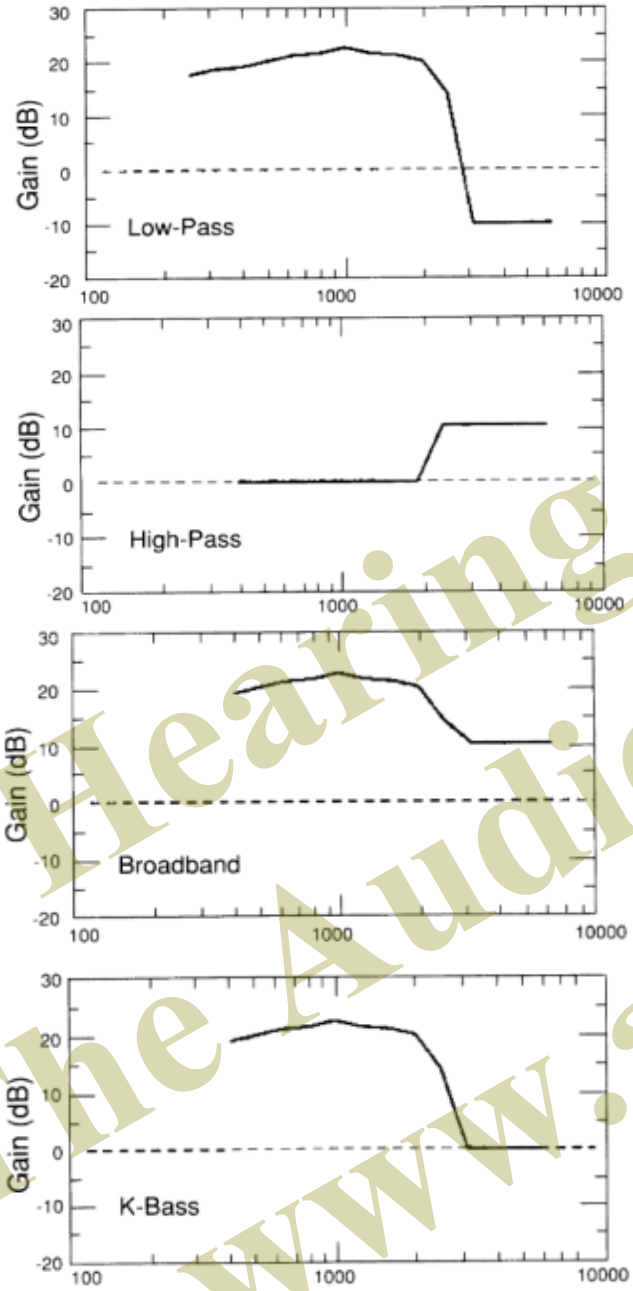
Allow the patient to choose the preferred bandwidth

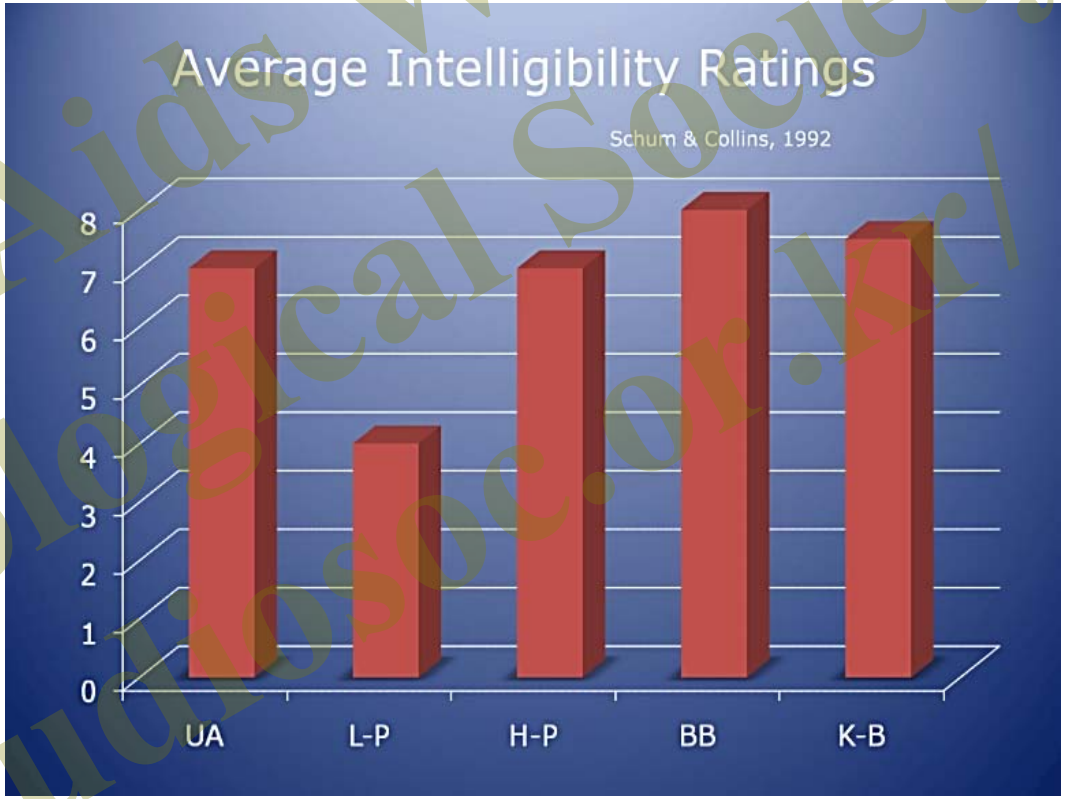
- Ski Slope Hearing Loss
- Severe SNHL
- Low Frequency SNHL

*Special Fitting Populations



(Schum and Collins, 1992)

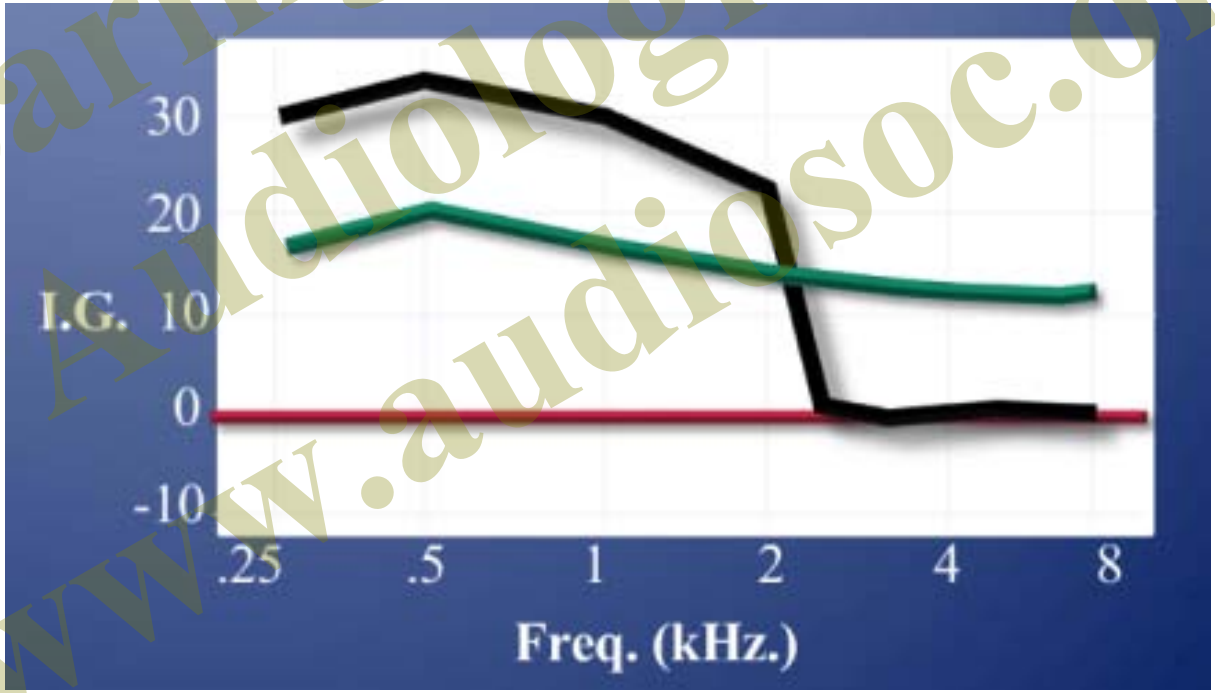




(Schum and Collins, 1992)

How Should Frequency Response Be Set?

- HF region (>2 kHz): at least 10-15 dB Insertion Gain
- LF & Mids Region (<2 kHz): no more than 15-20 dB Insertion Gain



Fitting Process for Severe HL

- More Adaptive Than We Are Used To
- Start with Moderate Compression, watch for signs
  - Get Loudness Right
  - Raise the kneepoint, if necessary
- Fine Tuning
  - Downshift (more LFs), but not too much
- Recalibrate Your Fine Tuning
- Encourage patience before extensive, circular fine tuning

2010 청각학회 보청기 W/S

Selection and Fitting

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