

# **Auditory Rehabilitation: State of the Art Hearing Aids and Other Factors**

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# Overview

- **Some statistics**
- **The impaired ear**
- **Causes of hearing loss**
- **Hearing aids**
- **Approaches to rehabilitation**
- **Prevention?**

# Hearing loss is a major health concern:

- 30 million in US with hearing impairment
- Prevalence increases with age: 21 million hearing-impaired in US over 45 years of age
- *About 30% of people over age 65 need hearing aids*





# Of these a HUGE percentage are veterans:

- About 414,412 veterans are service-connected for hearing loss
- Another 1.6 million have service-related hearing loss but are not receiving compensation

# Army/Marine VA Major Hearing Loss Disability Cases

## Percent of Change Since 1986



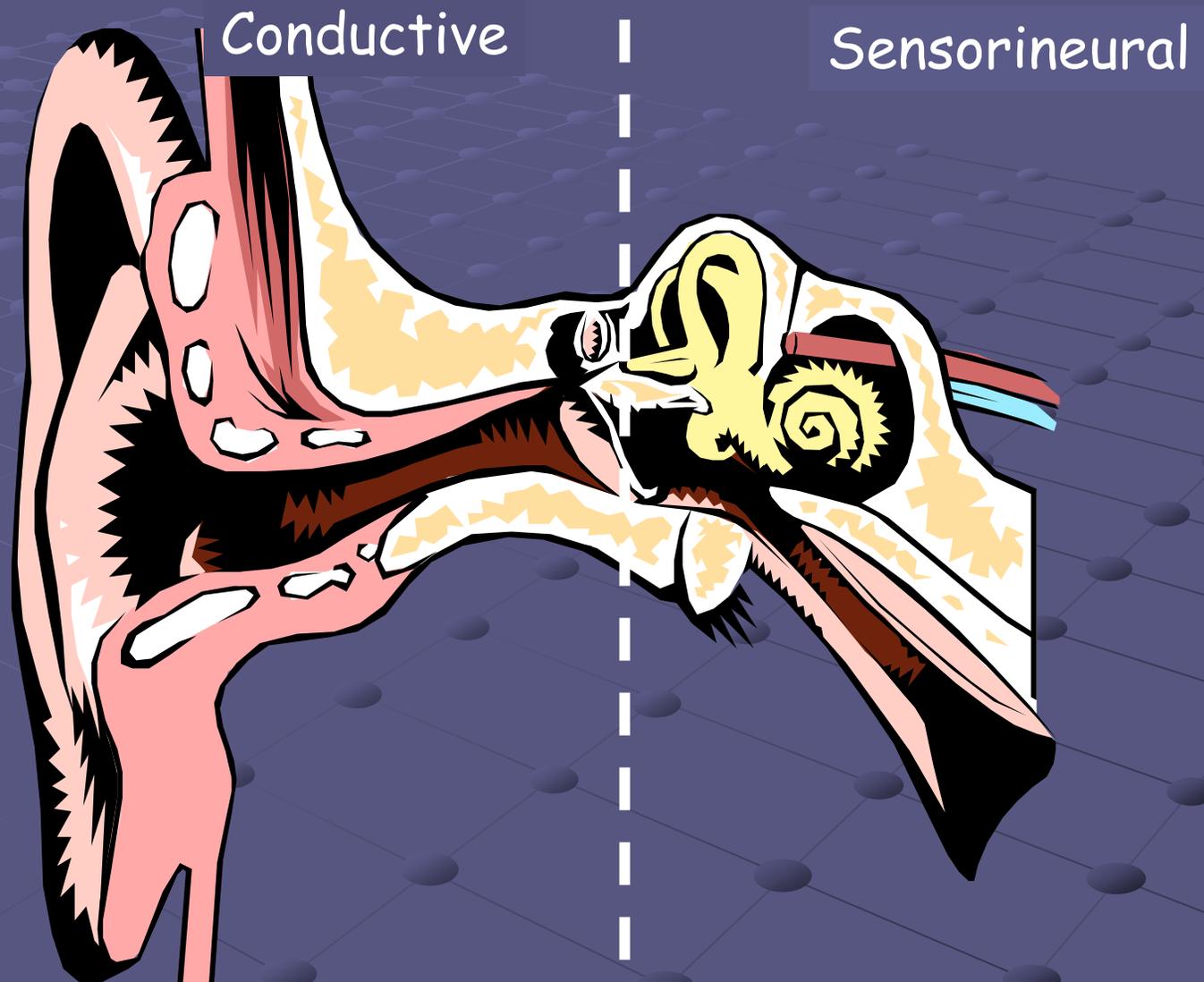
# Study of 141,856 active duty soldiers:

**Post-deployment 68% had some form of noise induced injury vs. 4% of non-deployed soldiers**

- 29% had permanent threshold shift
- 30% had tinnitus
- 16% had significant HL
- 5.6% had acoustic trauma

Helfer et al, 2005

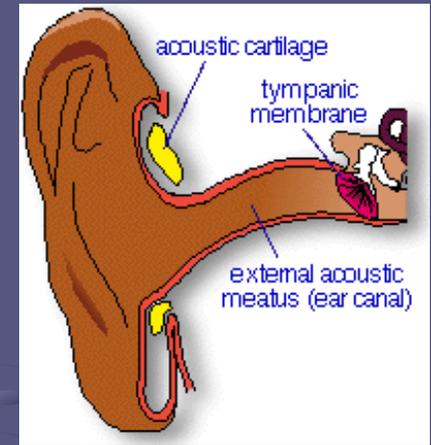
# Types of hearing loss



# Conductive loss

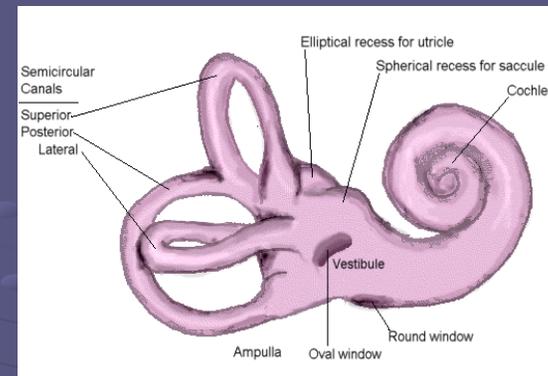
- Damage to the outer or middle ear
- Effect is attenuate sound level (decrease 'volume')
- Maximum loss is about 60dB HL
- Often correctable with surgery

*If not correctible, increasing the volume restores audibility & intelligibility*



# Sensorineural loss

- Damage to the hair cells
- Thresholds are increased
- Experience recruitment and poor frequency resolution

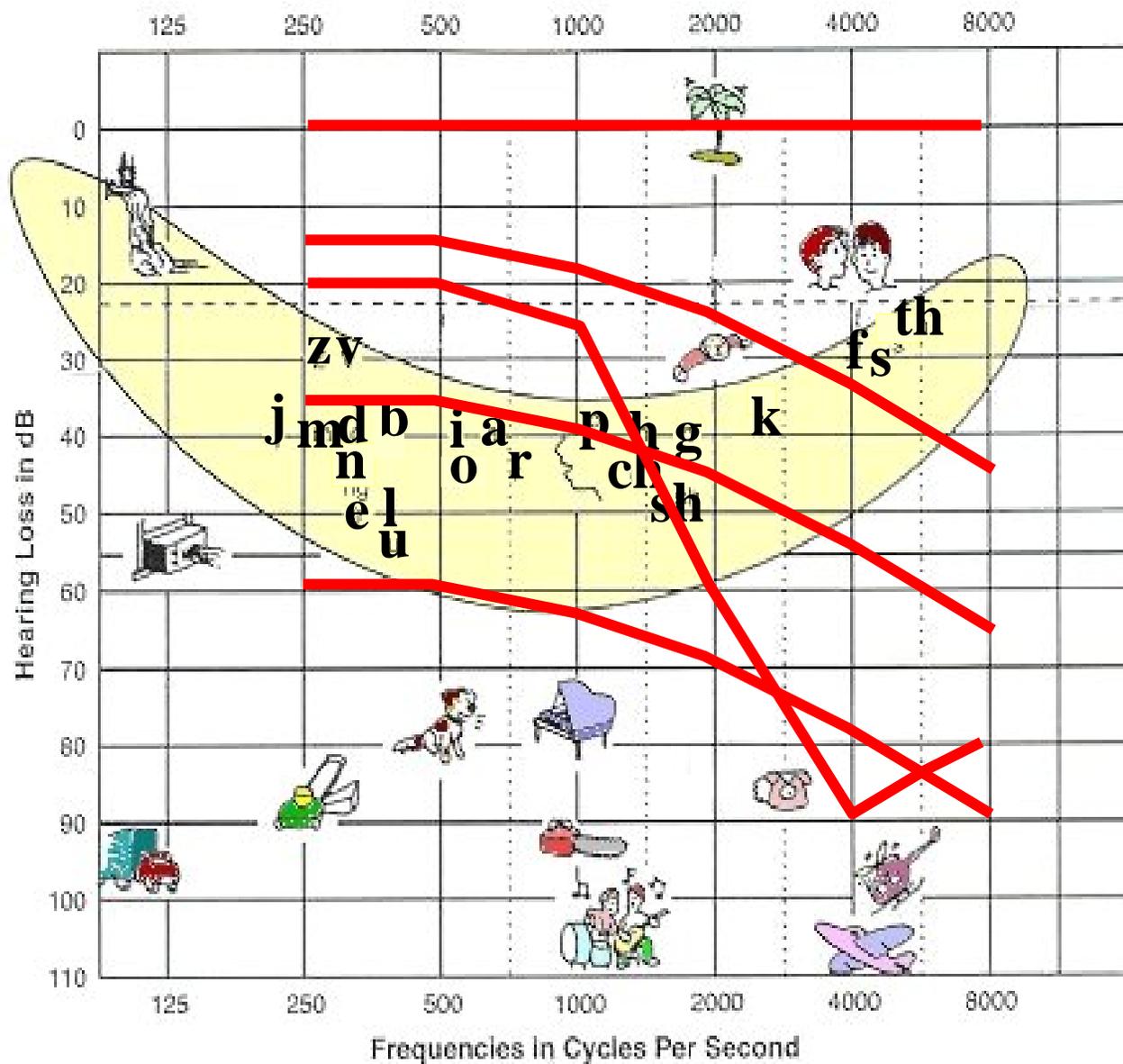


Raising the volume doesn't solve problems

*Much harder to correct with a hearing aid*

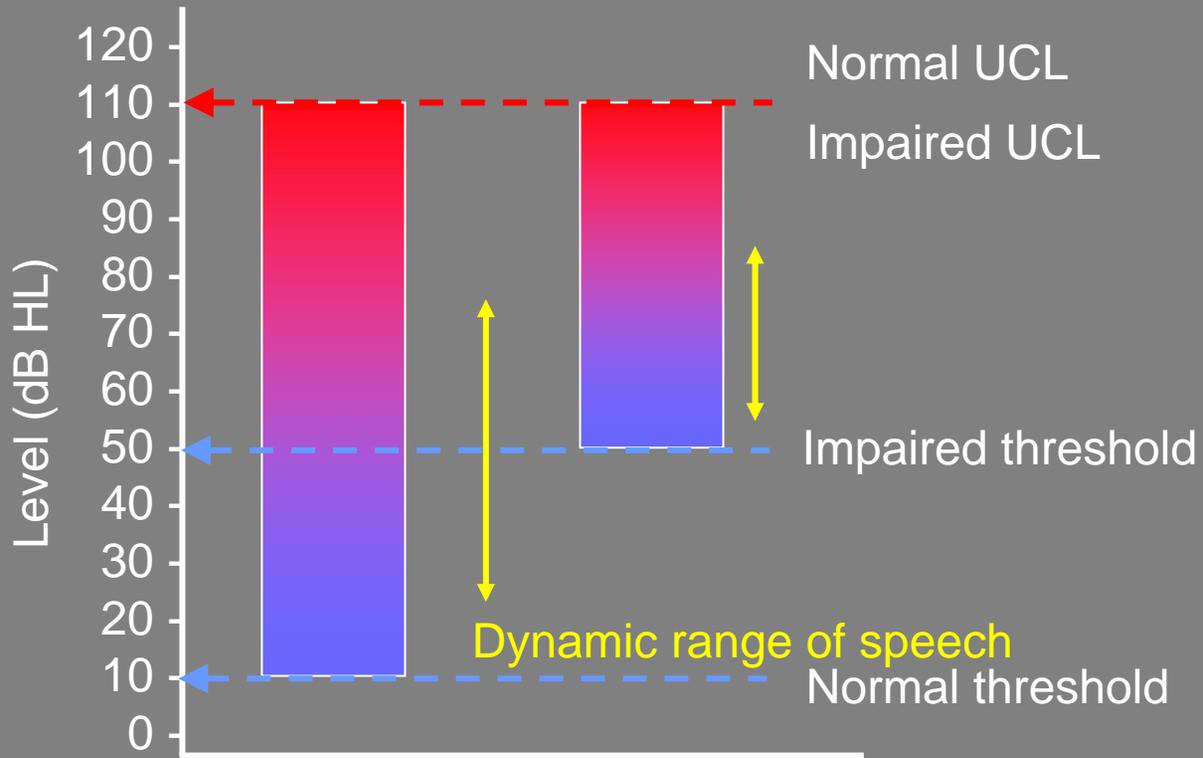
# Differential effects of changes in threshold

# Comparison of the Frequency and Intensity of Various Environment and Speed Sounds



# Recruitment

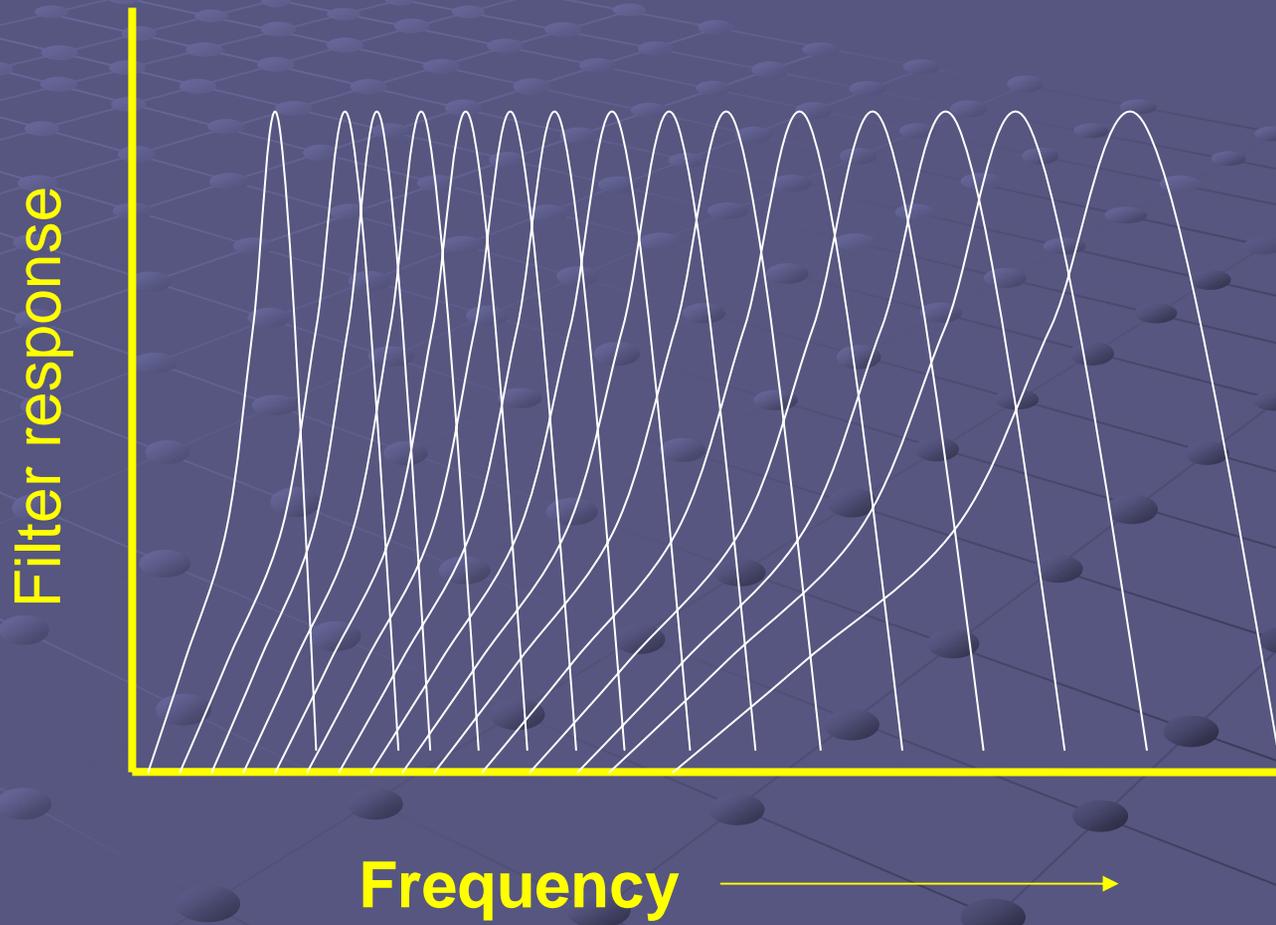
# Recruitment

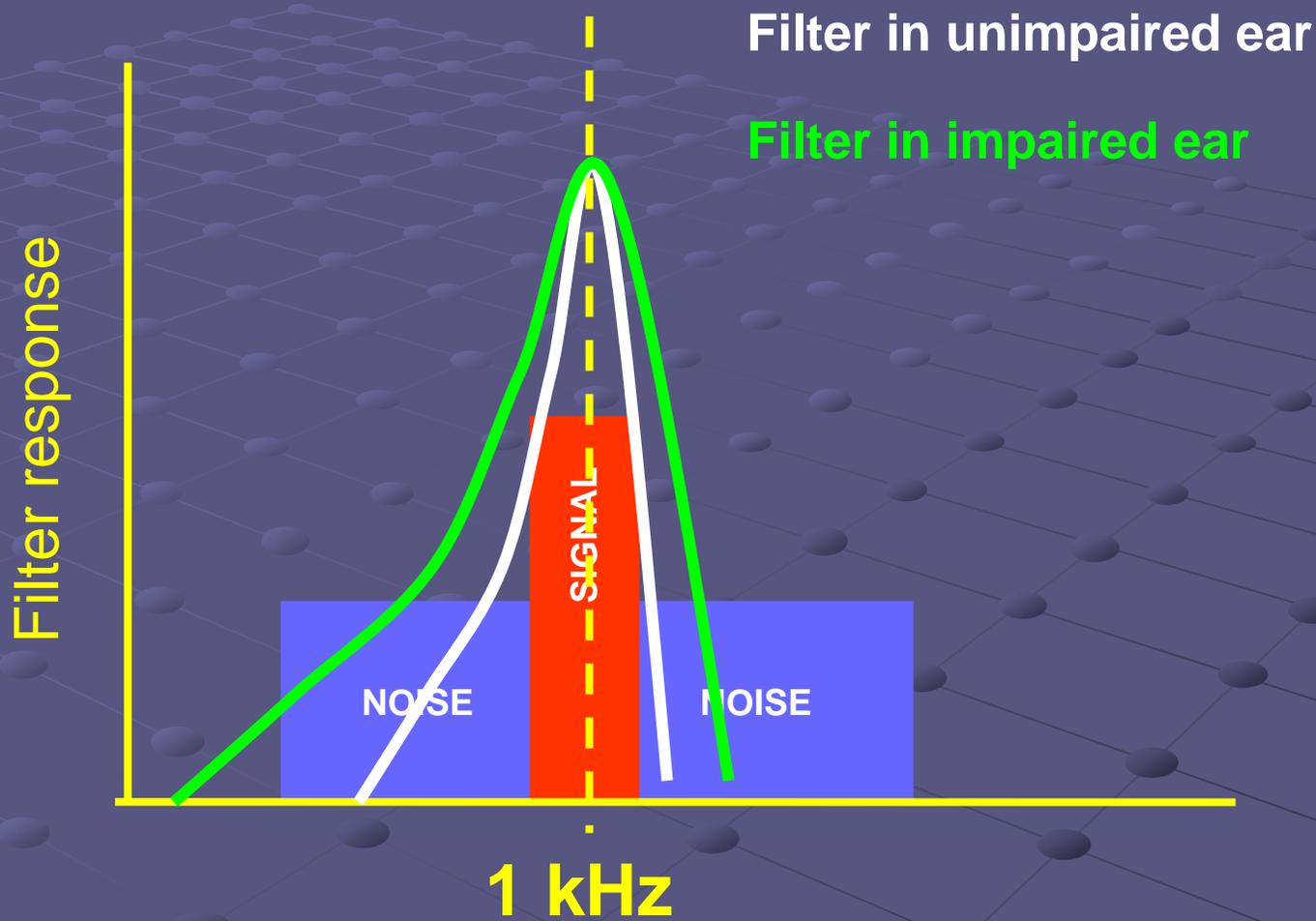


# Frequency resolution

- Can think of the cochlear as a bank of auditory filters
- These filters become broadened with SNHL

# Picture of auditory filters





# Hearing Aids

Hearing aid technology has vastly improved in the last 10 years

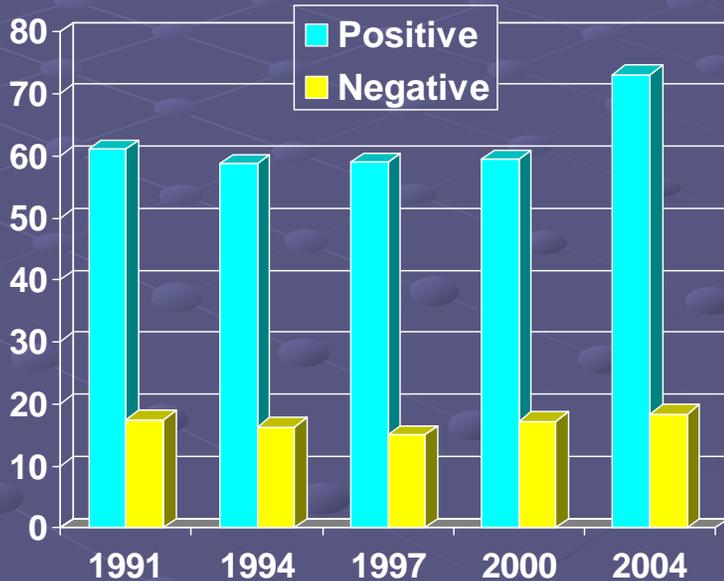
*However, hearing aids cannot fully remediate hearing loss*

# Hearing aids: what are they?

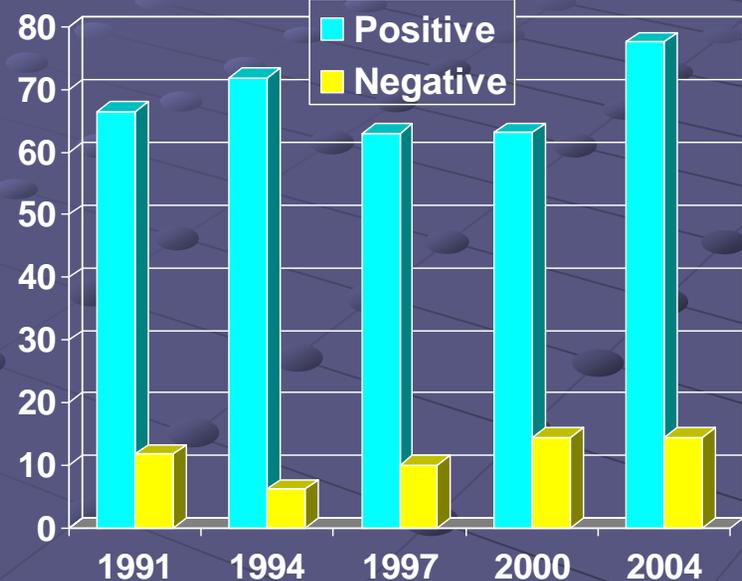
- are basically sophisticated amplifiers
- cannot improve the signal-to-noise-ratio (yet)
- cannot determine what is 'signal' vs. what is 'noise'
- cannot restore clarity

# Hearing Aids: Satisfaction

The good news (Kochkin, 2005):

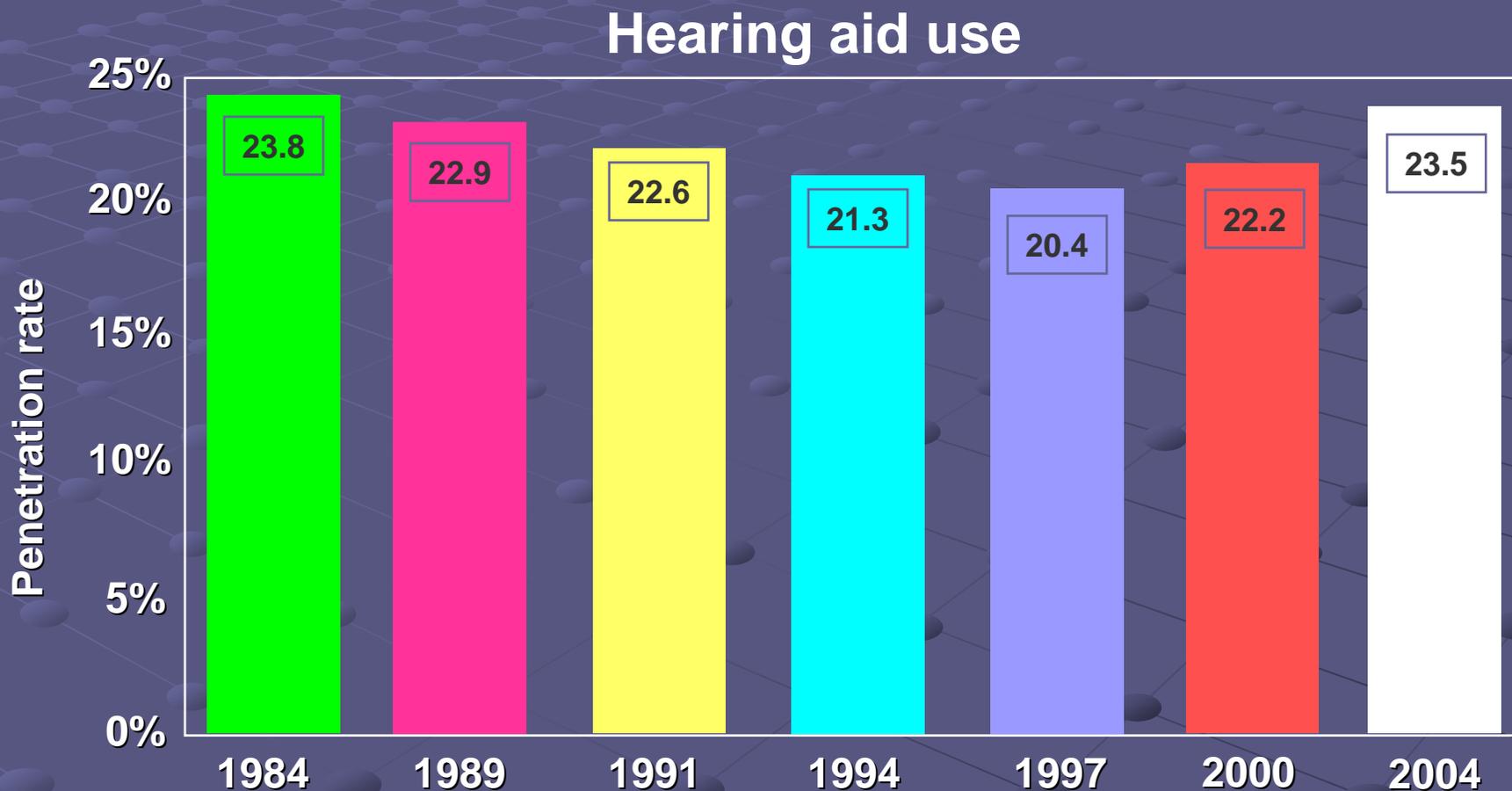


HAs 1-4 yrs. old



HAs <1 yr. old

# The not-such-good news



(Kochkin, 2005)

# Hearing Aids: Options

➤ **Style**

➤ **Technology**

**Signal processing options**

**‘Bells and whistles’**

➤ **The future**

# Hearing Aids: Styles

- Behind-the-ear
- In-the-ear
- In-the-canal
- Completely-in-the-canal
- Open canal



# Pros and cons of each style

Style	Power	Feedback	Battery size	Ease of insertion	Visibility
<b>BTE</b>	+++	Least	Largest	Can be hard	2
<b>ITE/ITC</b>	++		Small	Easiest	3
<b>CIC</b>	+	Most	Tiny	Difficult	1
<b>Open canal</b>	low gain		Small	Can be hard	1

# Hearing Aids: Signal Processing

- **Digital versus analog**
- **Compression**
- **Directional microphones**
- **Noise reduction**
- **Feedback cancellation**

# Hearing Aids: Digital vs. Analog

- 90% of aids fitted in 2005 were digital
- Describes method of signal processing
- Provides more options but is not intrinsically superior to analog

# Addressing threshold changes

Multiple channels that can each be programmed independently

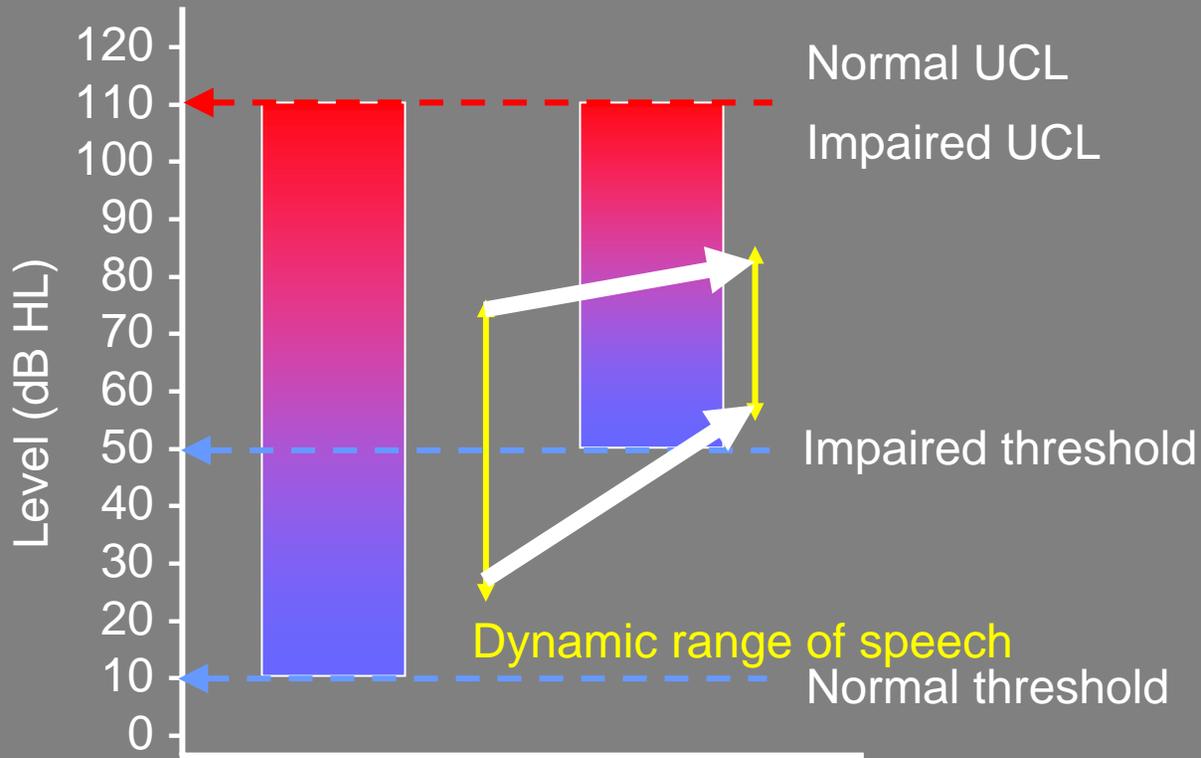
Potentially better ability to meet frequency-gain target and loudness growth issues

In reality there is cross-over between channels i.e. they are not entirely independent

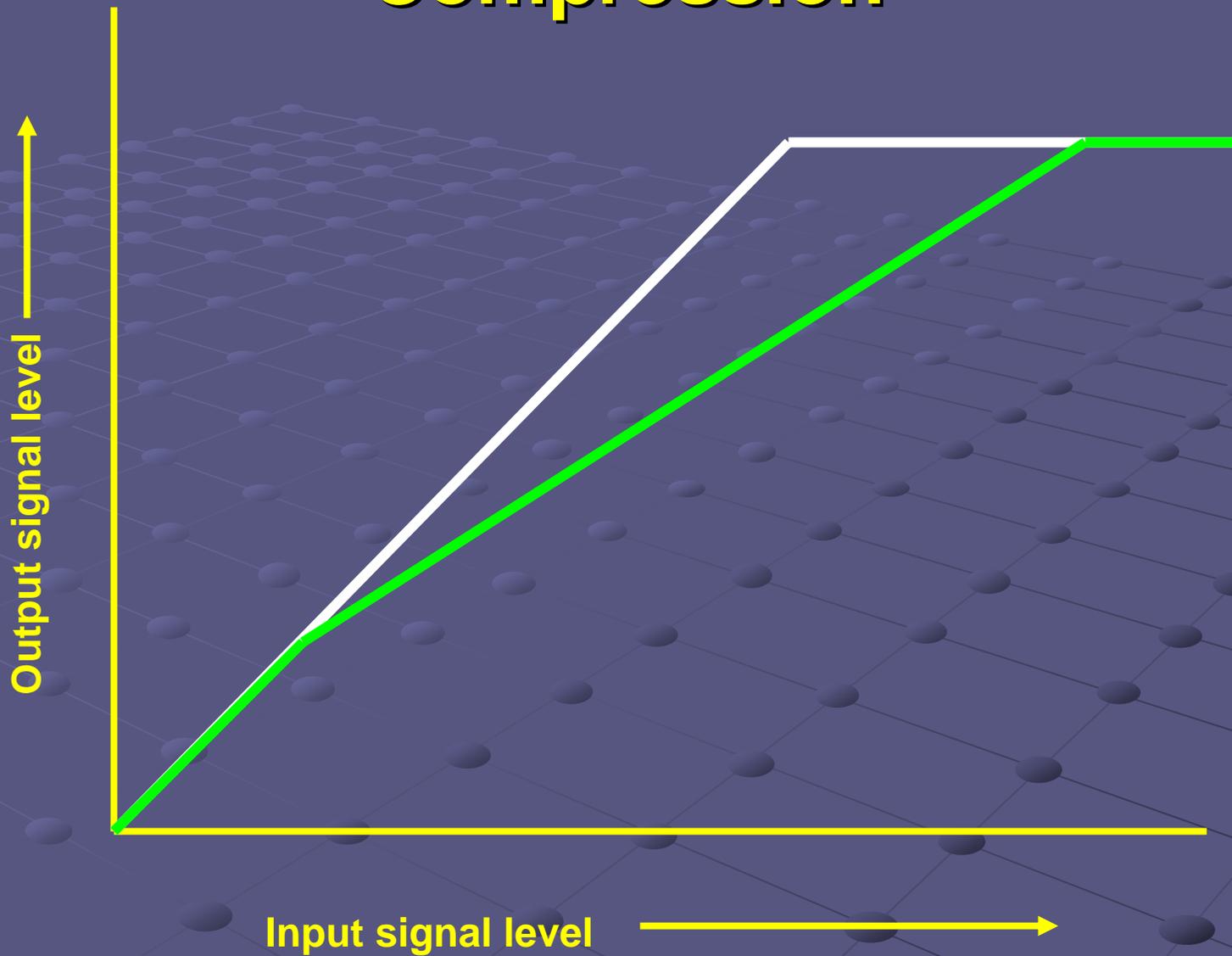
# Addressing Recruitment

Compression: gain provided is dependent of level of input signal. With recruitment we want to shrink range of speech levels into a smaller dynamic range

# Recruitment



# Compression



# Addressing poor frequency resolution

Need to improve the signal-to-noise  
(S/N) ratio

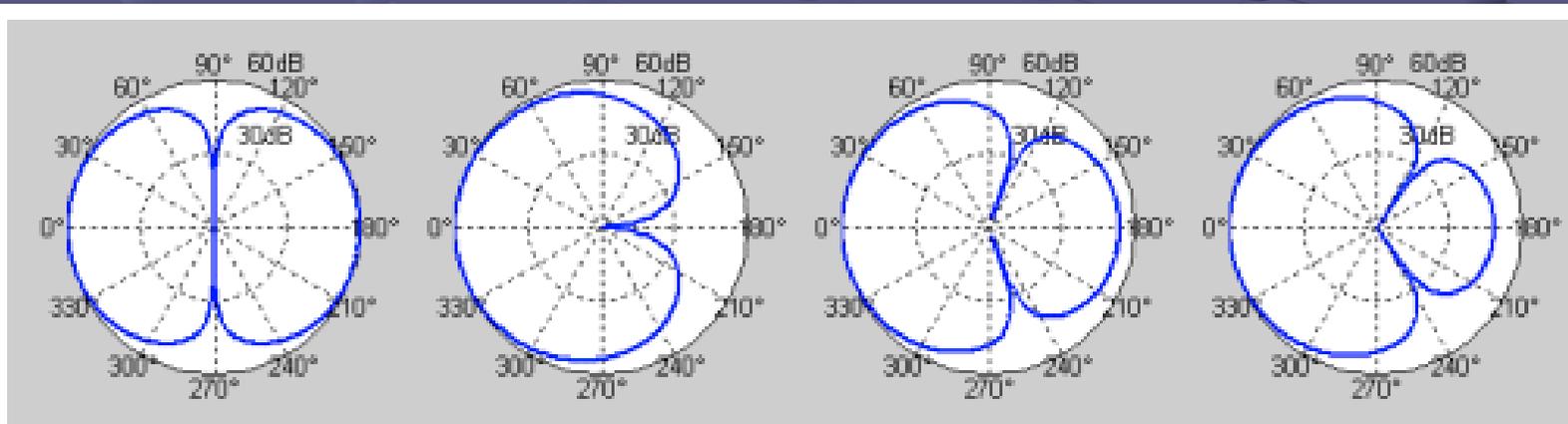
i.e. level of signal in relation to level of  
noise

# Hearing Aids: Directional Microphones

- Multiple laboratory studies show HAs with directional microphones are more effective than omnidirectional microphones for listening in noise

# Hearing aids: Directional Microphones

Describes the directional sensitivity of the microphone



BI-DIRECTIONAL

CARDIOID

HYPERCARDIOID

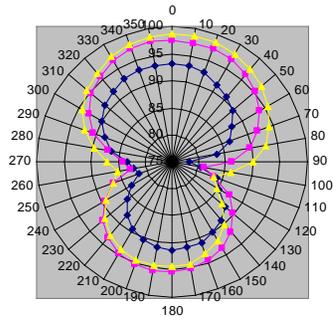
SUPERCARDIOID

# Considerations

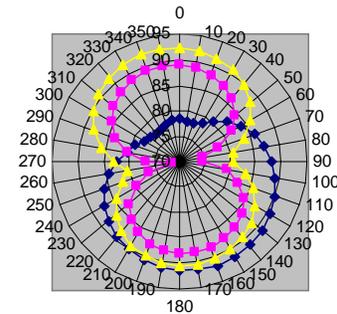
- Users often forget to switch settings.  
Adaptive directionality overcomes this
- Must mark orientation on impression so manufacturer can orient mics correctly
- Need to confirm directionality

# Some examples of polar plots we've measured

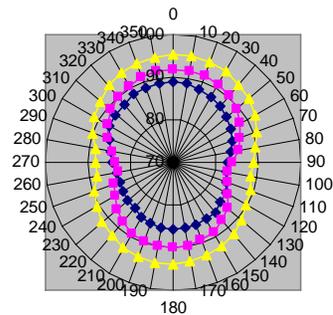
Banded Noise Polar Plot for Starkey 0307280277 dir



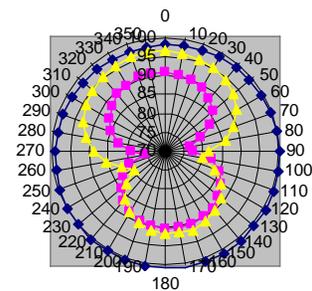
Banded Noise Polar Plot for HA0700259058Rhyper



Banded Noise Polar Plot for HA0700258912Lhyper



Banded Noise Polar Plot for HA0700258927Rhyper



# Hearing aids: Noise Reduction

- People like it
- Makes sound more pleasant
- No studies show significant benefit

It has been said that "the best hearing aid is one that will be worn...."

# Hearing aids:

## Feedback cancellation

Generally is effective  
without negative  
consequences

Algorithms use an  
adaptive filter for ongoing  
control

## Feedback

sound  
into amp

## Cancellation

feedback signal is estimated and then  
filtered

# Hearing aids: Bells and Whistles

- **Multiple programs** Coil of wire which converts electromagnetic energy into electrical energy
- **Remote control** Different hearing aid settings are stored in each program User switches programs as desired
- **Volume control**
- **T-coil** Smaller coil for switching between programs and controlling volume

Are pros and cons

# Hearing aids: The Future

## Binaural hearing aids: wireless between-aid communication (Blue tooth technology)

- **Permits binaural (over bilateral) hearing: localization, release from masking, echo suppression**
- **Signal processing opportunities: noise cancellation, beam forming**

- **Binaural hearing aids: wireless between-aid and other via (Blue tooth technology)**
- **cell phone to hearing aid**

# Hearing aids: User Issues

- **Manual dexterity**
- **Cognitive status**
- **Expectations**
- **Lifestyle**

# Hearing Aids: Manual Dexterity

- **Successful HA use requires good manual dexterity (insertion, manipulation, upkeep)**

# Hearing Aids: Manual Dexterity

Correlations between manual dexterity and HA outcome:

	Manual Dexterity	p<
Success using HAs	$r = 0.555$	$p < 0.01$
Performance with HAs	$r = 0.602$	$p < 0.001$
Satisfaction with HAs	$r = 0.802$	$p < 0.001$

Kumar et al (2000)

# Impacts of Hearing Impairment

➤ Social

➤ Psych

➤ Occu

➤ Fam

"Family of non-users more often said the HI relative was **CONFUSED, DISORIENTED, ARROGANT & NON-CARING** than did family of hearing aid users."

(Kochkin & Rogin 2000)

(Kochkin & Rogin 2000)



# Benefits reported following acquisition of a hearing aid:

Hearing aid users & their relatives reported *improvements* in:

- relationships at home
- self-esteem
- mental health
- social, physical & emotional life



# Questions to consider when planning auditory rehabilitation

- Is a hearing aid the best solution?
- Are there co-morbid conditions?
- How to assess it's effectiveness?
- What individual factors should be considered?

# Dual-Sensory Impairment

Presence of hearing loss and vision loss

Prevalence

1.7 million individuals in US

21% of adults over age 70 have DSI

Veterans with DSI in  
1995: 179,000  
Veterans with DSI by  
2010: 294,000  
Goodrich, 1995

# Dual-Sensory Impairment: Impacts

- DSI results in significantly more difficulties with ADLs and IADLs than single impairments
- Are the effects additive?
- Presumably  $1 + 1 > 2$

# Dual-Sensory Impairment: Impacts

- **Hearing people and vision people don't communicate**
- **Dual Sensory Loss Consensus Conference in Portland 2004 revealed more questions than answers**

# Dual-Sensory Impairment: Clinical Considerations

- Selection of appropriate hearing aids
- Use of hearing aids
- Provision of information
- Functional measures
- Outcome measures
- Clinical collaboration

# Cognitive status

Data shows interactions between cognitive status and ability to benefit from sophisticated signal processing

Should be considered when selecting hearing aid processing characteristics



# Expectations

- It usually takes many weeks for individuals to decide to acquire a HA after learning they have hearing impairment
- Thus by time of fitting they have distinct expectations about the HAs

# Expectations

➤ **Expectations affect outcome**

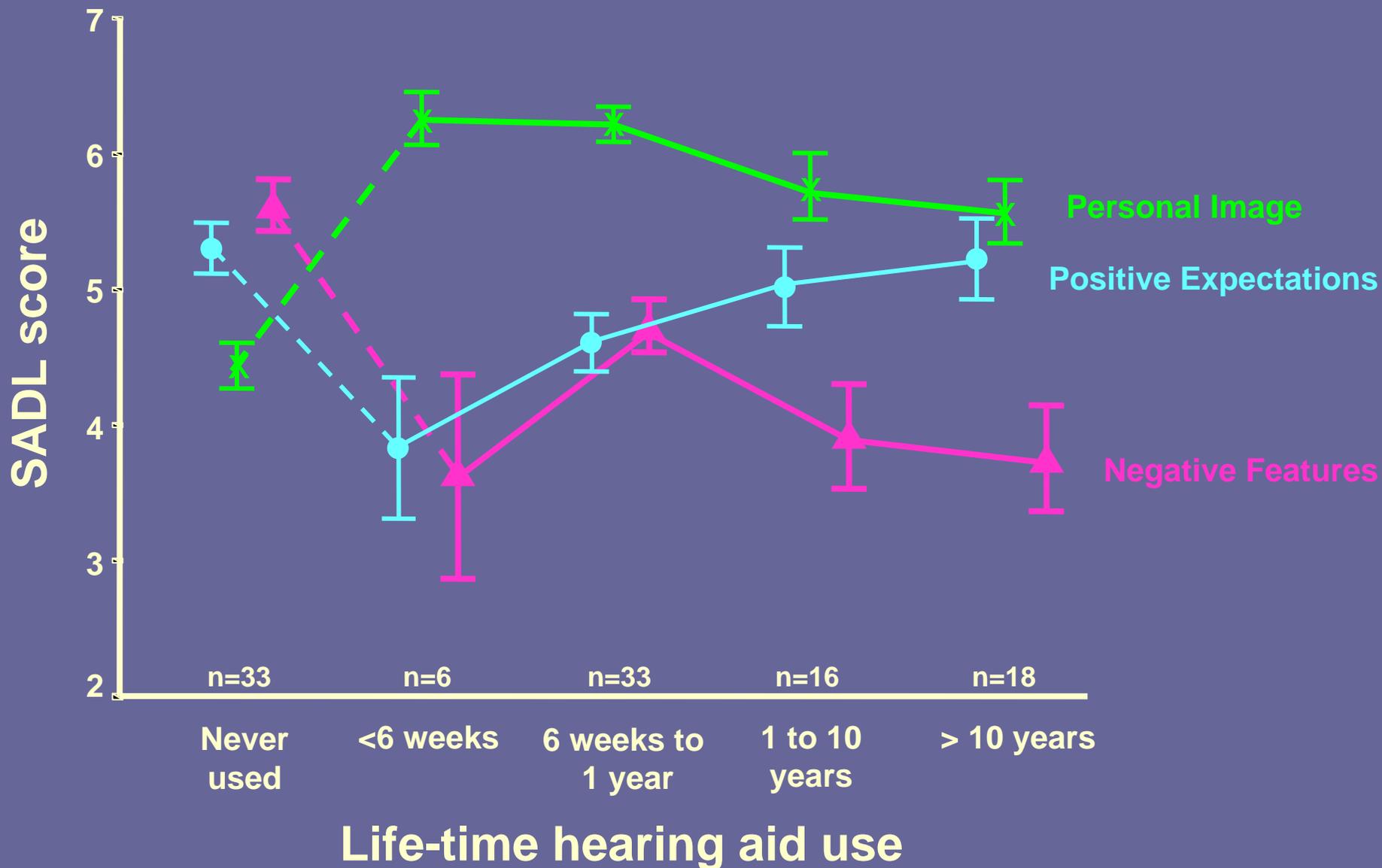
**Could go either direction:**

**Expectations too high → disappointment**

**or**

**Expectations too low → self-fulfilling  
prophecy**

# From Saunders & Jutai (2004)



# Lifestyle

Individual needs and wants vary, thus measured outcome might not reflect patient satisfaction if we aren't helping the patient in situations in which they want to hear.



Water aerobics anecdote!

# Assistive Listening Devices

➤ Personal

➤ All-in-one

also

frequency

response

System

g



Microphone and FM transmitter



Receiver



Receiver attached via 'audioshoe' to BTE hearing aid

# Ecological

i.e. Improv

ent

➤ Backg

➤ Room

➤ Room

- Use soft absorbent floor and furniture coverings
- Avoid restaurants with hard floors and bare walls

- Use good lighting
- Do not have talker sit in front of a window  
*Lip reading and facial expressions can increase speech understanding by 20% even without raining*

# **Auditory Retraining Therapies**

**Aim: to alter neural transmission of sound at the cortical and sub-cortical level to improve timing and synchronization of neural responses**

**Relies on neural plasticity of the central auditory system**

# Auditory Retraining Therapies

- Computer-based, interactive programs
- Require repetitive use
- Tasks are usually adaptive i.e. begin easy and get harder as performance improves
- Jury is out on effectiveness

- **Central system or peripheral systems mucked up**
- **Holds promise for rehab in the future**

- **Although HL seems simple on surface it is highly complex**
- **Is a need for understand cause via appropriate eval. prior to rehab. beginning**

- **Technology has vastly improved**
- **Will continue to do so**
- **However, non-tech rehab still necessary**
- **When hearing loss is present and need rehab. a holistic approach should be used**

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