LANTOS TECHNOLOGIES

Boston Audiology Consultants
Beautiful Sounds, Customized Care

Hearing Loss and Tinnitus from Noise: Diagnosis and Management Across the Lifespan

Brian Fligor, ScD, PASC

President, Boston Audiology Consultants, Inc.

Chief Audiology Officer, Lantos Technologies, Inc.

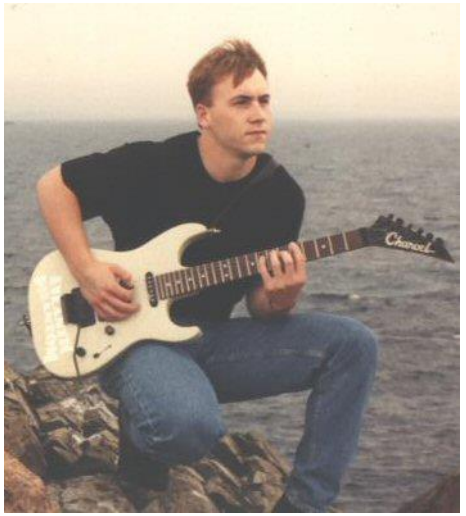
Adjunct Instructor, Salus University

brian.fligor@gmail.com

Disclosures:

Consultant to Lantos Technologies, Inc., was employee, have ownership interest

Owner, director of private practice (Boston Audiology Consultants, Inc.)



Guitarist since age 5

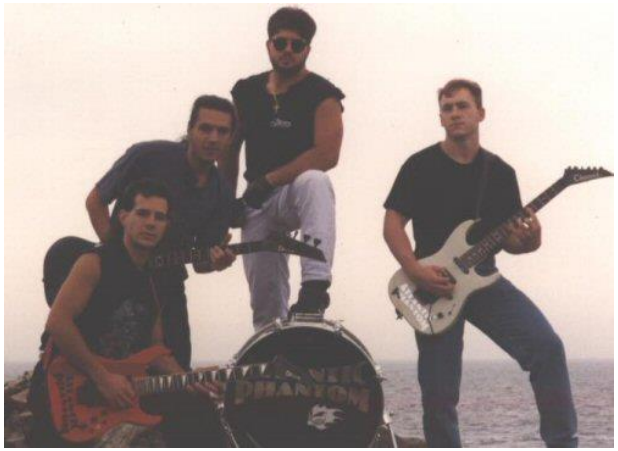
"Brain" Fligor since age 6

Have had tinnitus since age 14

Normal audiogram and DPOAEs (for now)

My chosen listening level is 89 dBA

Father of 4, "Daddy doesn't care who's right. He just cares about quiet."



http://eartunes.com/if/audiology-inf-108.shtml

OMSI: *Listen Up!*

Interactive museum exhibit, partnership with Dangerous Decibels™:

- Questions about sound exposure
- Self-test hearing threshold at 4000 Hz

August 2009:

55,000 aged 6-85 years participated

- 22% had PTS ≥ 30 dB HL at 4k Hz

16,000 boys and girls (11-19 years)

22,600 men and women (20-45 years)

http://dangerousdecibels.org/exhibit/omsi/

OMSI: *Listen Up!*

During the past year, the percentage of participants who:	Young Female	Young Male	Adult Female	Adult Male
Used stereo headphones	83%	78%	56%	59%
Used a gas-powered lawn mower or leaf blower	34%	56%	33%	73%
Rode on a jet ski, snowmobile, or motorcycle	32%	37%	19%	41%
Fired a gun	24%	40%	16%	45%
Rode in a car with a loud stereo	75%	66%	71%	73%
Played in band	22%	32%	7%	13%
Went to a motorcycle or car race	22%	26%	13%	26%
Went to a concert	50%	42%	54%	52%
Went to a tractor pull or monster truck show	15%	24%	10%	16%

Reported through 2008

http://dangerousdecibels.org/exhibit/omsi/

OMSI: *Listen Up!*

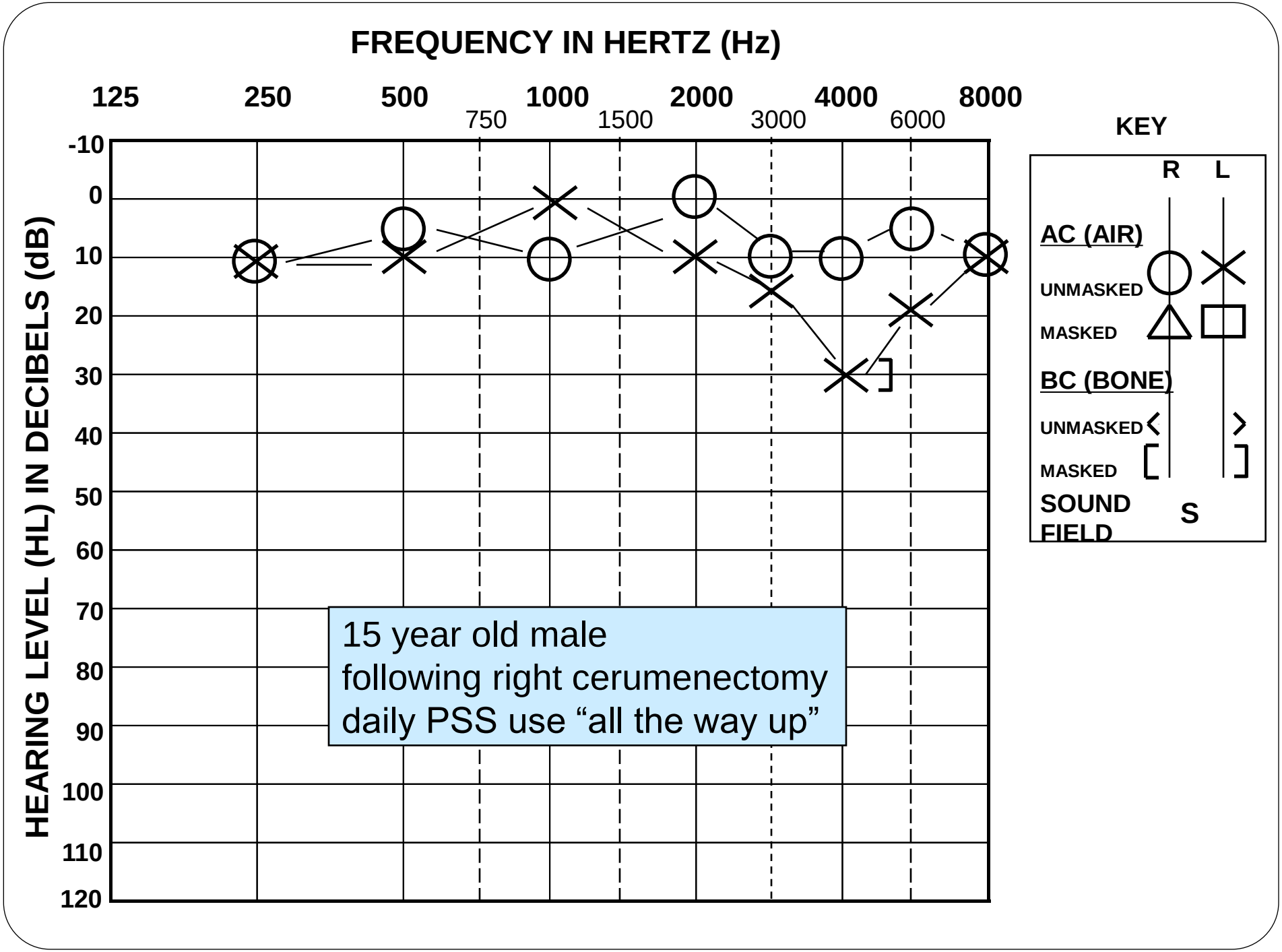
Youth group: 10% had ≥ 30 dB HL at 4k Hz

- 9% of the boys (6,400)
- 10% of the girls (9,700)

Adult group: 12% had ≥ 30 dB HL at 4k Hz

- 16% of the men (8,700)
- 9% of the women (12,000)

http://dangerousdecibels.org/exhibit/omsi/


FREQUENCY IN HERTZ (Hz)
125
250
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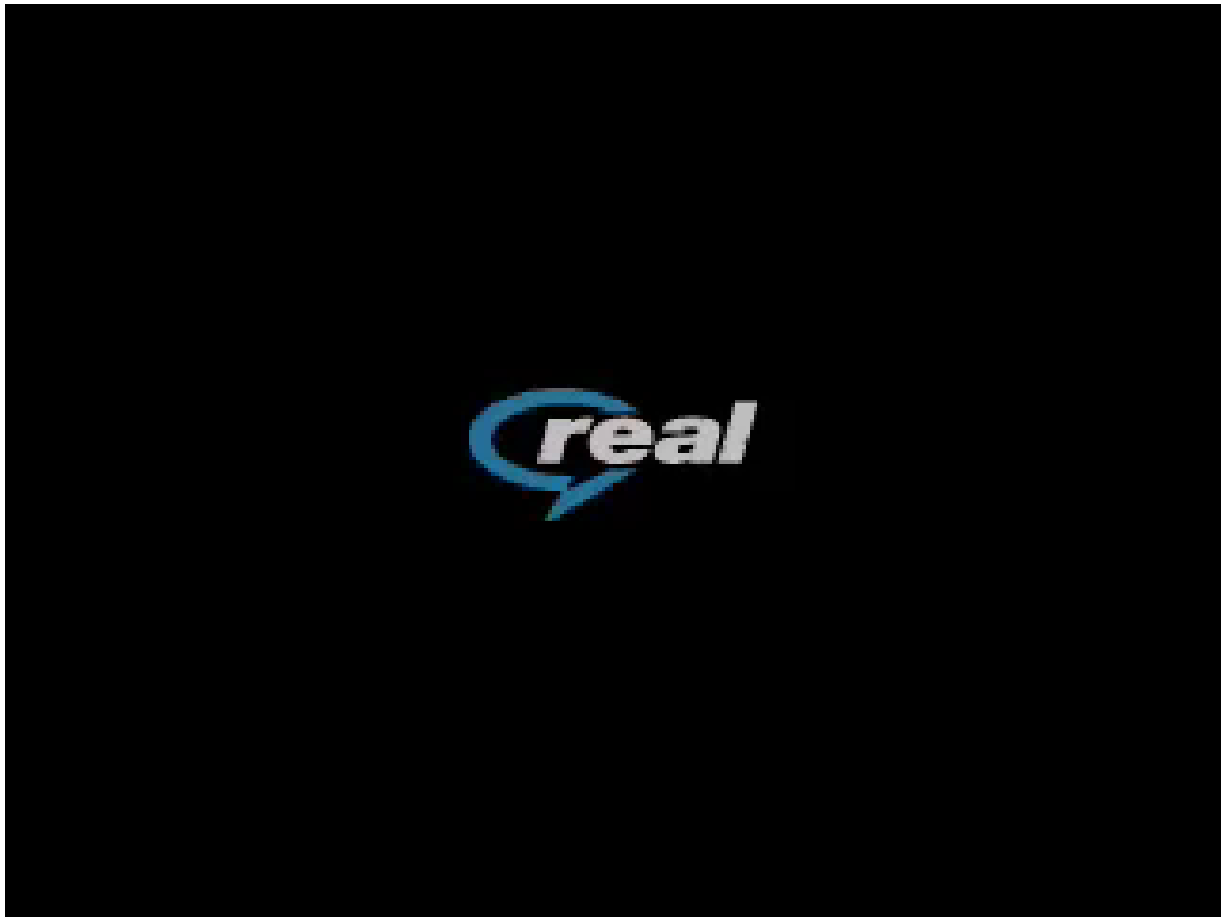
6000
8000
HEARING LEVEL (HL) IN DECIBELS (dB)
-10
0
10
20
30
40
50
60
70
80
90
100
110
120
15 year old male
following right cerumenectomy
daily PSS use “all the way up”
KEY
R
L
AC (AIR)
UNMASKED
MASKED
BC (BONE)
UNMASKED
MASKED
SOUND FIELD
S

2005: *It's all downhill from here*



Injury From Noise Exposure, Chronic Exposure AND Acoustic Trauma

- Noise-Induced Temporary Threshold Shift (NITTS), 3-6k Hz
- Noise-Induced Permanent Threshold Shift (NIPTS), 3-6k Hz
- Tinnitus (typically tone-like, hissing; pitch-matched ~ peak of noise-notch)
- Hyperacusis
- Diplacusis (abnormal pitch perception)
- Suprathreshold Speech Intelligibility In Noise Decline

Necrosis: lots of inflammation vs. Apoptosis: limited inflammation

Injury From Noise Exposure, Chronic

- Too loud, for too long, too often
  - The Greedy Outer Hair Cell (OHC): ~78 dBA to ~132 dBA
  - More waste product (oxygen byproducts) than can be managed by antioxidant defenses
  - Cascade of molecular events, programmed cell death (apoptosis)
  - OHC breaks into bits, supporting cells maintain structural integrity
- Some concern for glutamate excitotoxicity leading to cochlear synaptopathy (Kujawa)

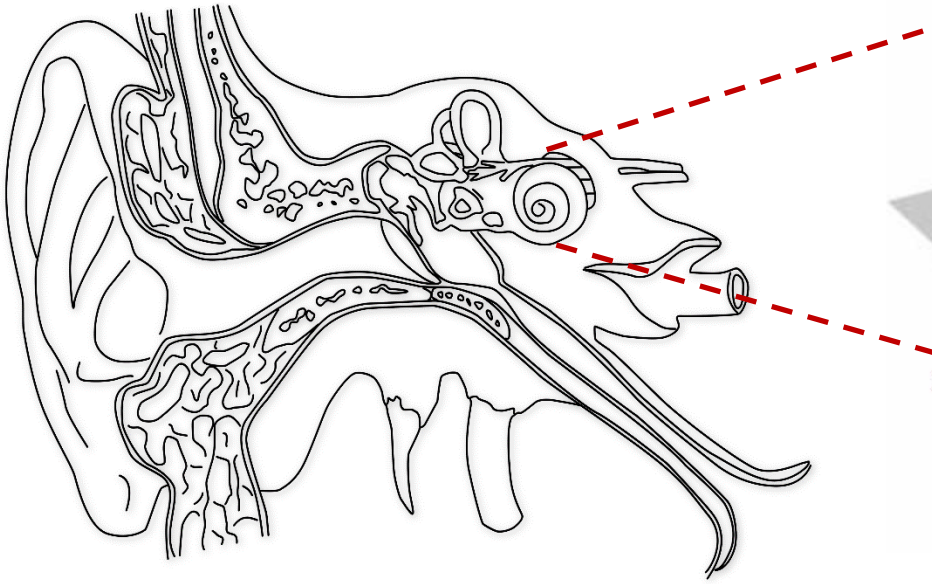
Injury From Noise Exposure, Acoustic Trauma

- Force of transient sound capable of exceeding the elastic limit of the tissue of the:
  - Organ of Corti (Sensorineural): ~132 to 184 dB SPL (peak equivalent)
  - Eardrum (Conductive): ~184 dB SPL to >194 dB SPL (peak equivalent)
    - 5 pounds per square inch (psi) = 184 dB SPL
    - 1 atmosphere = 14.7 psi (max dB at sea level = 194 dB SPL)

- Ossicular discontinuity (shock wave) >194 dB SPL
  - Also Traumatic Brain Injury, APD, lung and viscera injury

Injury From Noise Exposure, Acoustic Trauma

- Continuous sound that transfers enough energy to cochlea to result in necrosis of OHC, IHC, and cause glutamate excitotoxicity of 1st order afferent neurons of spiral ganglion (cochlear synaptopathy)
  - Rats: 4000% dose; Guinea pigs: 2500% (where 100% = 85 dBA, 8-hr Leq)
  - 109 dBA for 75 minutes (=4000%); 109 dBA for 47 minutes (=2500%)



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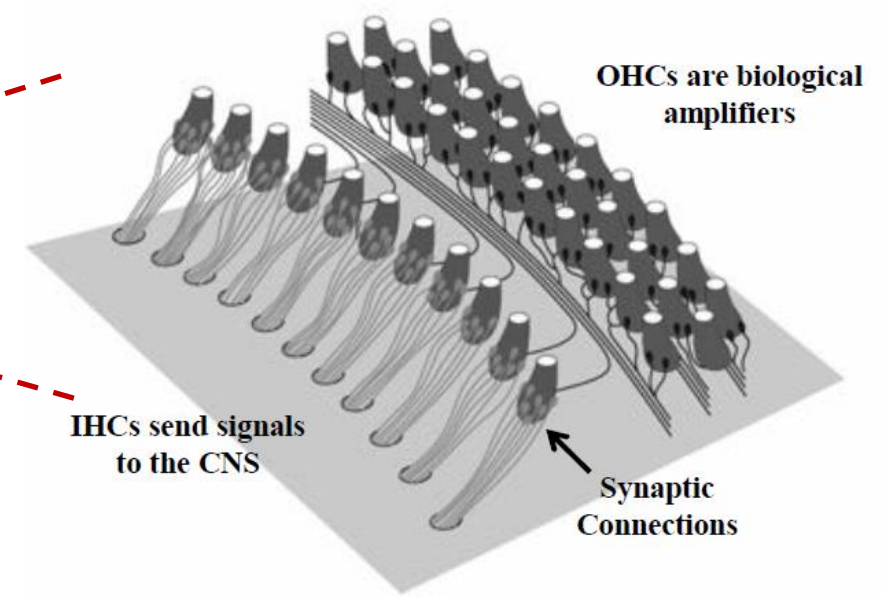
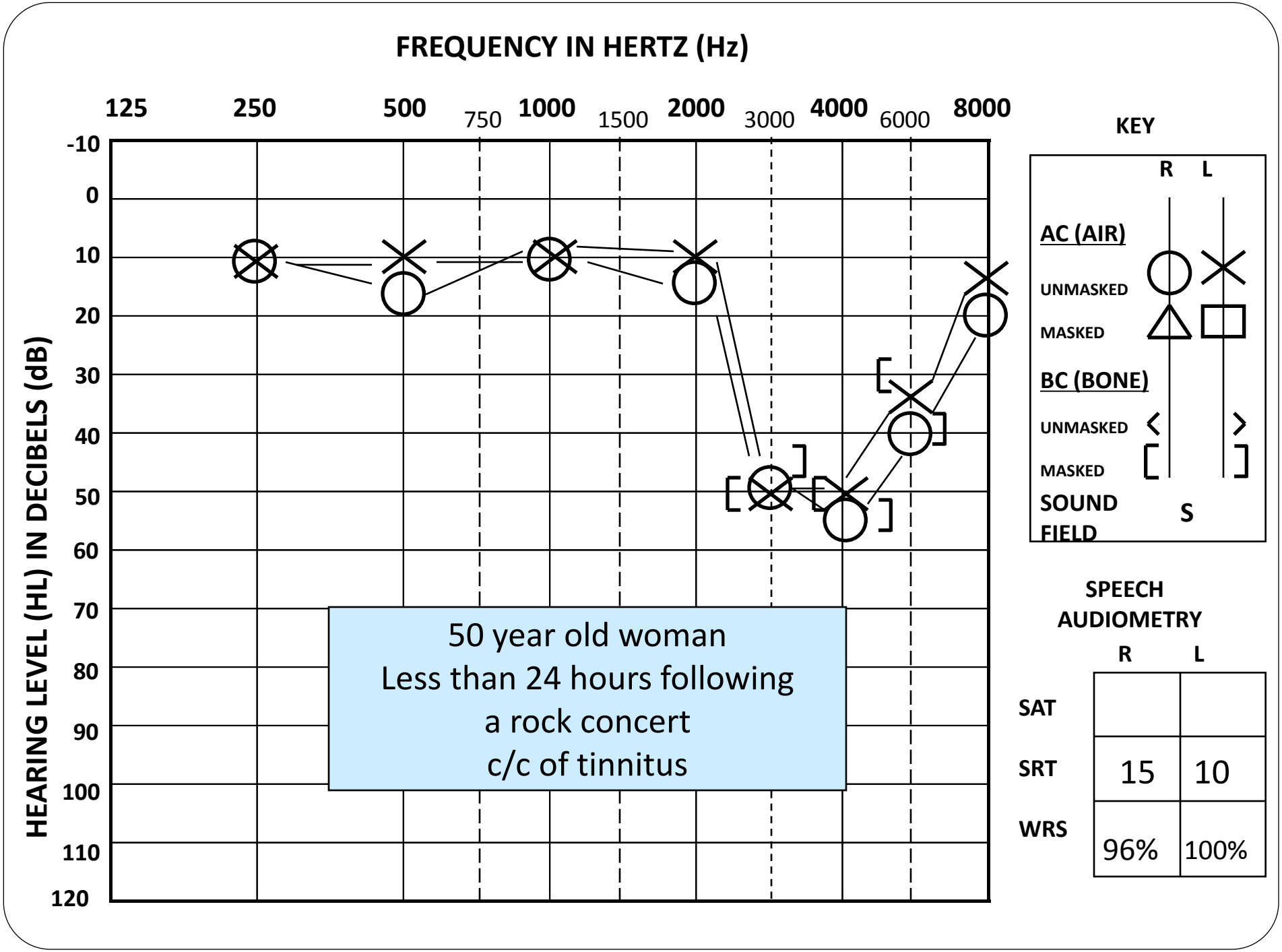


Permission: Liberman, 2017

Case Study: 50 year-old woman, acoustic trauma following rock concert

- 50-year-old woman attended a rock concert (2007) at a <1000 seat venue, left after ~1.5 hours as levels were "way too high."
- Experienced ringing in her ears on the drive home, still very pronounced ringing the next day so saw an ENT.
- Noise exposure history was otherwise negative, and otologic history was non-contributory to complaint of tinnitus.
- Lawsuit against the band and concert venue, citing unremitting tinnitus and hyperacusis, settled out of court.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-10
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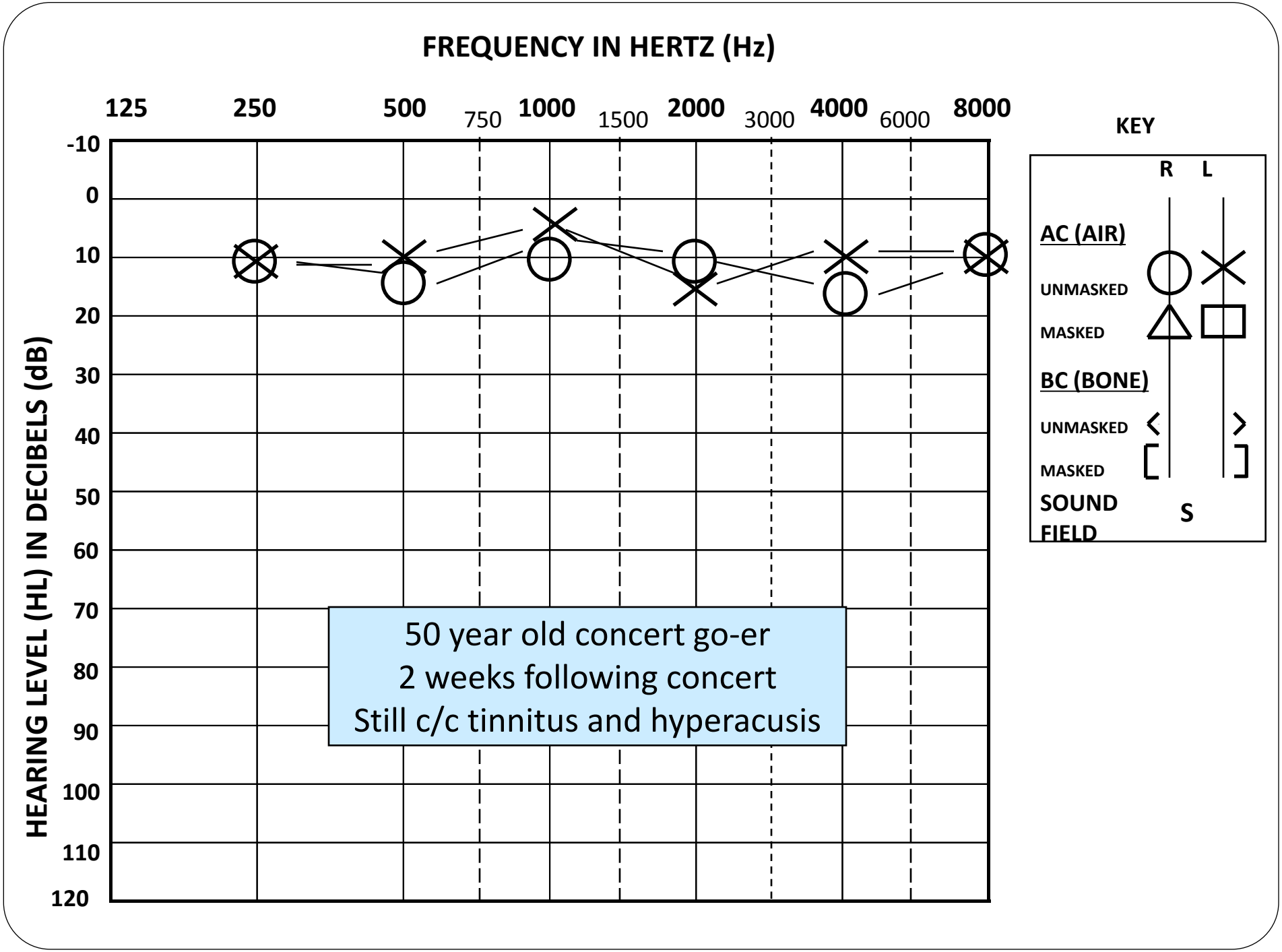
90
100
110
120
50 year old woman
Less than 24 hours following
a rock concert
c/c of tinnitus
KEY
R
L
AC (AIR)
UNMASKED
MASKED
BC (BONE)
UNMASKED
MASKED
SOUND FIELD
S
SPEECH AUDIOMETRY
R
L
SAT
SRT
15
10
WRS
96%
100%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-10
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120
50 year old concert go-er
2 weeks following concert
Still c/c tinnitus and hyperacusis
KEY
R
L
AC (AIR)
UNMASKED
MASKED
BC (BONE)
UNMASKED
MASKED
SOUND FIELD
S

Expert's opinion

- TTS of 35-50 dB, with unresolved tinnitus and hyperacusis is consistent with acoustic trauma
- Previous recordings made by me at the same venue on 2 different occasions of a different band indicated levels of 100-105 dB(A) and 107-110 dB(A); Avg level at outside venues = 103.4 dB(A) (Clark, 1992)
- Models of TTS growth indicated for fractile 0.5, the 35-50 dB TTS would result from 98.6-107.4 dBA
- 85 dB(A), trade 3 DRC:

  1-2 hrs, 98.6 dB(A) = 289% - 579% Noise dose

  1-2 hrs, 107.4 dB(A) = 2211% - 4422% Noise dose

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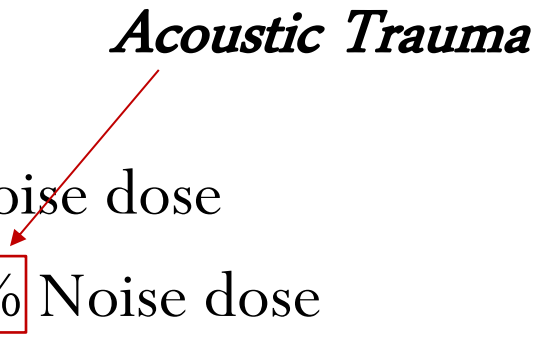


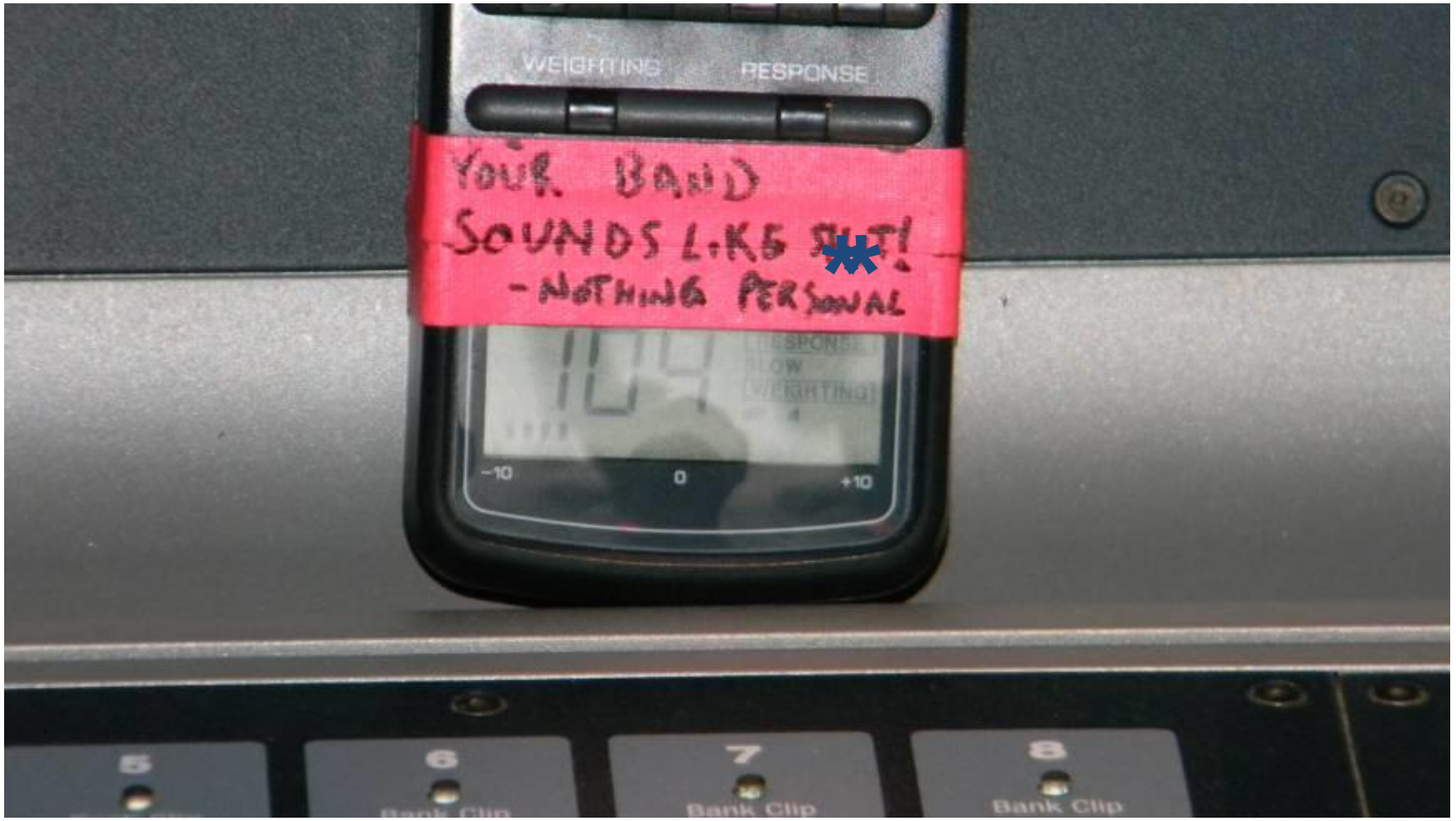
Elements of a Hearing Loss Prevention Program (HLPP)

Application to whole-life exposure

- Noise Survey (assessment)
- Engineering Controls
- Audiometric Monitoring
- Education and Motivation
- Hearing Protection Devices

Bamboozle Road Show, June 2010

Bamboozle Road Show, June 2010



Sound Exposures: Bamboozle Road Show

Leq* (dBA)	105
Time (hrs)	4
Noise dose**	5000%

Table 1. Total audience exposure

Leq* (dBA)	99
Time (hrs)	7
Noise dose**	2198%

Table 2. Total crew exposure (4 hours show + sound check and setup)

* Leq is the typical 5-minute equivalent continuous sound level in A-weighted decibels

** DRC for determining “Noise dose” = 85 dBA for 8-hr Leq, 3dB exchange rate

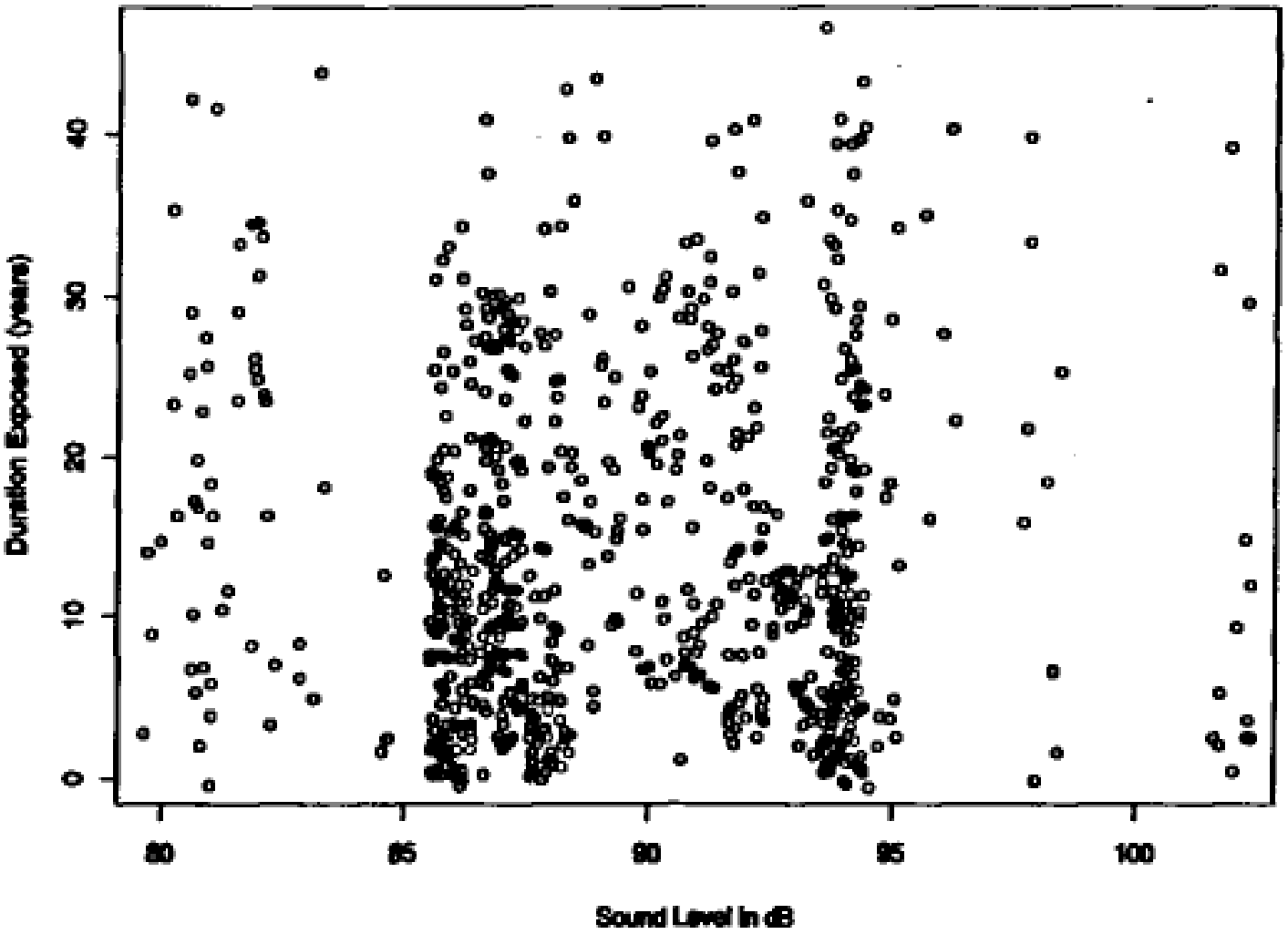
Audiology Today MayJune 2011: pp 30-40

How loud (and how long) is too loud (and too long)?

We thank those researchers and unprotected workers from decades ago:

- Passchier-Vermeer (1968)
- Robinson (1968, 1971)
- Baughn (1973)
- Lempert and Henderson (1973) – ONHS

ONHS 1968-1972



Scatter Plot of Noise Exposure (level and years) of 792 workers

Damage Risk Criteria

OSHA	NIOSH	WHO/EU
• 90 dBA	• 85 dBA	• 80 dBA
• 5 dB	• 3 dB	• 3 dB
Exchange rate	Exchange rate	Exchange rate
• 90 dBA | 8 hrs	• 85 dBA | 8 hrs	• 80 dBA | 8 hrs
• 95 dBA | 4 hrs	• 88 dBA | 4 hrs	• 83 dBA | 4 hrs
• 100 dBA | 2 hrs	• 91 dBA | 2 hrs	• 86 dBA | 2 hrs
• 105 dBA | 1 hr	• 94 dBA | 1 hr	• 89 dBA | 1 hr

LIBERAL ⋯⋯⋯⋯⋯⋯⋯⋯⋯⋯⋯⋯⋯⋯⋯⋯⋯⋯⋯⋯⋯⋯⋯⋯⋯⋯⋯▶ CONSERVATIVE

Risk for a "Material Hearing Impairment"

Max Noise Dose 85 dBA trade 3 vs. 90 dBA trade 5?

OSHA (1981): **Minimum Standard for Safety**

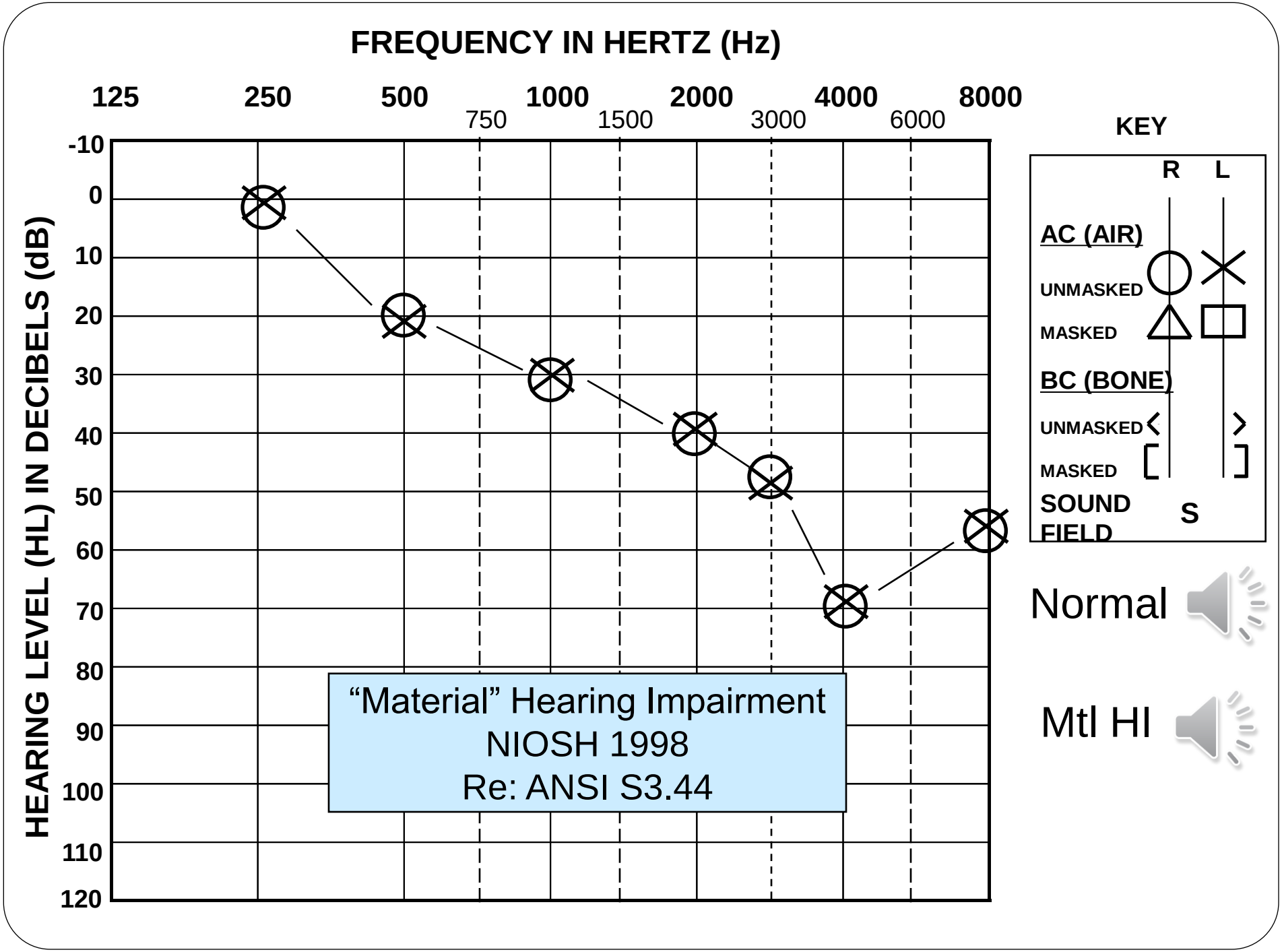
Organization	TWA Noise Exposure	Estimated % at Risk
ISO	*90 dBA*	*21%*
	85 dBA	*10%*
	80 dBA	*0%*
EPA	*90 dBA*	*22%*
	85 dBA	*12%*
	80 dBA	*5%*
NIOSH	*90 dBA*	*29%*
	85 dBA	*15%*
	80 dBA	*3%*
Prince, et al 1997	85 dBA	8%

Material Hearing Impairment?

NIOSH 1998 Definition:

> 25 dB HL Avg. 1k, 2k, 3k, and 4kHz

(What's that like?)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90
100
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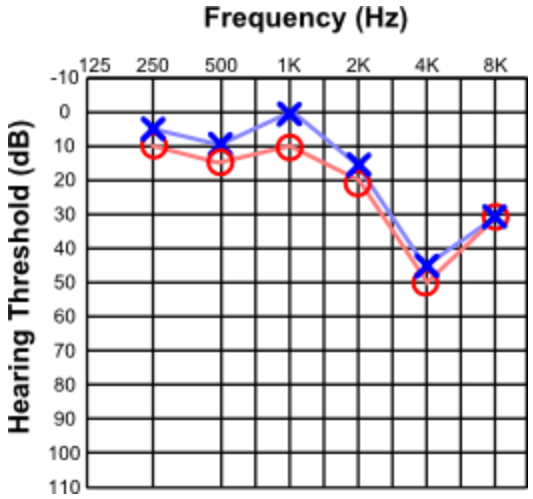
120
KEY
R
L
AC (AIR)
UNMASKED
MASKED
BC (BONE)
UNMASKED
MASKED
SOUND FIELD
S
Normal
Mtl HI
“Material” Hearing Impairment
NIOSH 1998
Re: ANSI S3.44

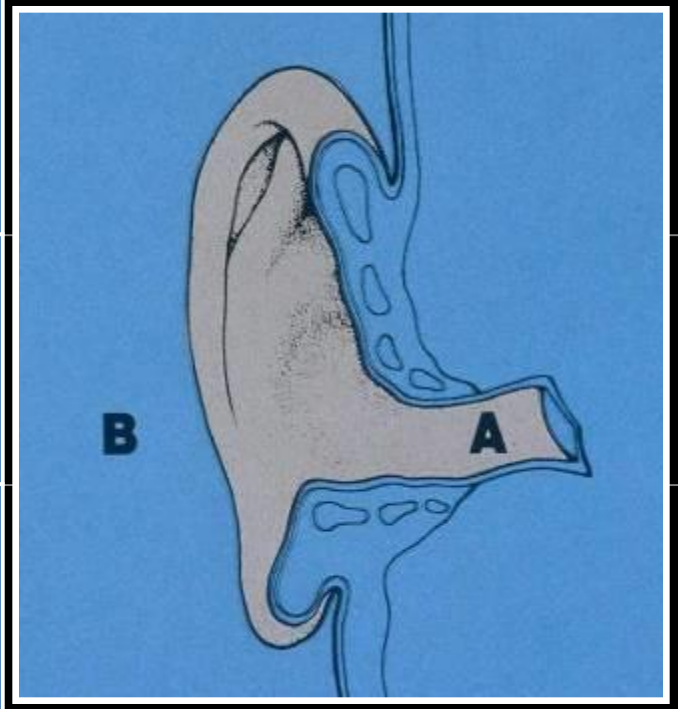
Why is a “noise-notch” at 4000 Hz?

Combination of ear canal acoustics, anatomy, and cochlear blood supply

- REUG/TFOE
- Humans: the region of maximum damage is ½ to 1 octave above frequency of maximum stimulation (different in other mammals, cochlear turn)
- Poorer blood supply in basal region than in apical region



Transfer Function of the Open Ear



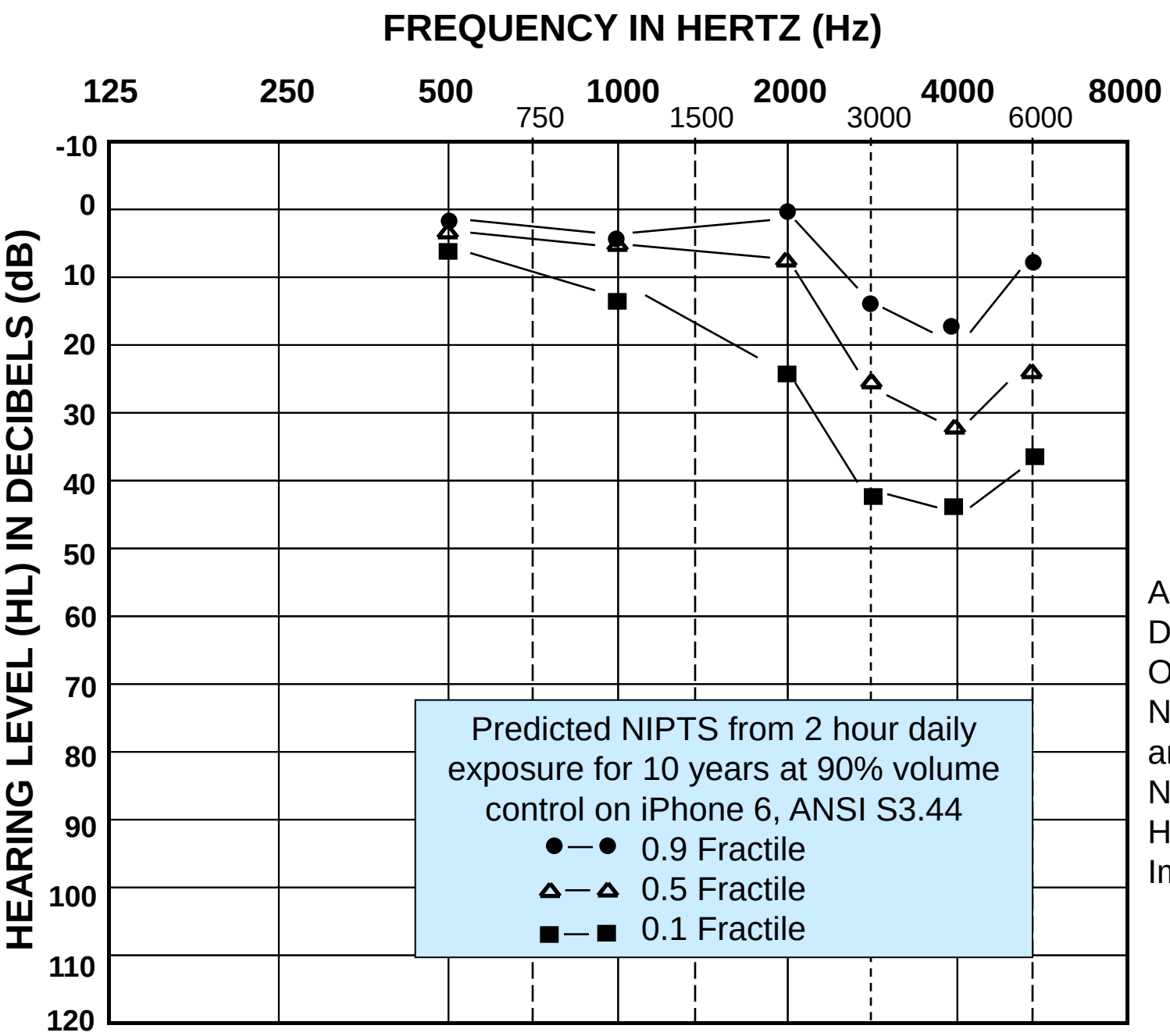
TFOE = A - B

Gain at Eardrum (dB)

20
15
10
5
0

125 250 500 1k 2k 4k 8k 16k

Frequency (Hz)



ANSI S3.44: Determination of Occupational Noise Exposure and Estimation of Noise-Induced Hearing Impairment

SIHD From Recreational Noise

- Firearms (unprotected firearms exposure)
  - Including, fireworks
- Live Music Events
- Recorded Music
- Musician, DJ, Audio Engineer
- Motor Sports (NASCAR, Indy, Truck Rally, etc.)

Firearms (and Fireworks): #1 Recreational Acoustic Trauma

Firearm Type	Peak Sound Level (dB):
Small Caliber Rifle	140-145
Medium Caliber Rifle	157-160
Large Caliber Rifle	160-174
Shotgun	152-166
Small Pistol	150-157
Large Pistol	158-174

Injury risk increases 10-fold with every 10-fold increase in rounds fired

Add SPL for short barrel, muzzle break, and shooting in enclosed area

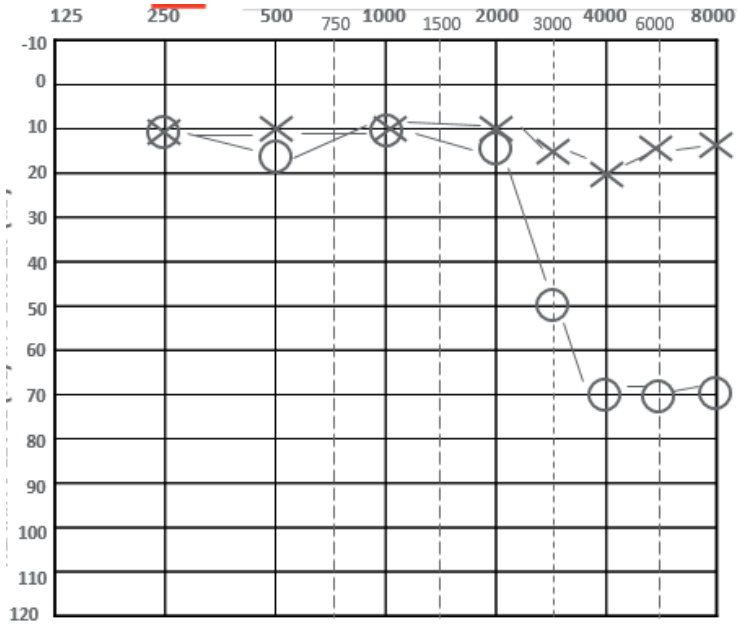
Michael Stewart, PhD, Audiology Online, July 3, 2008

Capt. William Murphy, PhD, Audiology Online, June 6, 2018

...and Fireworks

Gupta & Vishwakarma (1989), Deepawali festival fireworks at 3m: 126-156 dB SPL

Ward & Glorig (1961), case study 2"x3/16" firecracker went off in patient's hand, unilateral NIPTS and tinnitus



Live Music Events: Chronic Exposure SIHD vs. Acoustic Trauma?

- Individual Cases
  - Exposure exceeds ~2500% Dose (100% Dose = 85 dBA Leq, 8-hr)
  - Chicago (civil suit v. Tom Petty)
  - Boston (civil suit v. Whitesnake)
- Forensic Audiology
  - Community Noise Measurement Records (and distance from speakers where levels were documented)
  - Seating chart and ticket stubs
  - Loudspeaker/sound reinforcement location relative to seats
  - Inverse Square Law (6-dB decrease, every doubling of distance; 6-dB increase, halving of distance… assumes no reflections)

Live music: sound levels and hearing protection

Avg. Concert level 103.4 dBA (Clark, 1992)

4% of concert attendees use HPD (Gilles et al, 2013)

Hearing Protection Devices: The Benefits of Custom

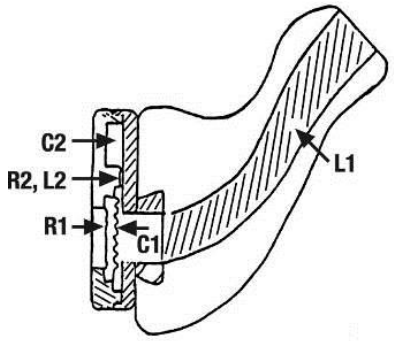
Non-Custom

Custom (15 dB)

Open ear (unprotected)

- Sound Quality
- Consistency of fit, predictability of protection
  - PAR vs. NRR of non-custom vs. custom (Neitzel, et al., 2004)
- Comfort, likelihood to use

Musicians Earplugs Design Specifications, and Consequences



Schematic side view of the ER-15

C = compliance
L = inductance
R = resistance

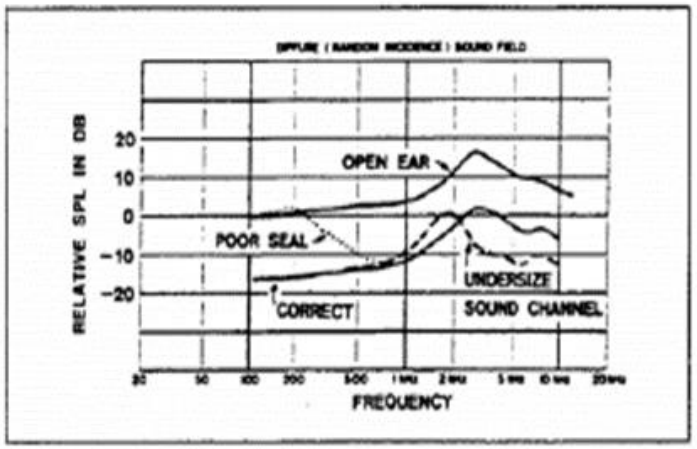
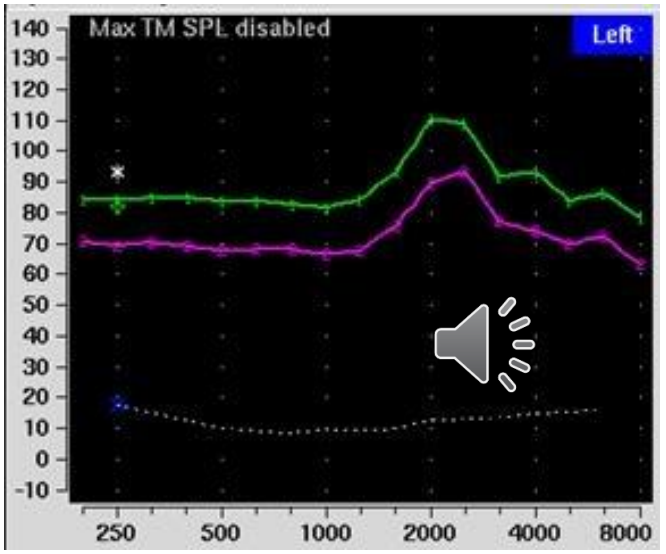


Figure 8. Expected eardrum SPL with ear open and with three constructions of ER-15 earmold.



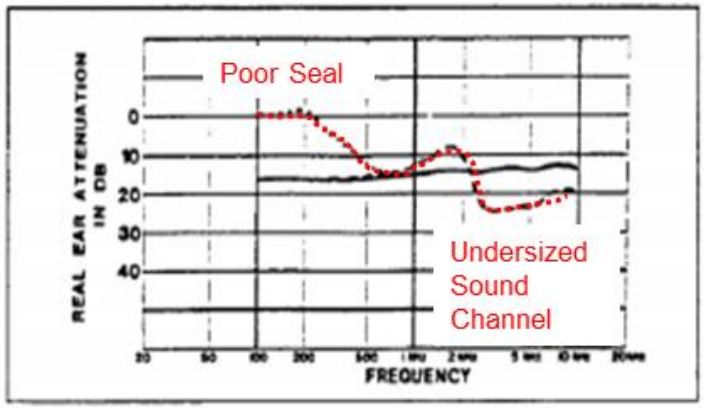
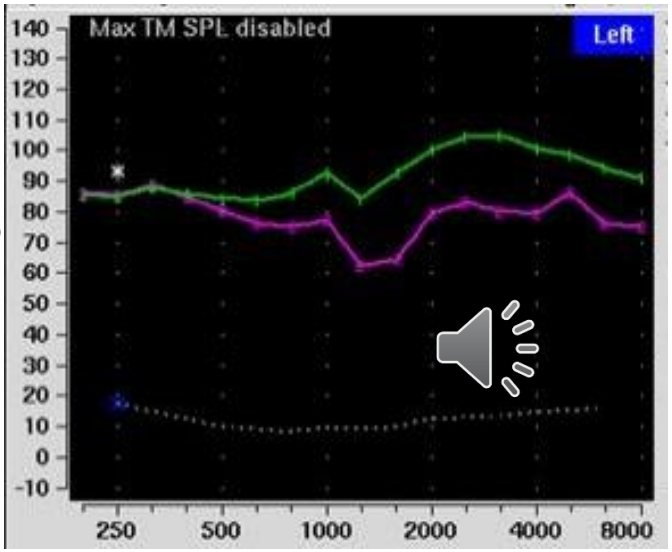
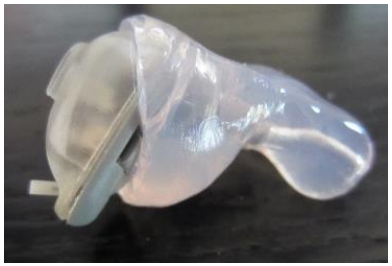


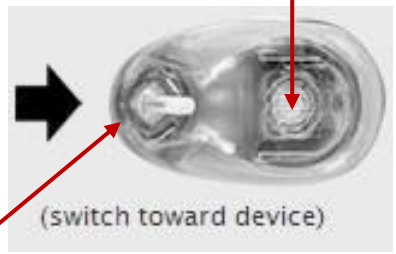
Figure 9. Calculated ER-15 performance vs. earmold construction: (—) correct (3.5 mm) sound channel, well-sealed; (. . .) poor seal, equivalent to 0.028" vent hole; (- - -) undersized sound channel (2-mm dia.).



Killion, DeVilbiss & Stewart (1988)

Active/Electronics HPDs





15-dB Mode

mode switch

9-dB Mode

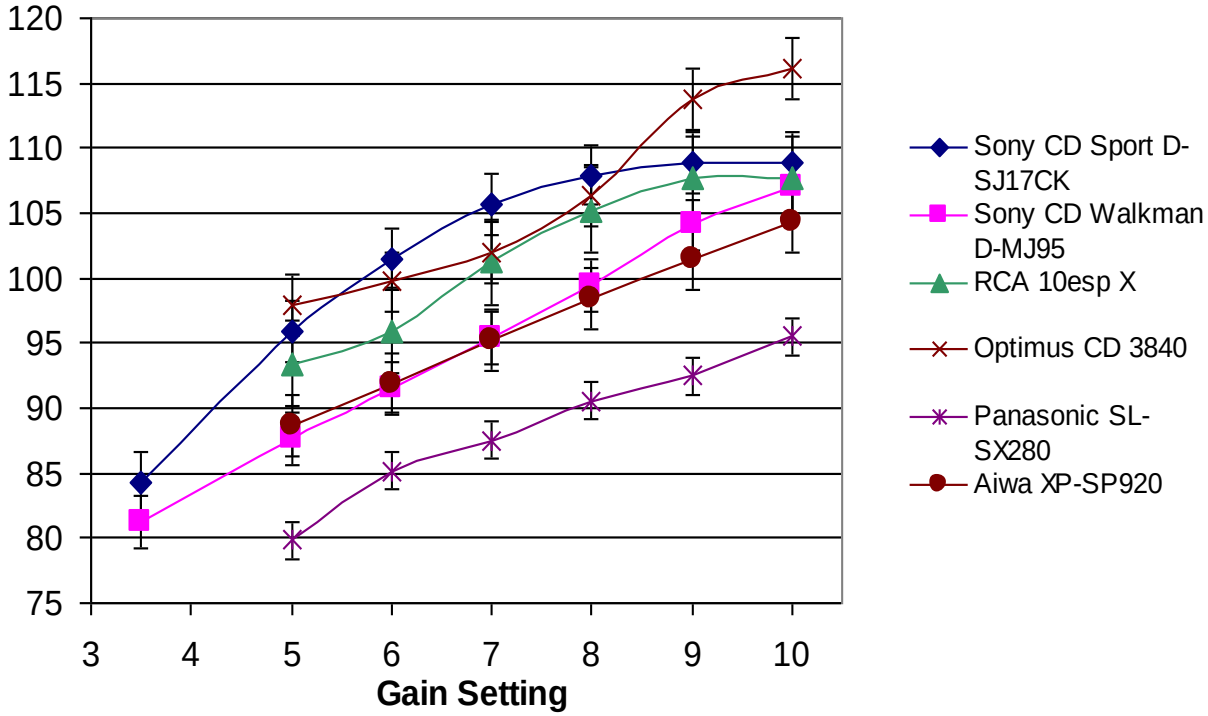
- 0 dB attenuation below 70 dBA
- 15 dB attenuation between 85-105 dBA (strong output compression for inputs >105 dBA, so >15 dB attenuation)

- +6 dB boost below 70 dBA
- 9dB attenuation 90-110 dBA (>9 dB attenuation for inputs >110 dBA)

Custom vs. Non-custom: necessity of indirect routing (through microphone), not direct (flanking the device, passing into canal)

Recorded Music: Chronic Exposure SIHD vs. Acoustic Trauma?

- Older Technology (e.g. CD Players)



Fligor & Cox (2004)

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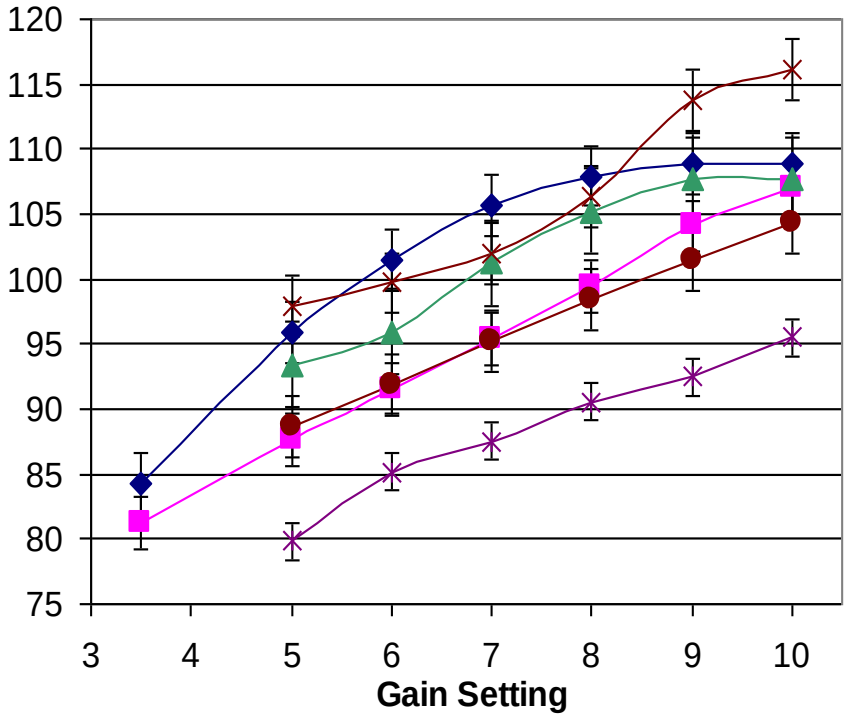

Aftermarket earphones, percussion peaks = 136 dB SPL

Fligor & Cox (2004)

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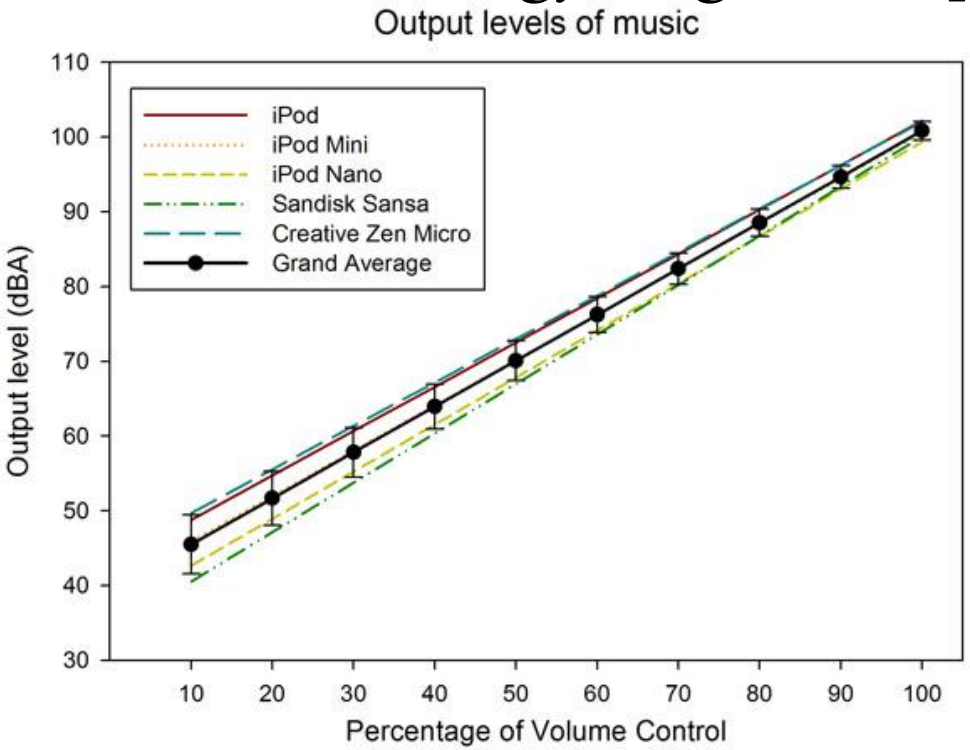

Portnuff, Fligor & Arehart (2011)

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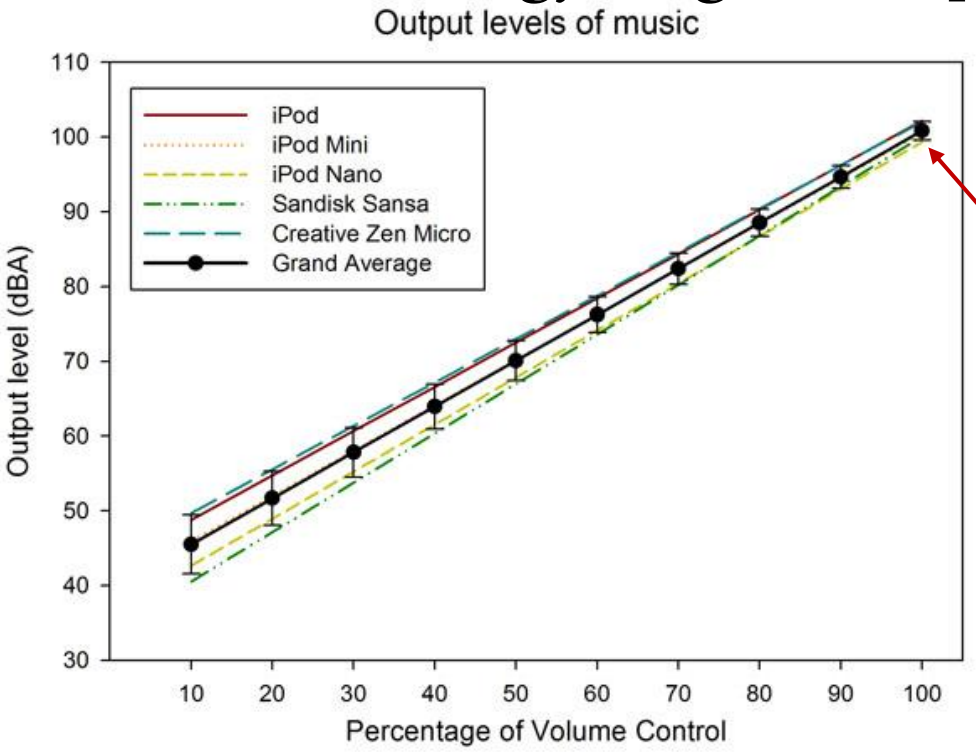


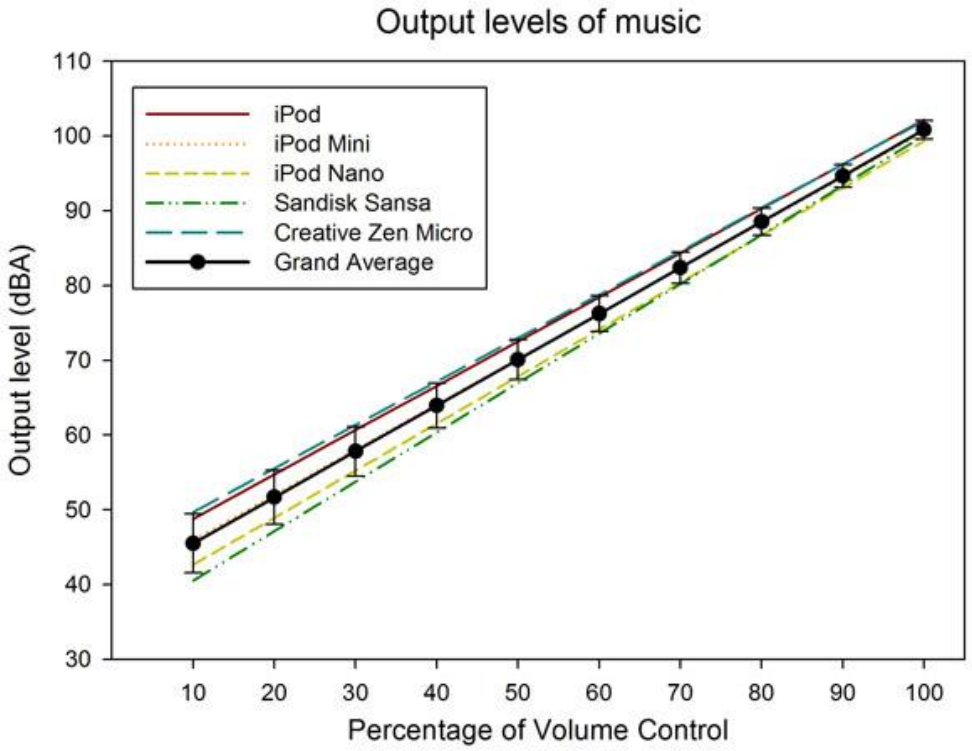
Percussion peaks = 104.6 to 126.9 dB SPL

(Max peaks Creative Zen Micro with iPod earbuds)

Portnuff, Fligor & Arehart (2011)

Recorded Music: Chronic Exposure SIHD vs. Acoustic Trauma?

- Aftermarket Audiophile, and Custom in-ear monitors?



Portnuff, Fligor & Arehart (2011)

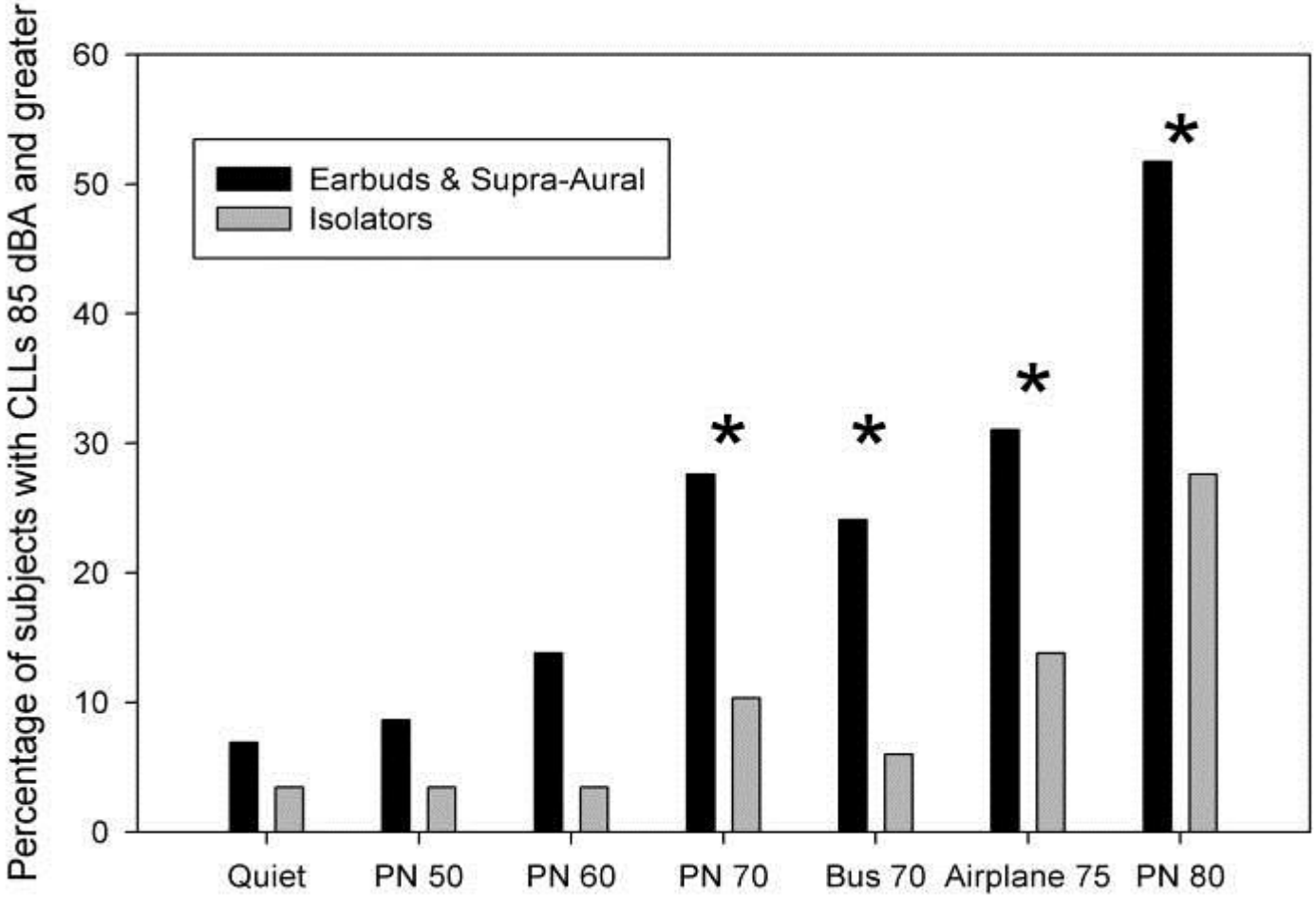
Max voltage output ~0.5 V

Apple Earpod = 105 dB/Volt at 1k Hz

UE quadruple driver = 139 dB/volt at 1k Hz

- **UE16?**
- **JH16?**
- **64 Audio A18?**

Teenagers and Earphones: Sound isolating vs. not isolating

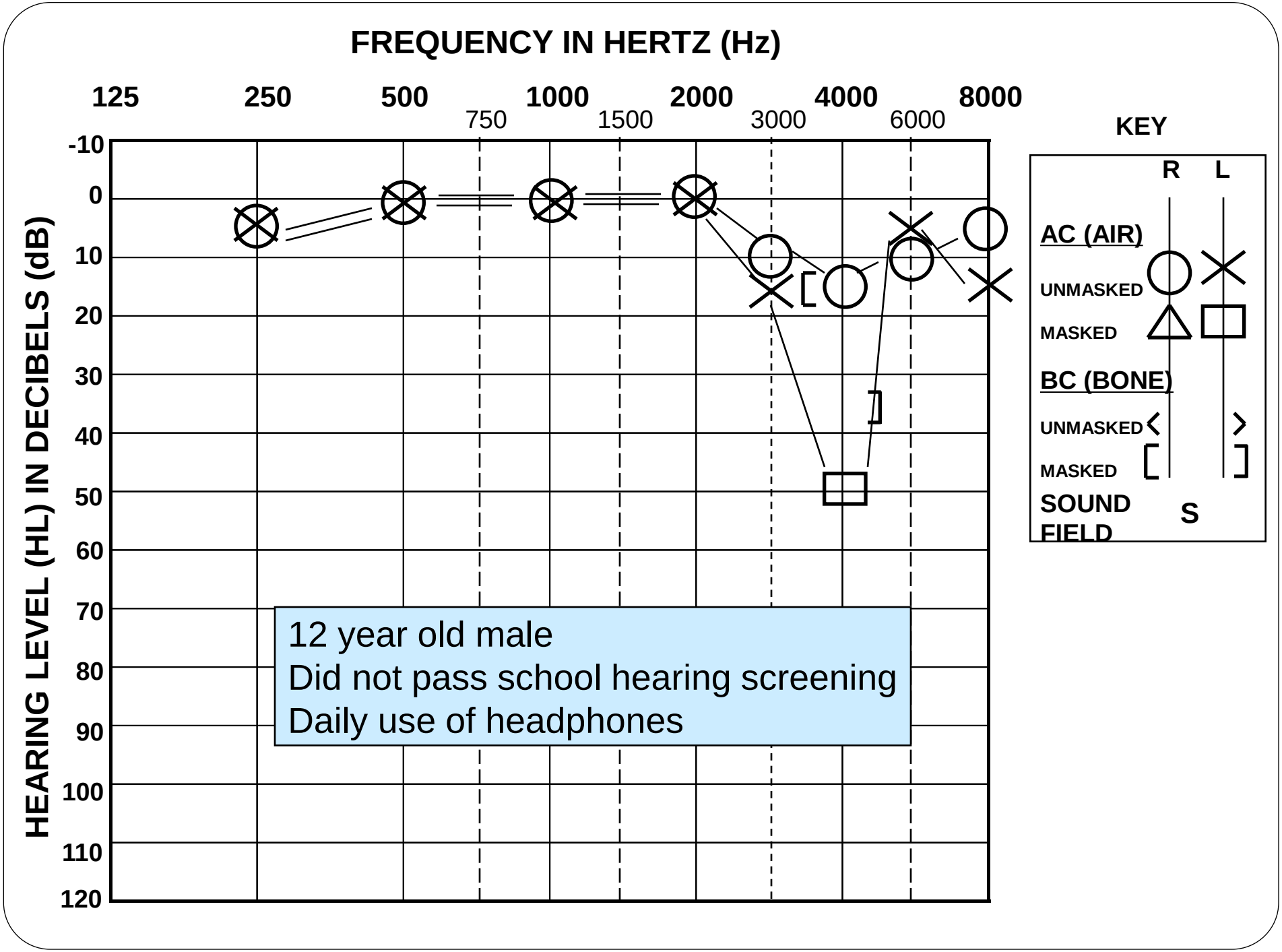


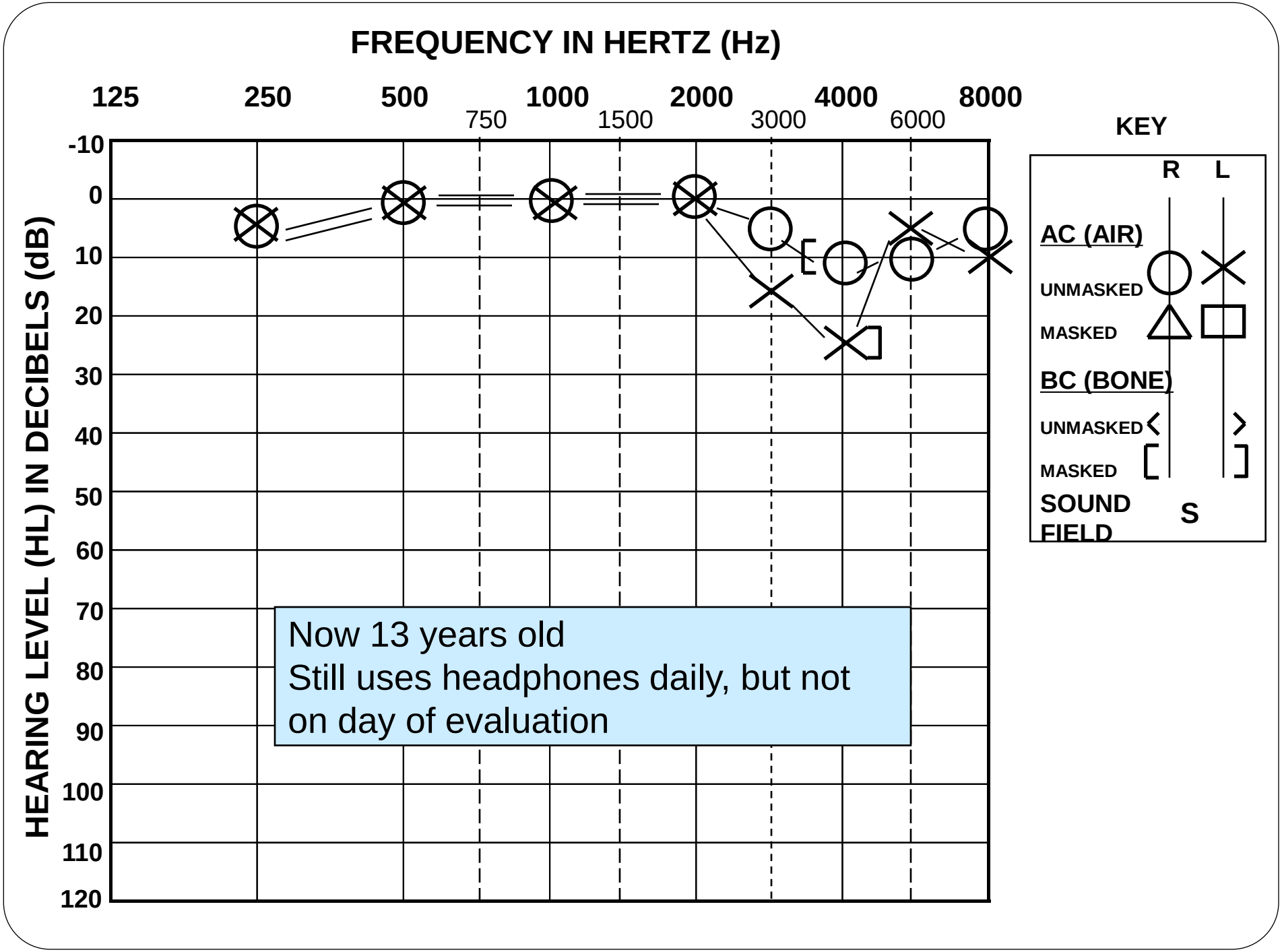
Portnuff, Fligor & Arehart (2011)

Acceptable strategy with PLD?

Sound isolation and comfort: custom vs. non-custom

Used with permission by Sensaphonics


FREQUENCY IN HERTZ (Hz)
125
250
500
750
1000
1500
2000
3000
4000
6000
8000
HEARING LEVEL (HL) IN DECIBELS (dB)
-10
0
10
20
30
40
50
60
70
80
90
100
110
120
12 year old male
Did not pass school hearing screening
Daily use of headphones
KEY
R
L
AC (AIR)
UNMASKED
MASKED
BC (BONE)
UNMASKED
MASKED
SOUND FIELD
S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SOUND FIELD
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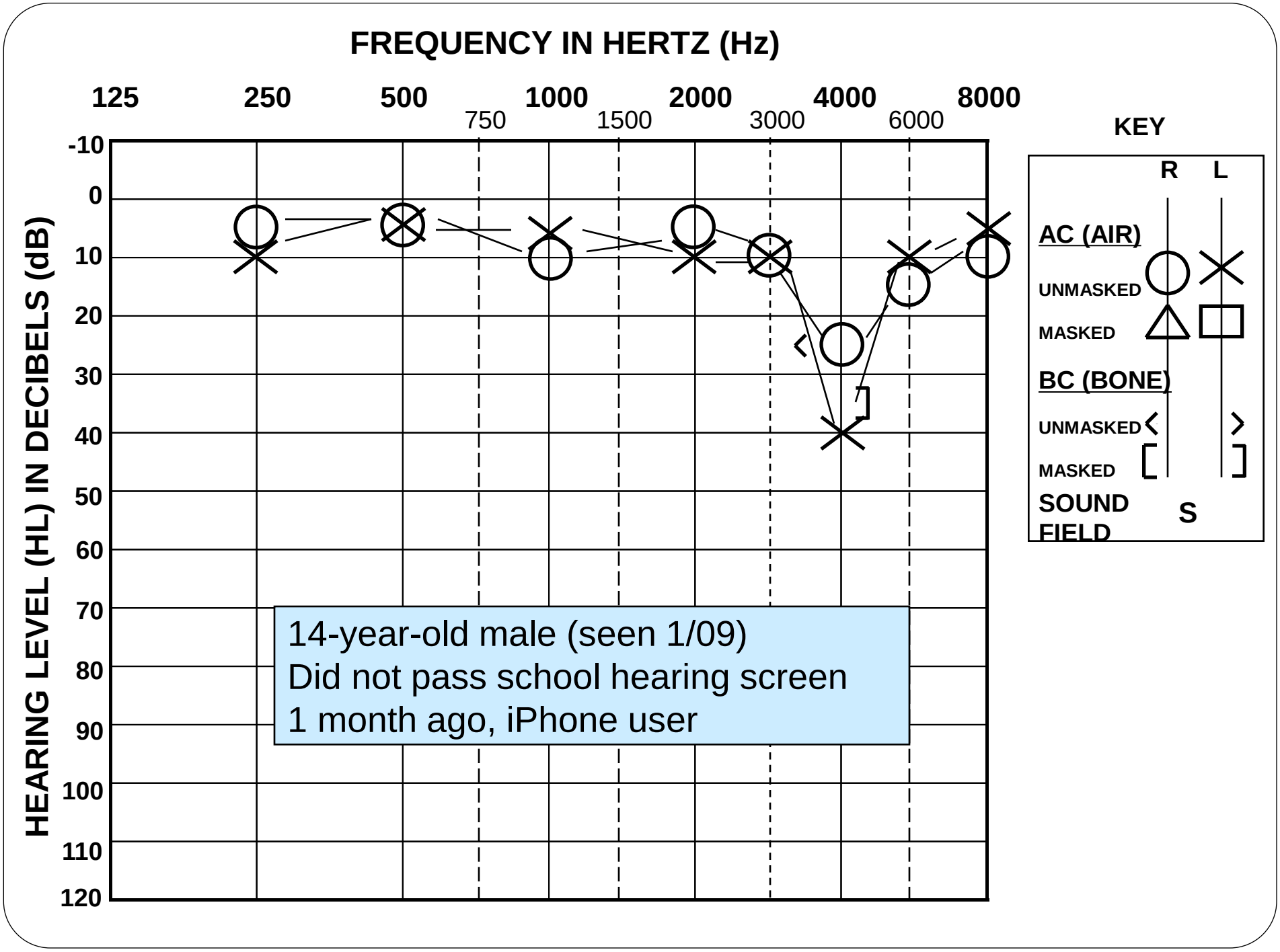
Now 13 years old
Still uses headphones daily, but not on day of evaluation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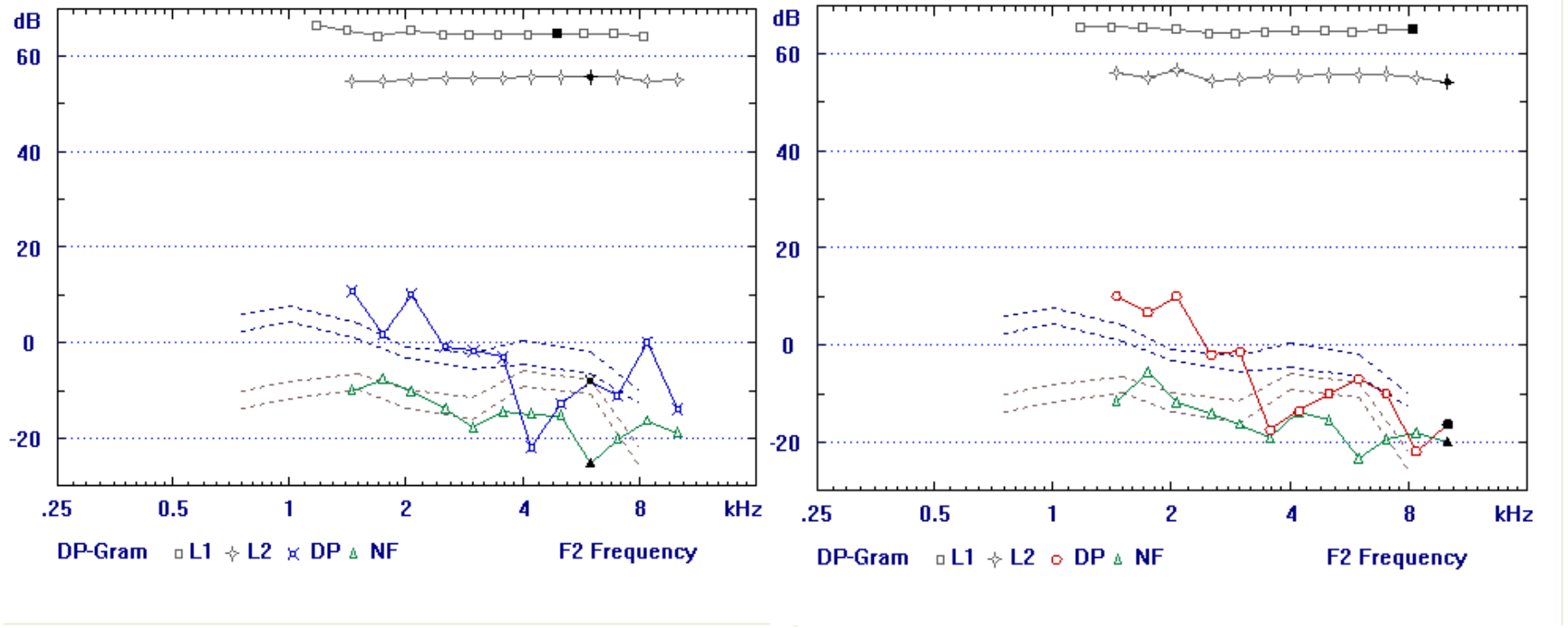
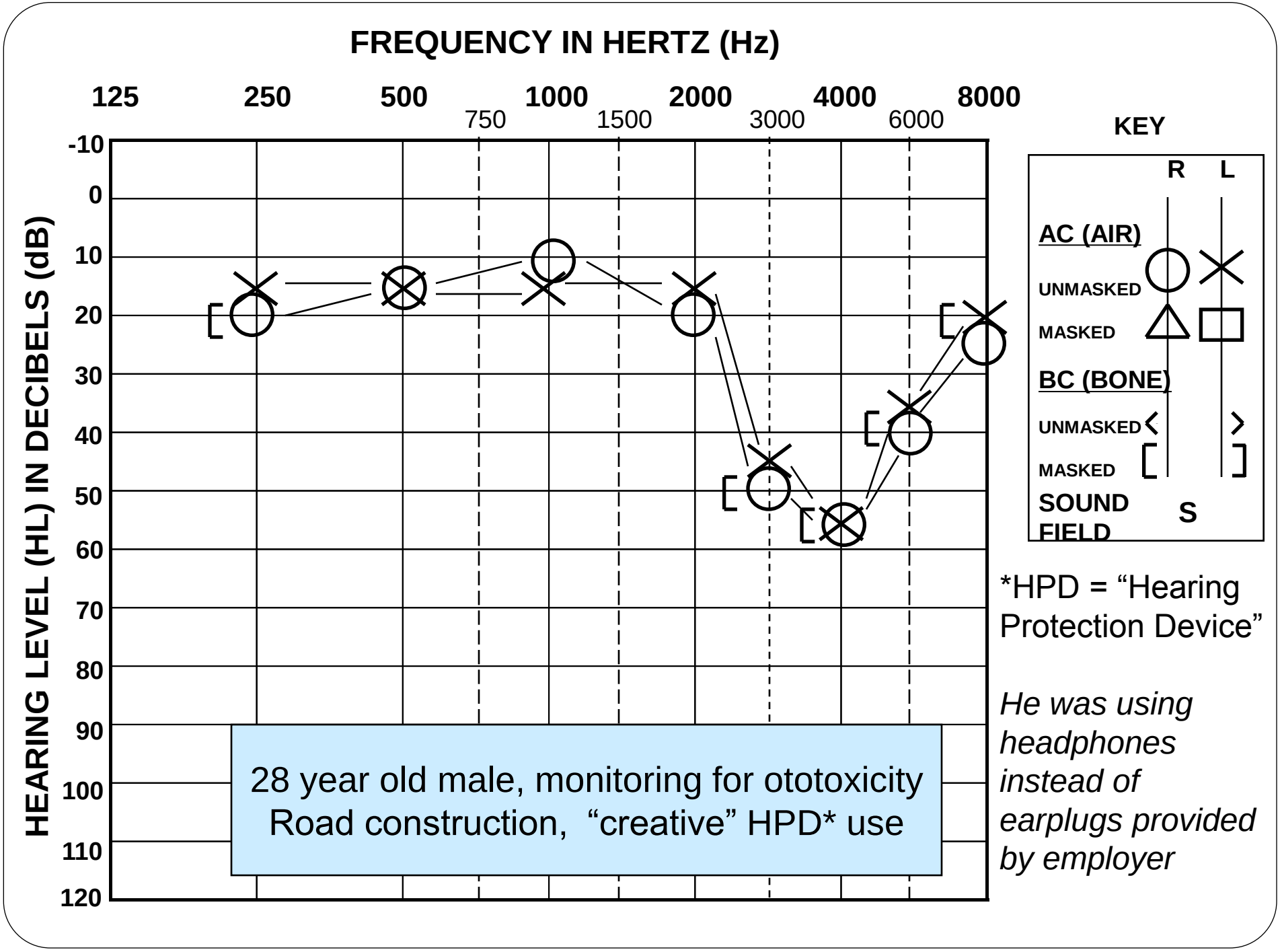
120
14-year-old male (seen 1/09)
Did not pass school hearing screen
1 month ago, iPhone user
KEY
R
L
AC (AIR)
UNMASKED
MASKED
BC (BONE)
UNMASKED
MASKED
SOUND FIELD
S

DPOAEs, 14-year-old iPhone users (1 ½ years), *notched audiogram*



- Reduced or absent DPOAEs at frequencies 4000 Hz and above re: 95% normals (Gorga, et al., 1997)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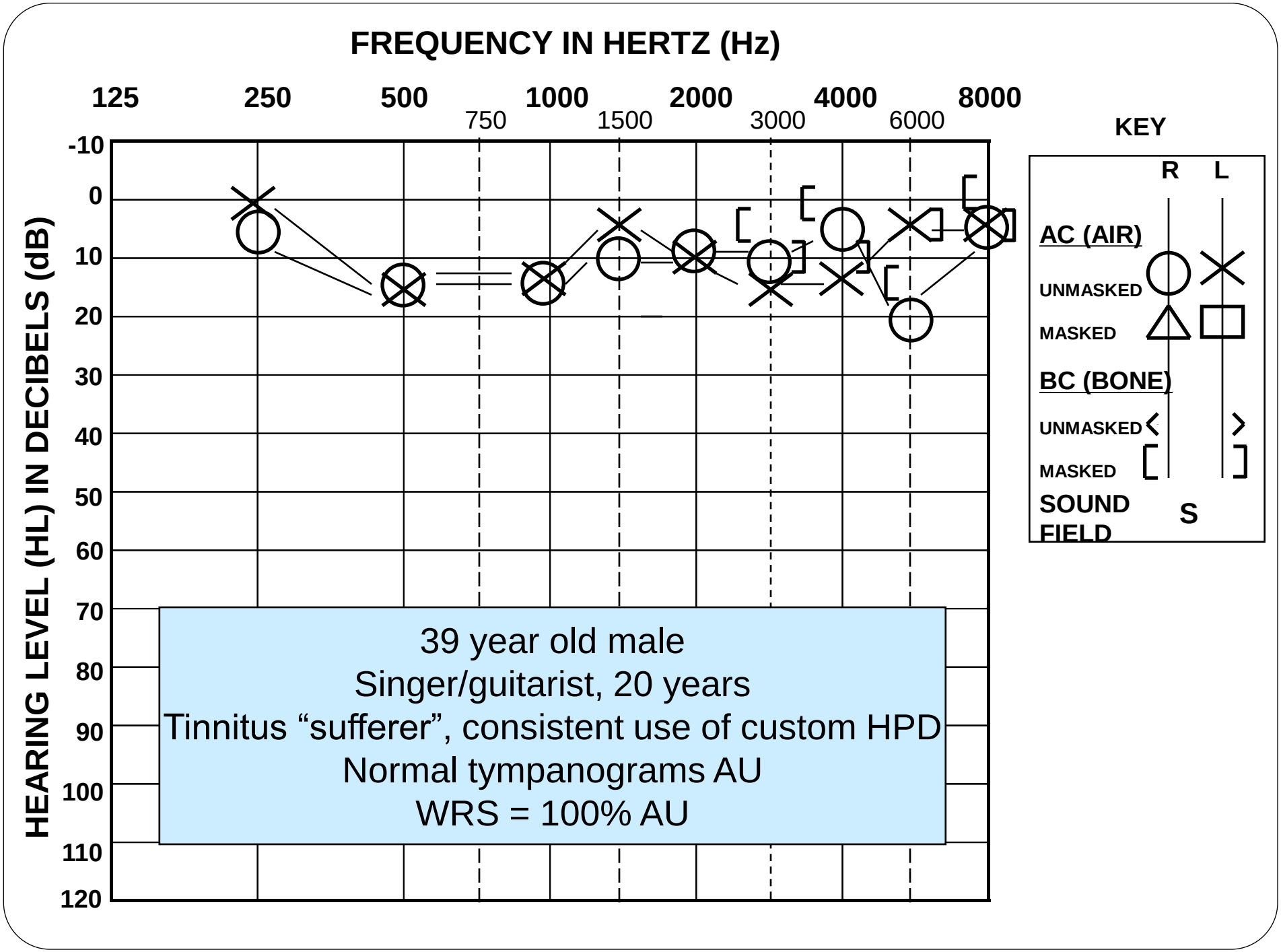
MASKED
BC (BONE)
UNMASKED
MASKED
SOUND FIELD
S
28 year old male, monitoring for ototoxicity
Road construction, "creative" HPD* use
*HPD = "Hearing Protection Device"
He was using headphones instead of earplugs provided by employer

Diagnostic Evaluation for Sound-Induced Hearing Disorders (SIHD)

- "Audiometric Monitoring" component of HLPP
  - Comprehensive audiometry (air, bone, speech) including 3k and 6k Hz
  - +/- Extended-high frequency (EHF) audiometry (9k Hz – 20k Hz): Le Prell et al (2013)
  - Immittance, +/- MEMR
  - DPOAEs, 1500-10k Hz, 4 freq's per octave

  At least annually, or as needed to evaluate TTS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L
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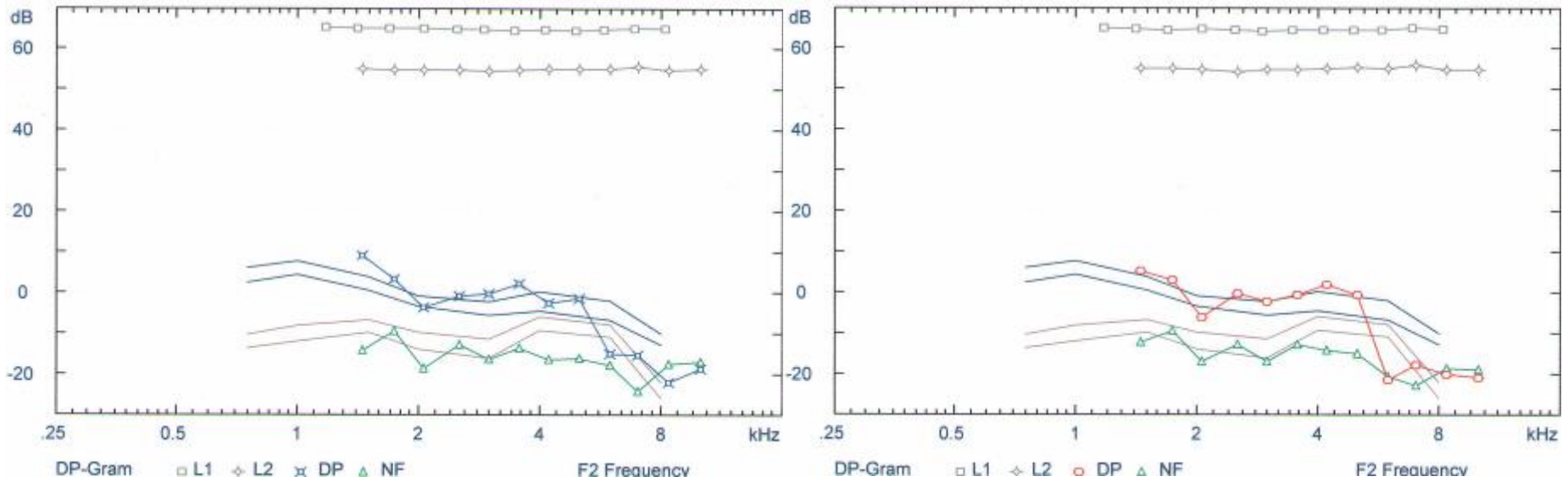
UNMASKED
MASKED
BC (BONE)
UNMASKED
MASKED
SOUND FIELD
S
39 year old male
Singer/guitarist, 20 years
Tinnitus “sufferer”, consistent use of custom HPD
Normal tympanograms AU
WRS = 100% AU

DPOAEs, 39 year old singer/guitarist (20 years experience), normal audiogram, tinnitus



- Absent DPOAEs at F2 = 6000 – 10,031 Hz Bilaterally
- Reduced DPOAEs at other discrete frequencies

re: 95% normals (Gorga, et al., 1997)

Diagnostic Evaluation for Sound-Induced Hearing Disorders (SIHD)

Additions to evaluation for tinnitus complaint:

- Tinnitus Reaction Questionnaire (Wilson et al 1991); Tinnitus Handicap Inventory (Newman et al 1996); Tinnitus Functional Index (Meikle et al 2011):
  - Meet criteria for "clinically significant"?
  - At intake and end point of therapy
- Minimum masking level
- +/- loudness and pitch matching, residual inhibition
- Informational Counseling
- Cognitive Behavioral Therapy

Tinnitus

A sensation that is perceived as a sound (ringing, buzzing, hissing, etc) that cannot be attributed to an external stimuli

- 93% report some sensation of tinnitus in quiet settings (Heller and Bergman, 1953)
- ATA: 50 million in U.S. have tinnitus (15% of population), 20 million (6% of population) have negative impact on Quality of Life; BTA: 10% of UK population have tinnitus
- Rosing, et al., (2016): 6-41.9% of children and adolescents have tinnitus, "troublesome/bothersome" = 0.6-42.9%
- Gilles, et al., (2013): 3892 high school students in Belgium, 74.9% noise-induced temporary tinnitus, and 18.3% permanent noise-induced tinnitus
- Noise exposure is the most common cause

Management of Tinnitus

Habituation of the Reaction

vs.

Habituation of the Perception

"There's no cure, so you're just going to have to learn to live with it…"
(Absence of hope, reinforcement of negative, repetitive thoughts)

Most patients approach tinnitus management backwards!

Tinnitus "Suffering"

- VERY high rate of co-morbidity with anxiety and depression
  - Are they already depressed and anxious? Low trigger for these behavioral health challenges?
- Not the perception of the tinnitus, but the reaction to it
- Inappropriate assignment of importance of the tinnitus, results in the limbic system (the "lizard brain") expressing a fear reaction
- Activation of the sympathetic response of the autonomic nervous system
  - Conditioned reflex (inappropriate assignment of cause-effect)
  - State of fight-or-flight
  - Persistence of tinnitus results in persistence of fight-or-flight (remains in hyperanxious state)

Tinnitus Interventions

- Informational counseling, Cognitive Behavioral Therapy
- Stress reduction, Mindfulness-based tinnitus stress reduction
- Sound enhancement (white noise generator; tinnitus maskers; combo devices- hearing aid with tinnitus masker)
- Tinnitus Retraining Therapy (Jastreboff)
- Behavioral Health, talk therapy, CBT
- Anti-anxiety, anti-depression medications (e.g., Prozac, Zoloft)
- Hearing loss prevention program to mitigate exacerbation of tinnitus and hearing loss

Barring sinister medical sources, the problem is not the tinnitus itself, but the patient's reaction to the tinnitus! Tinnitus activates the sympathetic response of the autonomic nervous system ("fight/flight/freeze") and because the tinnitus is persistent, sufferer is locked into state of hypervigilance and anxiety/fear/dread

The Teenager with Tinnitus

The Egocentric "Personal Fable" (Elkind, 1967)

1. Imaginary Audience: he/she is the center of attention, both good and bad
2. Unique and Special: "no one else has ever felt or experienced the things I do"
3. Invincibility: "consequences of known risks do not apply to me"

Inward-facing nature of a negative reaction to chronic, subjective tinnitus coupled with the Personal Fable results in a teenager engaging in unhealthy repetitive thoughts who can be very difficult to reach.

The Teenager with Tinnitus

Challenges specific to teenagers with tinnitus

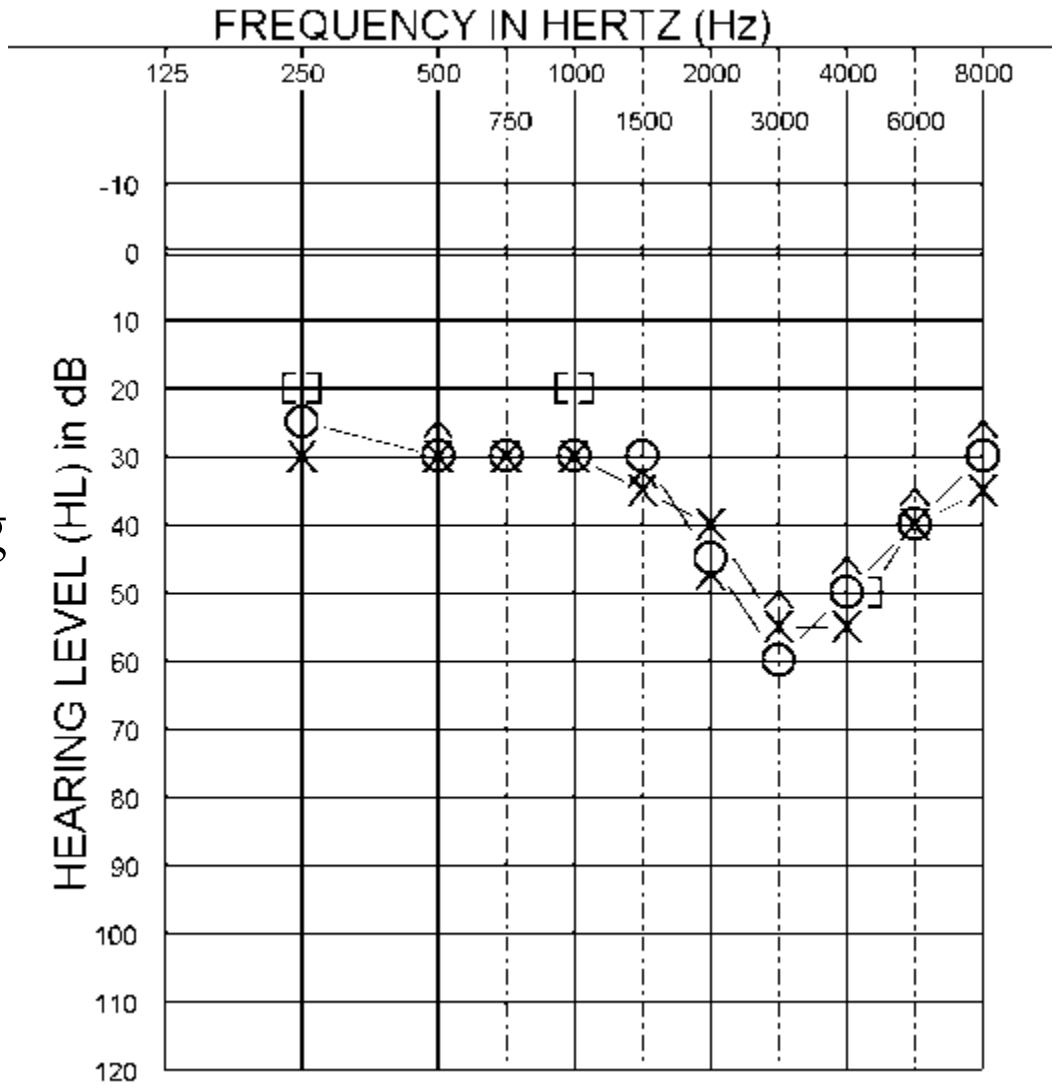
1. Limbic system (appetite, sleep, fight-flight-freeze) more fully developed than prefrontal cortex (logic, cause-effect)
2. CBT: works, but slower than in person with fully developed prefrontal cortex (Personal Fable interferes)
3. SSRIs: Careful, close observation by psychiatrist

July 6, 2016 https://www.audiologyonline.com/audiology-ceus/course/tinnitus-management-with-teens-27814

Fligor (2017). Audiological evaluation and management of teenagers with tinnitus. ENT and Audiology News, Vol 25(6) www.entandaudiologynews.com

Professional Drummer: a case study

- 42 year old male
- Two workplace acoustic trauma events, 5 years prior (within 6 months)
- Fitted with combination tinnitus-masker/hearing aids elsewhere
- Tinnitus most salient complaint (TRQ = 78)
- WRS = 92-100%
- Also hyperacusis (guarding)



Case study priorities

- Came for tinnitus management
- Has needs for amplification
- Has needs for further hearing loss and tinnitus prevention
- Has needs for addressing “hyperacusis”

Case study priorities

My approach:

1. Established he was under care for behavioral health (he was)
2. Addressed "hyperacusis" as this was blocking tinnitus management
3. Switched his in-ear monitors with system that had in-line sound level measurement device (and fitted solid earplugs)
4. Tweaked hearing aid settings (especially increased masking)

Psychiatrist with hyperacusis: a 2nd case study

- Mid-50s female, psychiatrist specializing in abuse survivors
- Abuse survivor herself, history (highly) pertinent to her chief complaint… does have tinnitus, which exacerbates with noise
- Found me by searching for "the best earplugs" and earmold lab sent her to me due to complaint of hyperacusis
- Modified TRQ to fit hyperacusis complaint (TRQ = 63)
- Normal hearing and word recognition, denied dizziness
- LDL's to speech = 70 dB HL, tones 65-75 dB HL
- Reflex thresholds normal (and tolerated)
- Daughter's wedding (with DJ) in 6 months

2nd case study priorities

- This patient needed to arm herself with data rather than fiction
- Needed earplugs
- Needed to understand her disorder, and why she had it
- Needed to know what was normal (and hearing was not "super normal")
- Needed knowledgeable guidance as she did her own therapy
- Needed to know this wasn't her fault

2nd case study priorities

My approach:

1. Established she was under care for behavioral health (she was)
2. Called out possible triggering event, and that her "hyperacusis" was guarding against tinnitus exacerbation – and address with her BH clinician
3. Fitted with solid earplugs
4. Exposed to music through audiometer with and without plugs, with her controlling levels

    - She was able to tolerate 110 dB HL in sound booth, attended wedding, gave a toast, danced

Medical Referral

- When to refer, when to manage in-house
  - Hearing Loss
    - Sudden hearing loss (even acoustic trauma)
    - *unexplained* asymmetry (particularly if doesn't look like a notch)
    - Conductive component (especially with abnormal tympanometry or elevated reflexes)
    - Poor WRS, especially unilateral
    - Concomitant dizziness, especially with intense sound (e.g., Tullio phenomenon)

Medical Referral

- When to refer, when to manage in-house
  - Tinnitus
    - Any indication that the patient might harm himself (or others)
      - Ask the question, document the answer
    - To a lay person, do they seem anxious or depressed? Past history of seeing behavioral health professional
    - Sleep disturbance, anxiety or depression that is not improving
    - *Unexplained* unilateral tinnitus
    - Concomitant dizziness
    - Poor WRS on affected side
    - Elevated or absent acoustic reflexes on affected side

Key Considerations for SIHD Across the Lifespan

- Seminal studies of dose-effect relationship in occupational NIHL provide baseline guidance ("Damage Risk Criteria")
  - Limitations of generalizing occupational noise exposure to non-occupational noise exposure
  - Durations of exposure (40-year working lifetime vs. lifespan)
  - Threshold for "acceptable" risk
- No clear dose-effect relationship between noise exposure and onset of bothersome tinnitus (or other auditory injury; e.g., hyperacusis, diplacusis)

Conclusions

- Acoustic trauma from recreational exposures is possible, SIHD from chronic exposure more common
- Tinnitus is more likely to bring patients to clinic than a 4000 Hz notch
- Unprotected firearms exposure is #1 cause of recreational NIHL, can cause immediate acoustic trauma
- Very high level continuous sound can result in severe noise overdose, leading to necrotic death of cells in cochlea, inflammatory process causes widespread damage

Conclusions

- Listening to recorded music can be a source of SIHD, watch max output of certain aftermarket earphones/custom in-ear monitors
- Ambient noise contributes strongly to chosen listening level, sound isolating earphones (custom) mitigates influence of ambient
- HPDs work well to protect hearing, if they are actually used
- Tinnitus can be managed, best with multidisciplinary approach and when habituation of reaction is given higher priority than habituation of perception
- While devices assist the audiologist in managing the patient's hearing loss and tinnitus, these are tools.
- Treat the patient, not the audiogram

He may be toast, but not his ears!

Thank you!

brian.fligor@gmail.com