Musicians With Conventional Noise Notches Have Poorer Extended High Frequency Sensitivity

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The Team

- Ongoing collaboration with Rush University AuD students to complete investigative projects:
  - Erin Chambers, Matthew O'Shea, Rachel Barr
- Rush University professor Kate Dunckley, PhD
- Sensaphonics
  - Hearing conservation clinic for professional musicians

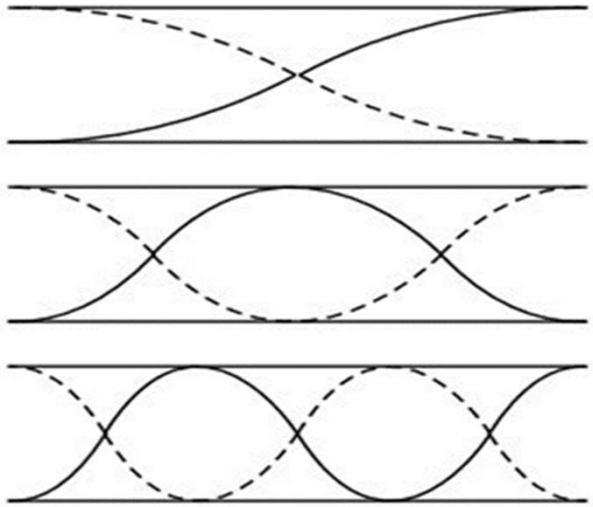
- *This presentation covers O'Shea's Investigative Project: Comparing musicians Extended High Frequencies (EHF) with an age-matched control group and viewing prevalence of noise notches within the music industry.*

Background

- Sensaphonics began testing EHF in 1987
  - The frequencies 9 kHz, 10 kHz, 11 kHz, 12 kHz, 13 kHz, 14 kHz, 15 kHz, 16 kHz, 17 kHz, and 18 kHz
  - Originally requested by post production engineers who work above 12 kHz
  - Became clinical protocol to test on all music-exposed patients if scheduling allowed

Harmonic structure

- Musicians use the harmonic structure of complex tones (overtone series above a fundamental) to differentiate timbre, tuning, and pitch
- Audio engineers work with equipment that have controls well into EHF



Current Study

- A retrospective analysis of EHF data from Sensaphonics
- HIPAA compliant, no participants were paid and all were de-identified
- The questions of O'Shea's data collection and analysis were to see rate of noise notches in different music industry roles, and if musicians with a present noise notch had poorer EHF thresholds

Literature Review

- Study done with iPod use and EHF concluded that that PLD users do not show clear signs of NIHL at conventional frequencies and, subtle damage may be occurring in the EHF thresholds (Sulaiman, et al., 2016)
- “It should be possible to detect small changes in [extended] high frequency hearing for participants/participants that undergo repeat testing at periodic intervals” (DeSeta, Bertoli, & Filipo, 1985).

Literature Review

- Study of 240 factory workers comparing extended high frequency audiometric (HFA) thresholds. (Mehrparvar, Mirmohammadi, Mollasadeghi, & Loukzadeh, 2011).

  - 120 workers (108 males and 12 females) continuous exposure over 85 dBA
  - 120 workers (106 males and 14 females) without exposure to hazardous noise
  - The study found that 54.2% of the noise exposed group had hearing loss at least in one ear and at one frequency in conventional audiometry, while only 5.1% of control group had HL with conventional audiometry.
  - *87.6% of noise exposed group had hearing loss at least in one ear and at one frequency in HFA, while only 12.3% of control group had HL in HFA*

Equipment and Procedure

- EHF data were collected on an ANSI calibrated (ANSI, 1996) Interacoustics high frequency audiometer, model AS10HF
- Sennheiser HDA200 closed circumaural headphones
- Modified Hughson Westlake procedure
  - Maximum outputs varied by working audiologist. For this study, any thresholds above 105 dBSPL were entered as “no response”
  - Any thresholds below 0 dBSPL were entered as 0 dBSPL
- .25 kHz- 8 kHz were completed on several models of audiometers with ER3 inserts and TDH headphones

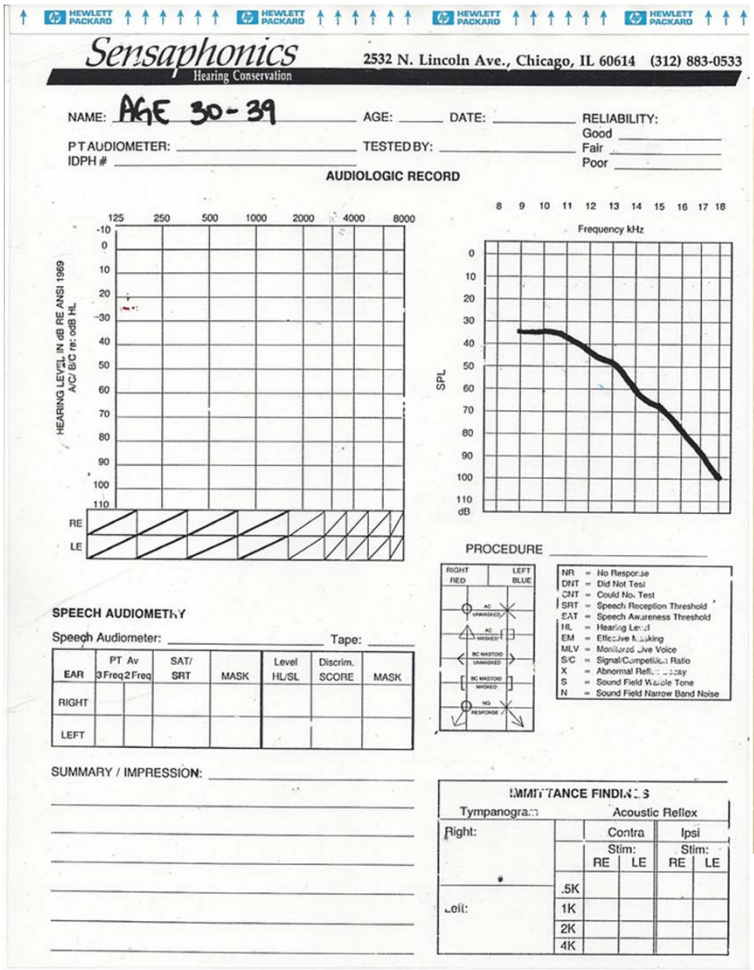

audiologysystems
High Frequency Audiometer
Model AS10 HF
Pulsing
Manual
Power
Microphone
Talk Forward
Tone
Response
0 10 20 30 40 50 60 70 80 90 100 110
Intensity dB SPL
Left Right
Output
Tone Switch
13K 14K 15K 16K 17K 18K 12K 11K 10K 9K 8K
Frequency Hz
10 8 6 4 2 0
Volume


13K
12K
14K
11K
15K
10K
16K
9K
17K
8K
18K
Frequency Hz

Inclusion in Study

- Completed musicians' case history form
- No history of retrocochlear pathology or head/neck surgery
- No air bone gaps greater than 10 dBHL (.25-8 kHz)
- Completed EHF testing
- Of the estimated 10,000 charts at Sensaphonics, 1,000 were included in this analysis

Clinical Use of Data/Past Averages



Sensaphonics
Hearing Conservation
2532 N. Lincoln Ave., Chicago, IL 60614 (312) 883-0533

NAME: AGE 30-39 AGE: DATE: RELIABILITY: Good Fair Poor
PT AUDIOMETER: TESTED BY:
IDPH #

AUDIOLOGIC RECORD

125 250 500 1000 2000 4000 8000
-10 0 10 20 30 40 50 60 70 80 90 100 110
HEARING LEVEL IN dB RE ANSI 1969 A/C/ B/C re: odB HL
RE
LE

8 9 10 11 12 13 14 15 16 17 18
Frequency kHz
0 10 20 30 40 50 60 70 80 90 100 110 dB
SPL

PROCEDURE

RIGHT RED LEFT BLUE
AC UNMASKED
AC MASKED
BC MASTOID UNMASKED
BC MASTOID MASKED
NO RESPONSE

NR = No Response
DNT = Did Not Test
CNT = Could No. Test
SRT = Speech Reception Threshold
SAT = Speech Awareness Threshold
HL = Hearing Level
EM = Effective Masking
MLV = Monitored Live Voice
S/C = Signal/Competition Ratio
X = Abnormal Reflex Decay
S = Sound Field Warble Tone
N = Sound Field Narrow Band Noise

SPEECH AUDIOMETRY

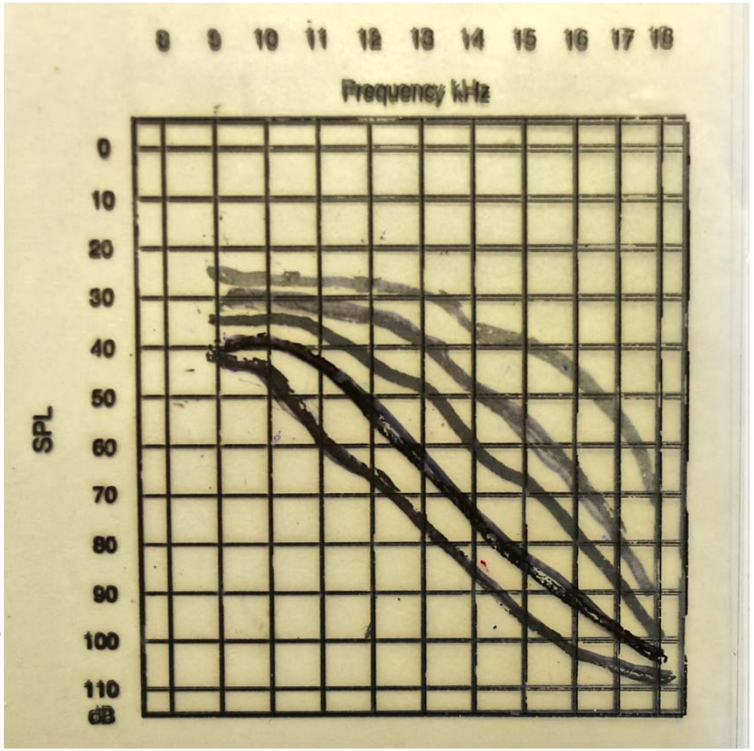
Speech Audiometer: Tape:

EAR	PT Av 3Freq	2 Freq	SAT/ SRT	MASK	Level HL/SL	Discrim. SCORE	MASK
RIGHT							
LEFT							

SUMMARY / IMPRESSION:

IMMITTANCE FINDINGS

Tympanogram		Acoustic Reflex			
		Contra Stim:		Ipsi Stim:	
		RE	LE	RE	LE
Right:	.5K				
	1K				
Left:	2K				
	4K				



Age (Years) Categories

- < 20
- 20-29
- 30-39
- 40-49
- 50-59

Categorization of Participants

- Age in decades (18-65)
- Biological sex
- Type of work
  - Instrumentalist, engineer (studio or live), and “other,” covering music educators, jobbing artists, agents, artist relations, bartenders, club managers, etc.

Investigative Project Questions:

- 1: Is there a significant difference in the prevalence of an audiometric notch between different roles in the music industry?
  - Presented for context of sound exposure

- 2: Is there a significant different in EHF thresholds when comparing participants with and without an audiometric notch in the clinical frequency range (3 kHz-6 kHz)?

Research Question 1: Is there a significant difference in the prevalence of an audiometric notch between different roles in the music industry?

- Participants with at least one notch were categorized by role
  - Any role with fewer than 25 participants was disregarded
- These categories were compared with a non-musician control group

Categories and Control Group

Role	N	Median Age (years)
Audio Engineers	205	32
DJs	40	29
Jobbers	296	31
Live Performers	524	31
Music Educators	27	30
Studio Workers	233	31
Control Group	165	30

Analysis

- A two-population Z-score test examined significant differences in the proportion of a notch between the categories and the non-musicians

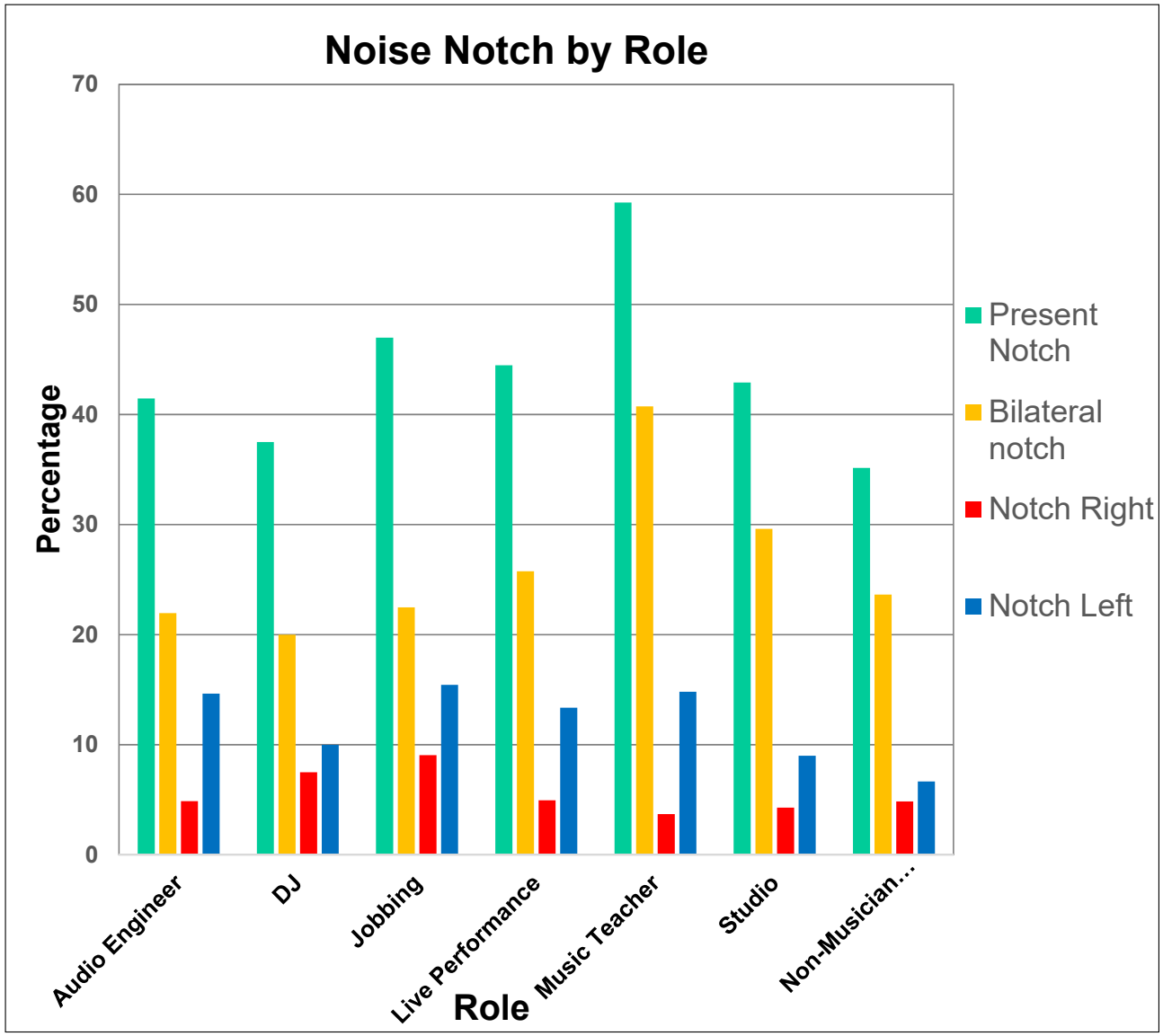
Results: Notch Counts For Each Role

Role	Participants	Notch Present	Notch Absent	Bilateral Notch	Notch Right	Notch Left
Audio Engineer	205	85	120	45	10	30
DJ	40	15	25	8	3	4
Jobbing	298	140	158	67	27	46
Live Performance	524	233	291	135	26	70
Music Teacher	27	16	11	11	1	4
Studio	233	100	133	69	10	21
Control Group	165	58	107	39	8	11

Results

Role	Percentage With Audiometric Notch
Audio Engineer	41%
DJ	37.5%
Jobbing	47%
Live Performance	44.4%
Music Teacher	59.2%
Studio	42.9%
Control Group	35%

Results


Noise Notch by Role
70
60
50
40
30
20
10
0
Percentage
Present Notch
Bilateral notch
Notch Right
Notch Left
Audio Engineer
DJ
Jobbing
Live Performance
Music Teacher
Studio
Non-Musician…
Role

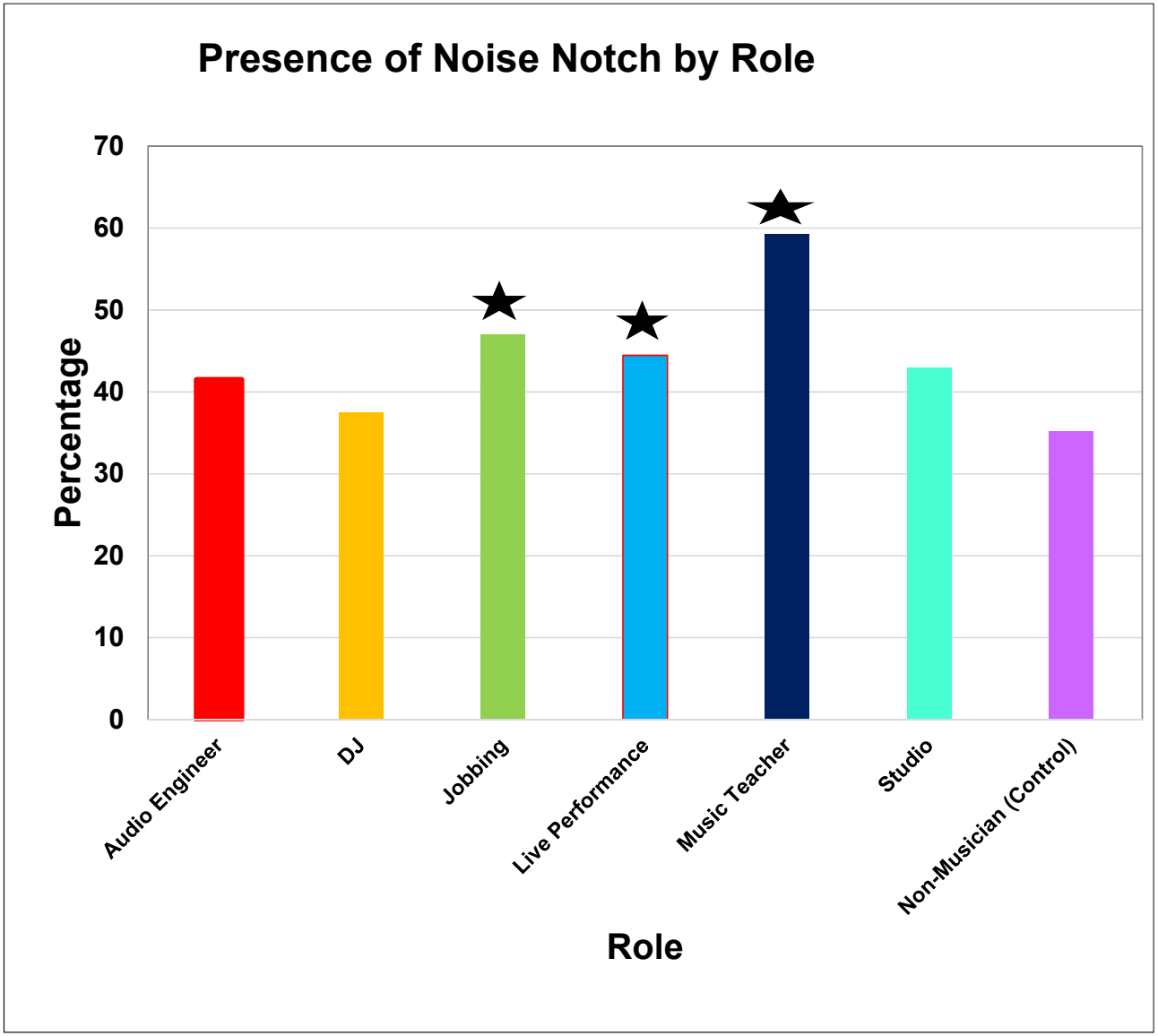
Results

Role	One Tail Z-Score	P-Value
Audio Engineer	1.2394	0.107
DJ	0.2783	0.390
Jobbing	2.4638	***0.007***
Live Performance	2.1124	***0.017***
Music Teacher	2.386	***0.008***
Studio	1.5602	0.059

Z-score Analysis of Proportion of Notches Compared to Non-Musicians. This table displays the z-scores and p-values for each role when comparing the prevalence of audiometric notches to the non-musician, control group. Significant differences are represented *in red font*.

Results

Stars indicates significant differences compared to non musicians (p<.05)



Research Question 2: Is there a significant different in EHF thresholds when comparing participants with and without an audiometric notch in the clinical frequency range (3 kHz-6 kHz)?

- For this study, a notch was defined as a decline in hearing of 10 dBHL or more compared to 2 kHz, before rising to within normal limits at 8 kHz
- 665 participants were grouped as follows:
  - Unilateral right notch (86)
  - Unilateral left notch (192)
  - Bilateral notches (387)
- Any PTA (.5 kHz, 1 kHz, and 2 kHz) or PTA8 (.5 kHz, 1 kHz, 2 kHz, and 8 kHz) greater than 25dBHL were excluded from analysis

Age-Matching

- Of the 665, 217 participants could be age-matched with controls from Sensaphonics non-musician charts
  - Could only match from males ages 20-41

Literature Review

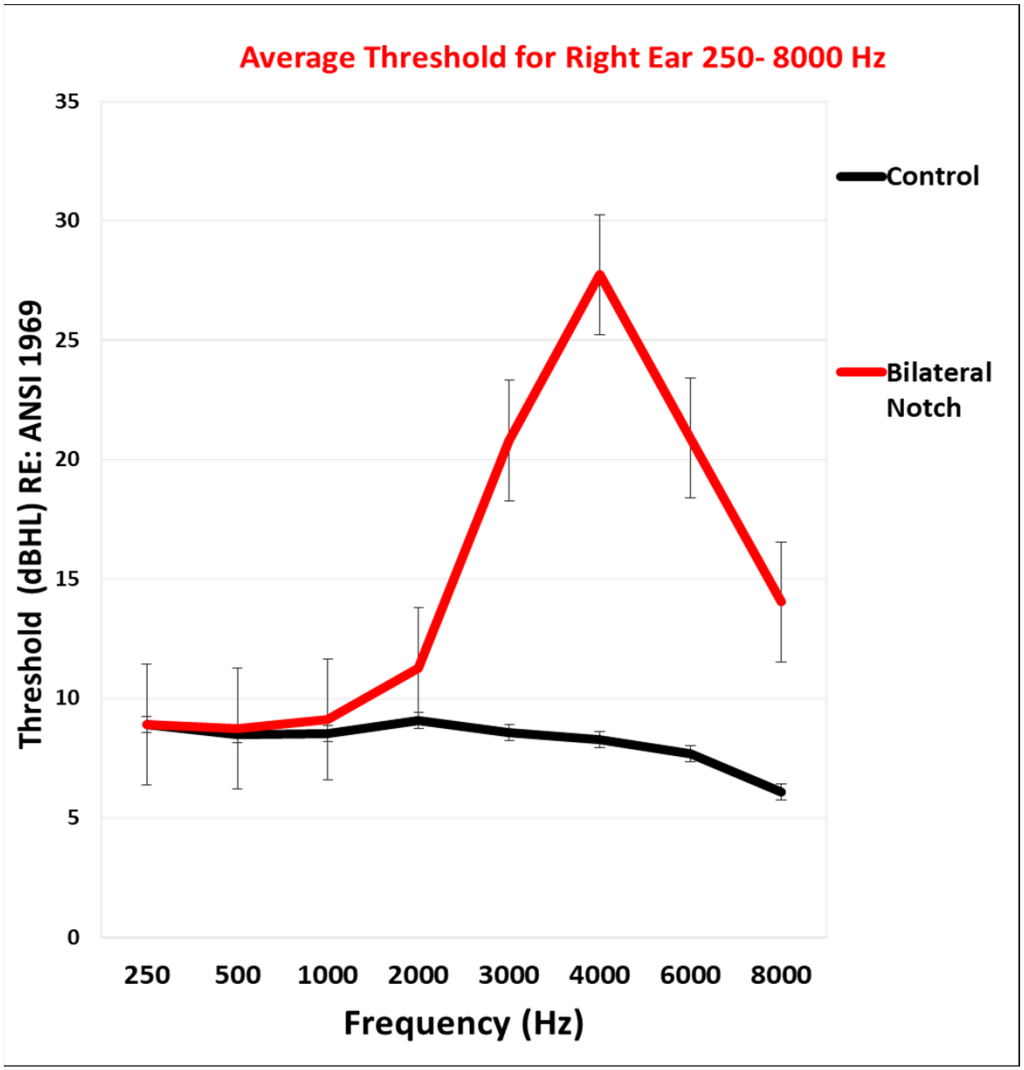
- Why we age-matched within the clinic/on the same equipment:

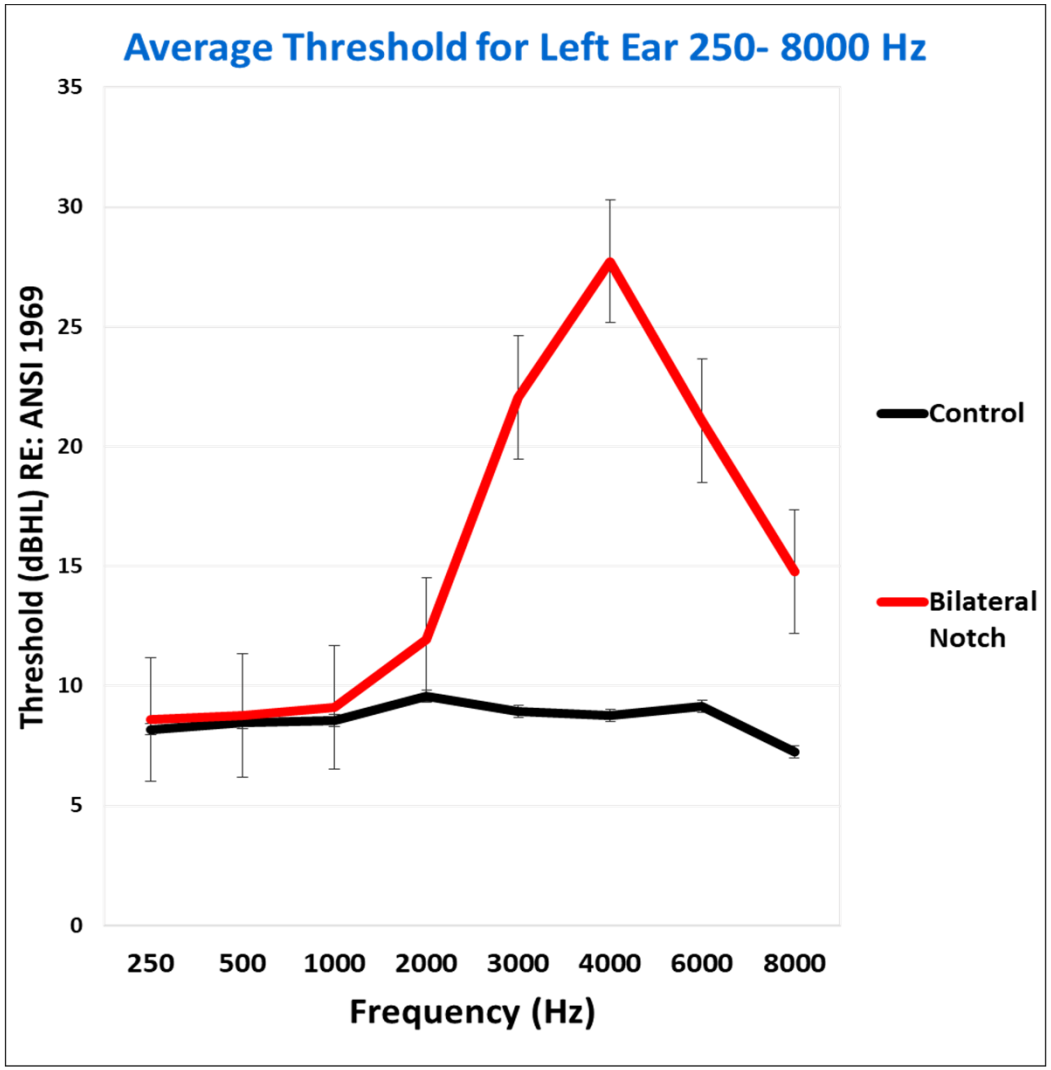
O'Shea found no widely used or accepted standards for normal hearing or degrees of loss in the EHF for unbiased populations, simply for monitoring individual hearing.

Valiente, Berrocal, Fidalgo, and Camacho (2014) reported reference thresholds for EHF up to 20 kHz on 645 adult participants. The authors concluded it would be possible to establish international standard thresholds; however, *additional studies are needed to update and establish reference equivalent threshold sound pressure levels* (RETSPL).

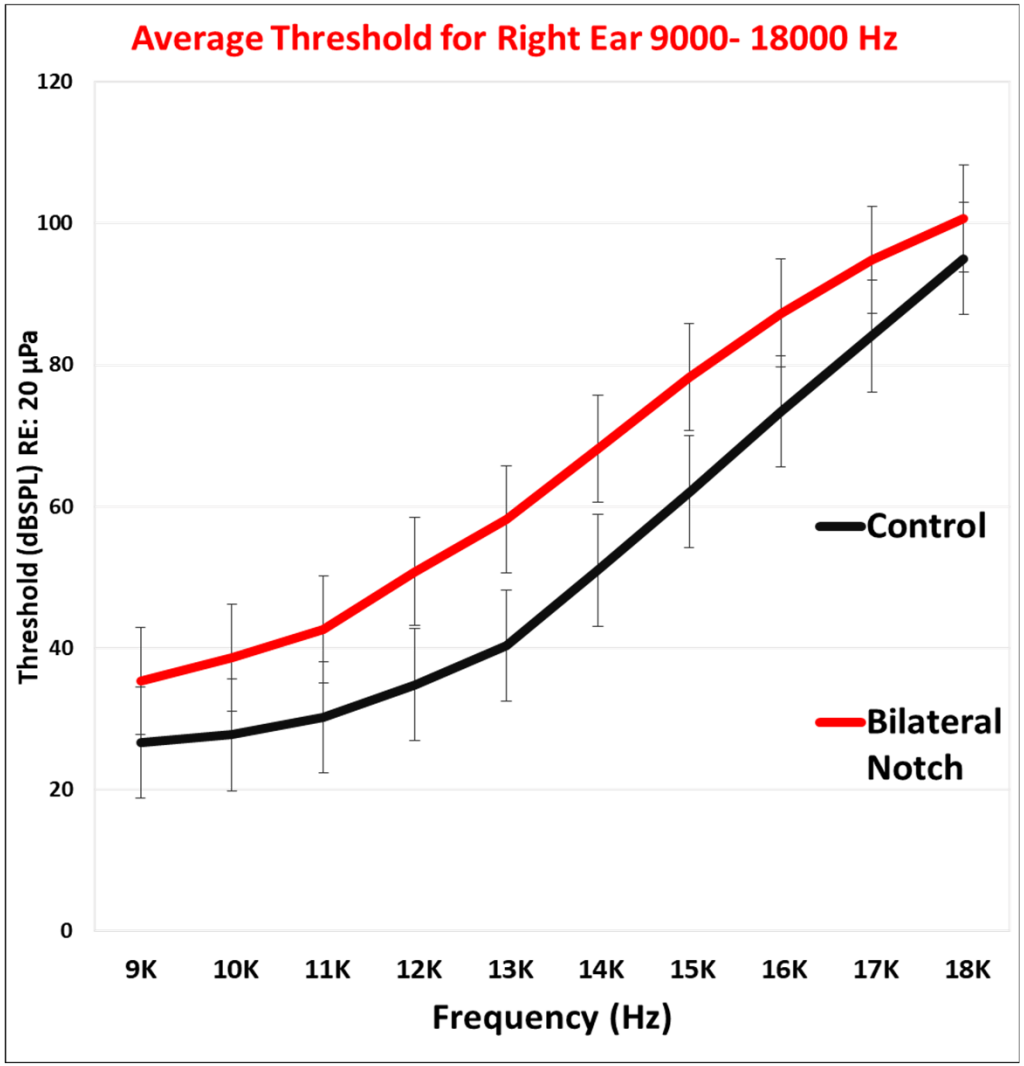
LOESS Analysis for Question 2

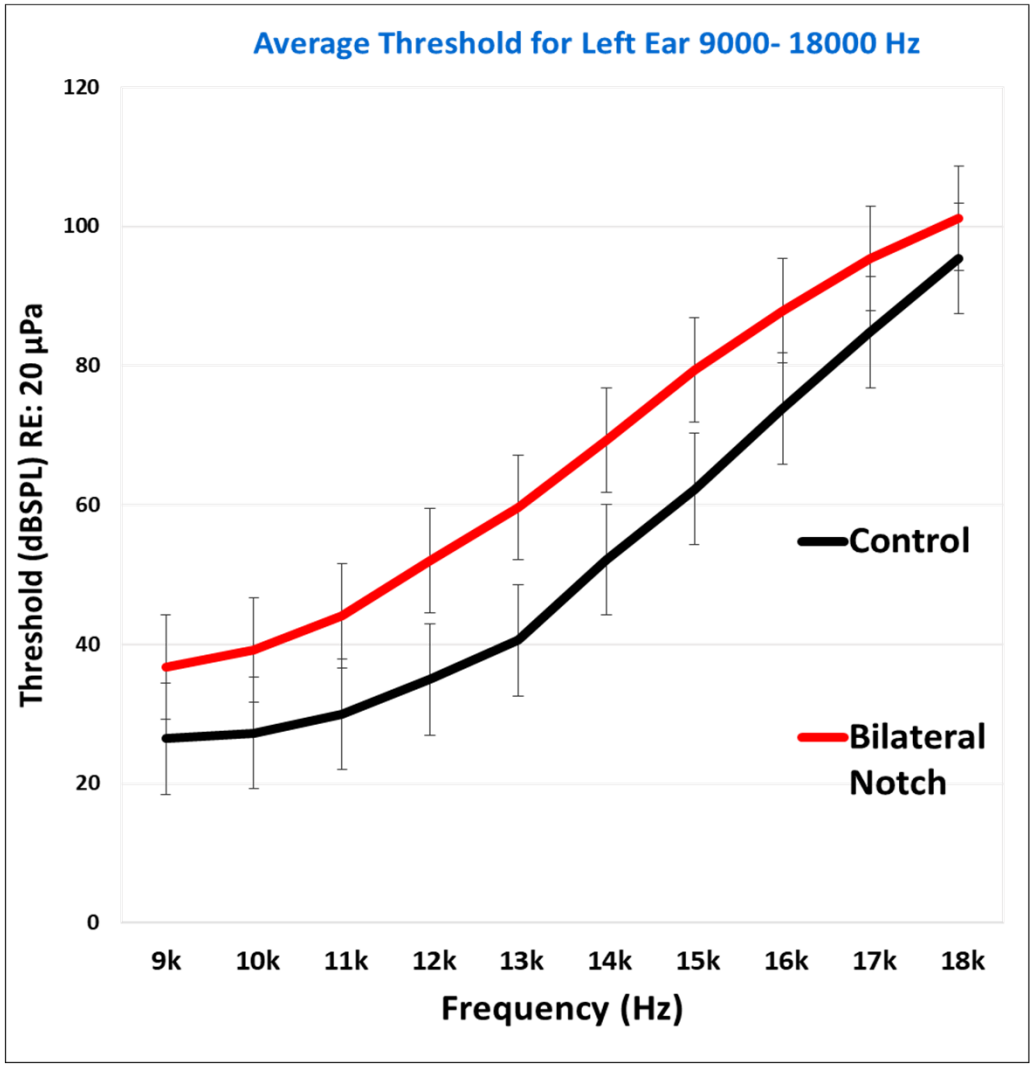
- An analysis of group distributions was used to determine if there was overlap or independence





Average threshold for the right and left ears .25 kHz- 8 kHz (dB HL) with + 1 standard error. The bilateral notch group is depicted in red, while the control in black.

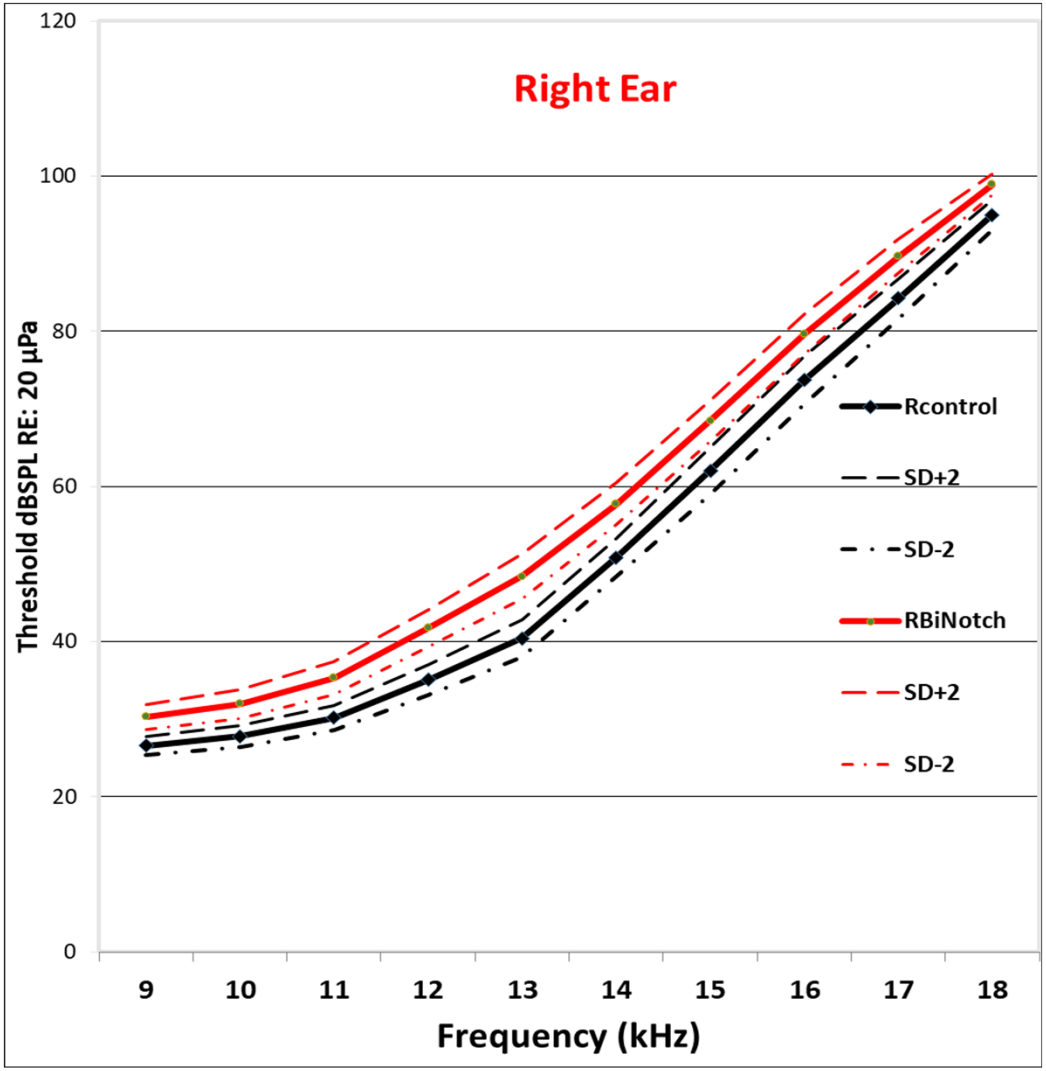


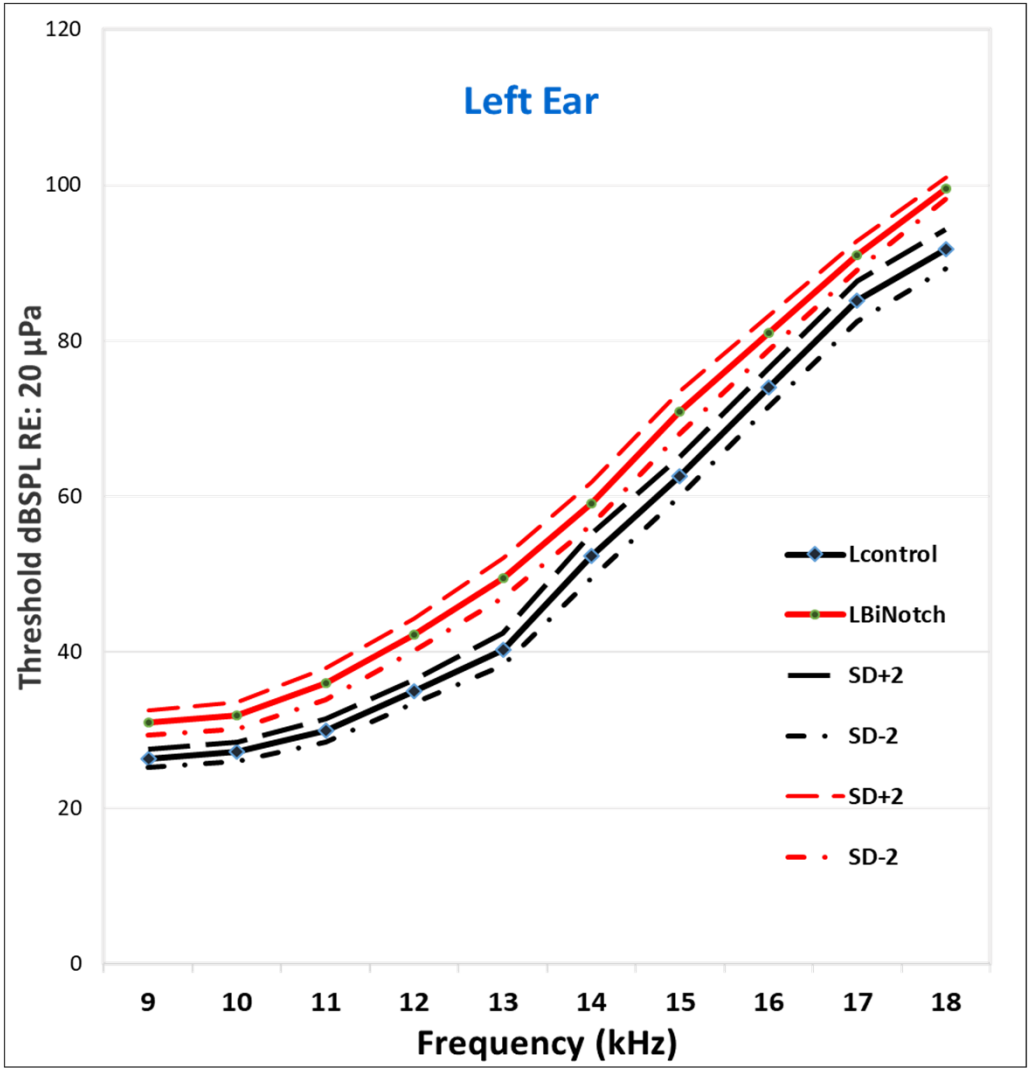


Average Threshold for the right and left ears 9 kHz- 18 kHz (dB SPL) with ± 1 standard error. The bilateral notch group is depicted in red, while the control in black

Results

- In both the bilateral notch group and the control group, as the Hz increased the mean threshold increased
- A significant difference in the distribution of EHF thresholds. The two groups do not overlap with 95% confidence interval





LOESS fit (solid) and 95% confidence intervals (dashed) for the right and left ear EHF 9 kHz- 18 kHz (dBSPL). Red depicts the bilateral notch group, while black depicts the control group.

Conclusion/Discussion

- EHF thresholds are significantly different in participants with bilateral audiometric notches and those without notches

Limitations

- While this study did not investigate whether one group reported more sound exposure than the other, it can be hypothesized that the group with bilateral notches had more exposure than those without
- Only males, ages 20-41 were included due to small number of female participants and difficulty age-matching
- Limitations of self-reporting

Future Studies

- Prevalence of tinnitus (currently being studied by Rush/Sensaphonics)
- Reported use of hearing protection and status of EHF thresholds
- Smoking status and use of ototoxic medications
- Instrument type and prevalence of noise notch/comparison of EHF

References

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