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Hearing Loss and Tinnitus Treatment for Musicians

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Chief Audiology Officer, Lantos Technologies

Acknowledgements and Disclosures

- Owner of Tobias & Battite, Inc., Hearing Wellness Centers of New England
- Consultant to Lantos Technologies, Inc., service as Chief Audiology officer
- Has ownership interest in Lantos Technologies, Inc.
- Receives an honorarium from continued for presentation and being guest editor
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Agenda

- Tinnitus therapy for musicians
  - Sound enhancement (apps, tinnitus maskers, personalized sound therapy etc.)
  - Informational, Adjustment, and Cognitive Behavioral Therapy
- Amplification for music vs. for speech
  - Important acoustic differences
  - MPO, Compression ratio, and frequency-gain characteristics
  - Coupling to the ear

Professional Drummer: worker’s compensation claim

- 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 (TFI = 68)
- WRS = 92-100%
- Also hyperacusis (guarding)
Professional drummer, tinnitus management strategies

- In quiet, perception
- Ambient noise (improvement?)
- Hearing aids (improvement?)
- Combo masker-hearing aids (improvement?)

- Are we able to offer sense of control over perception, so that we can give the patient “space” to begin to manage his or her reaction?
How the Audio Professional “listens”
Four principal Music-Induced Hearing Disorders resulting from acoustic injury

1. Noise-induced Permanent Threshold Shift (NIPTS); also NITTS
2. Tinnitus
3. Hyperacusis
4. Diplacusis

- Comprehensive audiometry (air, bone, speech) including 3k and 6k Hz
  - +/- Extended high frequency (EHF) audiometry (9k – 20k Hz): Le Prell, et al. (2013)
- Immittance, +/- MEMR, +/- LDL
- DPOAEs, 1500 – 10k Hz, 4 frequencies per octave

Additions to evaluation for tinnitus complaint:

- Tinnitus Functional Index (Meikle et al 2011); 8 domains describing tinnitus severity and impact
  - Meet criteria for “clinically significant”? (≥ 25)
  - At intake and end point of therapy (13-point shift = clinically significant change)
- Minimum masking level, +/- residual inhibition
- +/- loudness and pitch matching
- Informational Counseling
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)

Presentations of Tinnitus

- Does tinnitus pitch matter?
  - Often multi-tonal, if tonal at all
  - May approximate frequency region of a noise-notch
  - Some tinnitus sound therapies require tinnitus pitch match
- Does tinnitus “loudness” matter?
  - Most tinnitus is loudness matched to within 12 dB of threshold of hearing sensitivity (Snow, 2004)
  - Absolute sensation level not correlated with “tinnitus suffering”
  - Some tinnitus sound therapies require tinnitus loudness match
- Minimum Masking Level
  - Matters, for the sake of modifying perception of tinnitus
Tinnitus Interventions

- Informational counseling (and adjustment counseling)
- Stress reduction
- Sound enhancement (white noise generator; tinnitus maskers; combo devices—hearing aid with tinnitus masker)
- Directed sound therapies (Signia notch therapy; Otoharmonics Levo)
- Tinnitus Retraining Therapy (Jastreboff)
- Behavioral Health (CBT)
- Anti-anxiety medications
- Hearing loss prevention program to mitigate exacerbation of tinnitus and hearing loss (target < 50% daily noise dose on 85 dBA-trade 3)

**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.**

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### Damage Risk Criteria

<table>
<thead>
<tr>
<th>Damage Risk Criteria</th>
<th>OSHA</th>
<th>NIOSH</th>
<th>EPA / WHO</th>
</tr>
</thead>
<tbody>
<tr>
<td>OSRHA</td>
<td>90 dBA, 8-hr TWA</td>
<td>85 dBA TWA</td>
<td>80 dBA TWA</td>
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<td>5 dB Exchange rate</td>
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<td>94 dBA</td>
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</tbody>
</table>

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**Notices:**
- **OSHA:** 90 dBA, 8-hr TWA
- **NIOSH:** 85 dBA TWA, 3 dB ER
- **EPA / WHO:** 80 dBA TWA, 3 dB ER

**Disclaimer:**
- For educational purposes only.
- Please consult a qualified professional for medical advice.

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**Note:**
- Updated: 6/5/19
Risk for a “Material Hearing Impairment”
Max Noise Dose 85 dBA trade 3 vs. 90 dBA trade 5?

**OSHA (1981):**

<table>
<thead>
<tr>
<th>Organization</th>
<th>TWA Noise Exposure</th>
<th>Estimated % at Risk</th>
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<tbody>
<tr>
<td>ISO</td>
<td>90 dBA</td>
<td>21%</td>
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<tr>
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<td>80 dBA</td>
<td>3%</td>
</tr>
</tbody>
</table>

Prince, et al 1997
85 dBA
8%

**Key**

- R     L
- S

"Material" Hearing Impairment
NIOSH 1998
Re: ANSI S3.44
> 25 dB HL Weighted-Avg 1-4kHz
Management of Tinnitus: Reaction Habituation

1. It’s not their fault…
2. It’s not the tinnitus, it’s their reaction to it.
3. The tinnitus is neutral: it’s like the amplifier turned up and you hear the hum of the circuit noise
4. Enhanced environmental sound.
5. ENSURE future exposures are less than 100% noise dose (prefer 50%)
6. Connect with a team of providers in complementary fields.

Considerations for hearing aids

Music ≠ Speech

1. Maximum input (and dynamic range)
2. Crest Factor (Peak – RMS)
3. Spectral structure
4. Time domain envelope
5. “Intent”
Considerations for hearing aids

Music ≠ Speech

1. Maximum input (and dynamic range)
   - Speech = 80 dB (30-40 dB)
   - Music = >100 dB (60-100 dB)

2. Crest Factor (Peak – RMS)
   - Speech = 12 dB
   - Music = 18 dB

3. Spectral structure
   - Fundamental frequency: voice = 82 – 1046 Hz
   - Fundamental frequency: piano = 27.5 – 4186 Hz; violin = 196 – 2637 Hz
   - Speech = Formants; < 8k Hz
   - Music = Harmonics; >10k Hz

http://www.bwmusic.com/goodies/RangeE.jpg

http://www.musicianswithhearingloss.org/

Full compliment of instruments and voice at
http://www.bwmusic.com/goodies/RangeE.jpg
Considerations for hearing aids

Music ≠ Speech

3. Spectral structure

Fundamental frequency: voice = 82 – 1046 Hz
Fundamental frequency: piano = 27.5 – 4186 Hz; violin = 196 – 2637 Hz

Violin playing A_440 http://www.nagyvaryviolins.com/
Considerations for hearing aids

Music ≠ Speech

4. Time domain envelope
   Rise-time of signal: violin bow vs. piano key strike vs. drums
   …as opposed to voice-onset time, formant transitions

   compression attack time and release time:
   Slow-attack/slow-release (live music: 0.5 sec – 10 sec) vs. fast-attack/slow-release vs. fast-attack/fast-release (syllabic compression: ~10msec to 200 msec)

5. “Intent”
   Communication of emotion, not content

http://ec-concord.iied.edu.hk/phonetics_and_phonology/wordpress/learning_website/chapter_3_consonants_new.htm
Mild-Moderate Sensorineural Hearing Loss

- Speech, 65 dB SPL
- Speech, 65 dB SPL NAL-NL1, 40 dB
- Music, 75 dB SPL NAL-NL1, 40 dB
- Music, 75 dB SPL Flat 20 dB gain, 60 dB

Hypothetical music listener, active male in his late 50’s

- Music, 80 dB SPL
- "General/All-Around"
- "Music"
- Flat 20 dB gain, 60 dB
Hearing Aid Selection

- Open Dome vs. Closed Dome vs. Custom (with adequate venting); consider tinnitus, low-frequency hearing sensitivity, ear canal shape
- Ability to turn off processing (non-linear signal processing, noise reduction, feedback management, frequency compression); noise-reduction may not be helpful in person with tinnitus
- Omni-directional microphones (not directional) (but, room acoustics may influence choice)
- "Fake it" into thinking single channel?
- Option of patient to perform self-tuning
- Peak input limiting: 94 dB SPL vs. 104-112 dB SPL

Summary: Hearing Loss and Tinnitus Treatment for Musicians

- Tinnitus complaint (more common than SNHL complaint), and more salient (Treat the patient, not the audiogram)
- Evaluate and refer as needed
- Counseling (informational, adjustment, “reframing”)
- Manage hearing loss if present and communicatively significant
- Music ≠ Speech
- Appropriate HPD
Resources


- 11 chapters: Jastreboff, Dobie, Henry, Newman and Sandridge, Burchard, etc.
- Audiological assessment and therapy/management, medical, imaging science, epidemiology