

Acceptable Noise Levels in Hyperacusic Individuals

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Introduction

- Hyperacusis is a complex and poorly understood phenomenon, defined as decreased or collapsed tolerance to sound. It has been reported in patients with both peripheral symptoms eg: Bell's palsy and central symptoms eg: William's Syndrome.
- Hyperacusis is usually associated with increased gain in the central auditory system and that gain can be influenced by issues of anxiety or depression.
- Loudness discomfort level (LDL) measurements are often used for the evaluation of hyperacusis and are typically done with pure tones or narrow band noise stimuli
 - Normative data for LDLs are not uniform and numerous extraneous factors can influence and confound loudness judgments (Formby 2005, Skinner 1988).

Introduction

- Testing of hyperacusic individuals rarely involves listening in background noise due to the perceived aversion to any of these signals.
- The ANL is quickly becoming a test of choice for measuring acceptance of background noise.
 - The ANL is a procedure used to quantify an individual's willingness to listen to speech in the presence of background noise.
 - The procedure is quick and reliable as well as safe for hyperacusic individuals because they can decide when the noise levels become uncomfortable.

Purpose

- This is an exploratory study in evaluating the ANL for individuals who report hyperacusis. We compared their results to normal hearing participants who reported no unusual sensitivity to sounds.
- LDLs do not give a very accurate estimation of the difficulties encountered in everyday life. Edgerton et.al. reported that speech LDLs also show considerable variability even among listeners with similar thresholds.
- We wanted to see if an acceptance of background noise protocol such as the ANL would help define hyperacusis. In addition, this information could be helpful for the desensitization process and as an outcome measure following treatment for hyperacusis.

Methods

- 7 normal hearing subjects (6 females, 1 male)
 - Age range: 27-62 years
- 7 hyperacusic subjects (2 females, 5 males)
 - Age range: 31-71 years
- Test Procedure
 - Pure Tone air conduction thresholds .5-8 kHz
 - Loudness Discomfort Levels (LDLs) .5-4 kHz pure tone
 - Distortion Product Otoacoustic Emission (DPOAE) screen
 - Acceptable Noise Level (ANL)
 - ANL = Most Comfortable Level (MCL) – Background Noise Level (BNL)
- Subjects also completed a Hyperacusis Questionnaire

Hyperacusis Questionnaire

Name (optional)

Age

1. How long have you had hyperacusis? _____
2. Do you associate the onset of hyperacusis with a specific event? ___Yes ___ No
3. In which ear is the sensitivity to sound a problem for you?
___Right ear only ___Left ear only ___Both ears
4. Does your hyperacusis vary? ___yes ___no
5. Please list the type(s) of sound that are bothersome to you. _____
6. Are you sensitive to other sensory stimuli? (ex. light, touch, etc.) ___Yes ___No
If yes, please explain. _____
7. Are you taking any medication? ___ yes ___ no
If yes, please list: _____
8. Do you also have tinnitus? (ringing or other noises in the ear(s) or head) ___Yes ___ No

9. Has your hyperacusis affected your relationship(s) with others? ___Yes ___No
10. Has your hyperacusis caused you to change jobs or employment settings? ___Yes ___No
11. Has your hyperacusis affected your social activities? ___Yes ___No
12. Does your hyperacusis interfere with your sleep? ___Yes ___No
13. Do you use ear protection? ___Yes ___No
If yes, what type of ear protection?

If yes, when did you start using ear protection? _____
If yes, how often do you use ear protection? _____
14. Do you have a hearing loss? ___Yes ___No
15. Have you seen a doctor or other health professional regarding this condition?
___Yes ___No
If yes, please list the professional(s).

Methods

- ANL Procedure
 - Subjects tested in an audiometric booth, situated 1.5m from the loudspeaker.
 - Speech and noise stimuli presented through one loudspeaker at 0° azimuth.
 - ANL test CD calibrated according to instructions.
 - Prior to testing, subjects were given oral and written instructions which were posted inside the booth.
 - Subjects were instructed to signal the examiner (verbally, hand gesture, or response button) to increase/decrease intensity of signal.

ANL Procedure

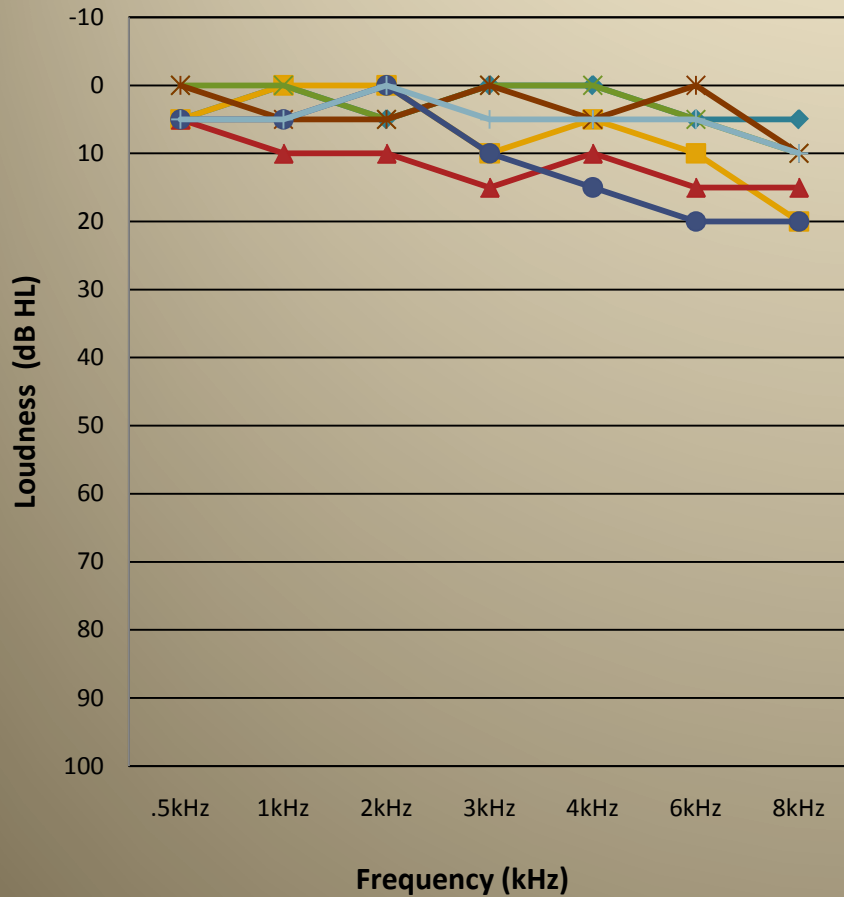
- $ANL (dB) = MCL (dB HL) - BNL (dB HL)$
- Establishing Most Comfortable Level (MCL)
 - Speech passage presented at 30 dB HL and increased in 5 dB HL steps until subject indicated story was too loud.
 - Decreased level in 5 dB HL steps until subject indicated that speech passage was too soft.
 - Increased presentation of speech passage in 2 dB HL steps until subject indicated most comfortable loudness level (MCL).
 - MCL determined after 3 consecutive responses using a 2 dB HL adaptive approach

ANL Procedure

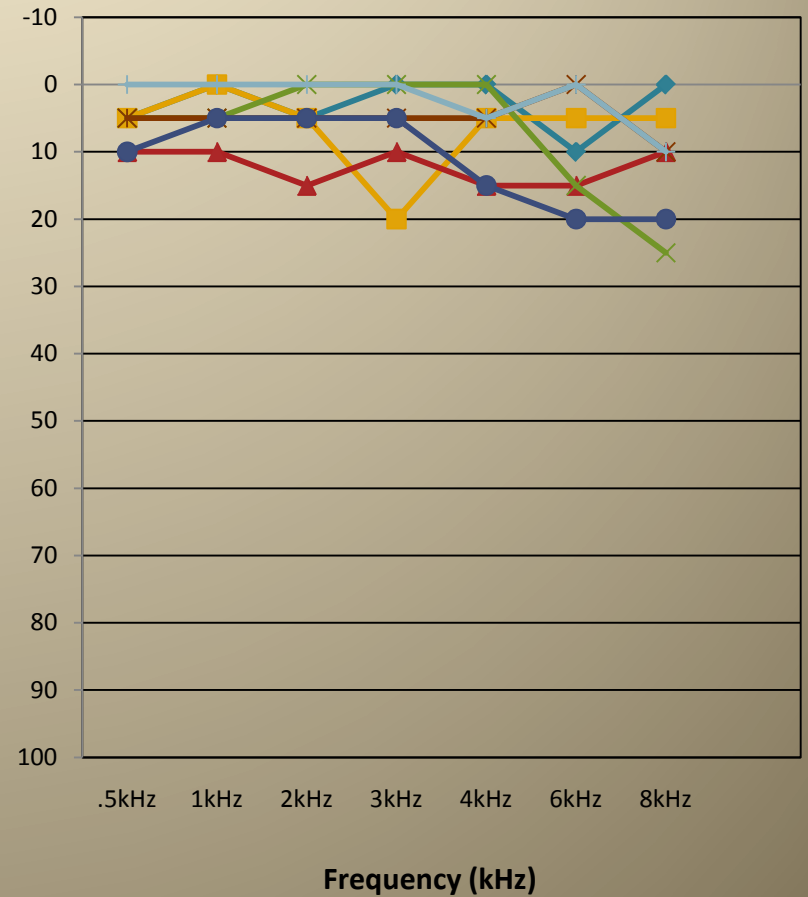
- Establishing Background Noise Level (BNL)
 - Speech passage presented at subject's MCL
 - Introduced background noise (speech babble) starting at 30 dB HL
 - Increased level of background noise in 5 dB HL steps until subject indicated that speech passage was incomprehensible
 - Background noise was then decreased in 5 dB HL steps until subject indicated that speech passage became very clear and easily understood
 - Background noise was then increased in 2 dB HL steps until subject indicated that the level of the background noise was the MAXIMUM level they would be willing to “put up with” for a long time while following the story.
 - BNL determined after 3 consecutive responses using a 2 dB HL adaptive approach

Audiogram – Normal Subjects

Left Ear

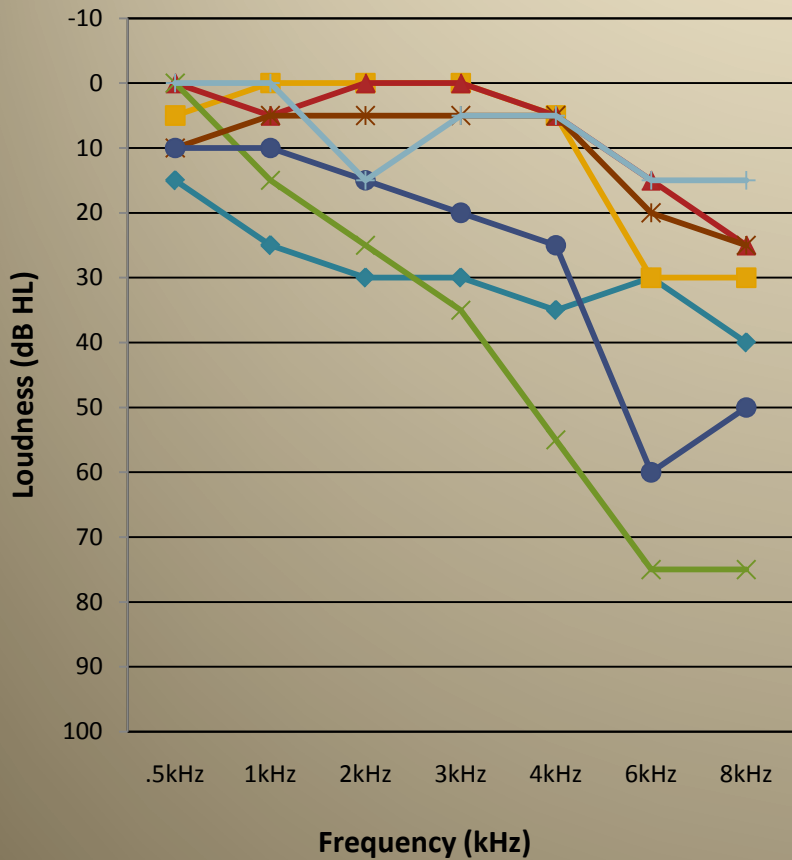


Right Ear

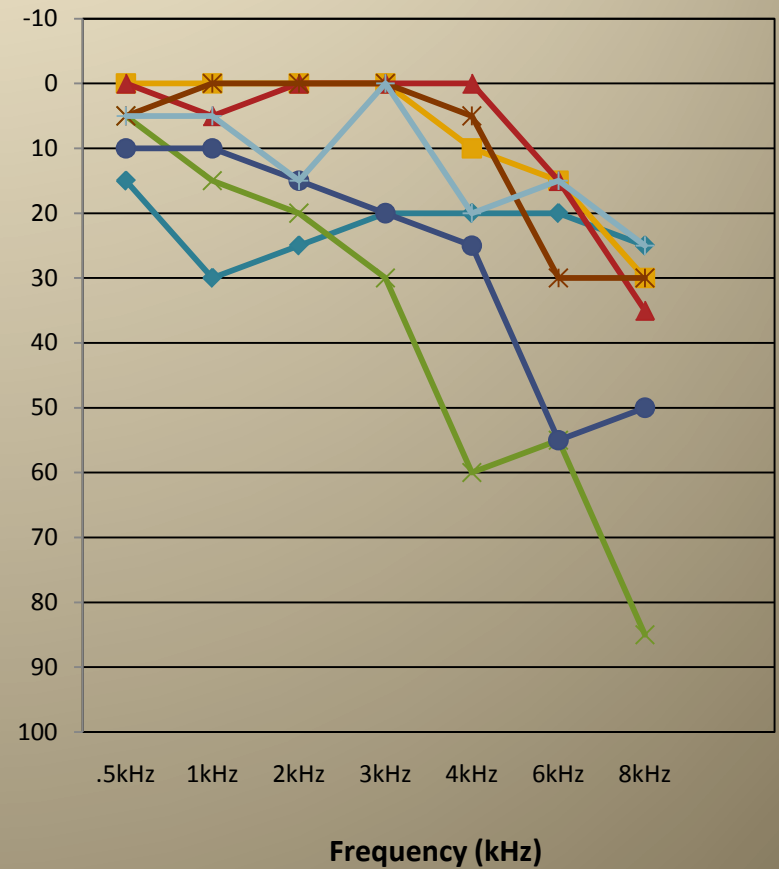


Audiogram – Hyperacusis Subjects

Left Ear

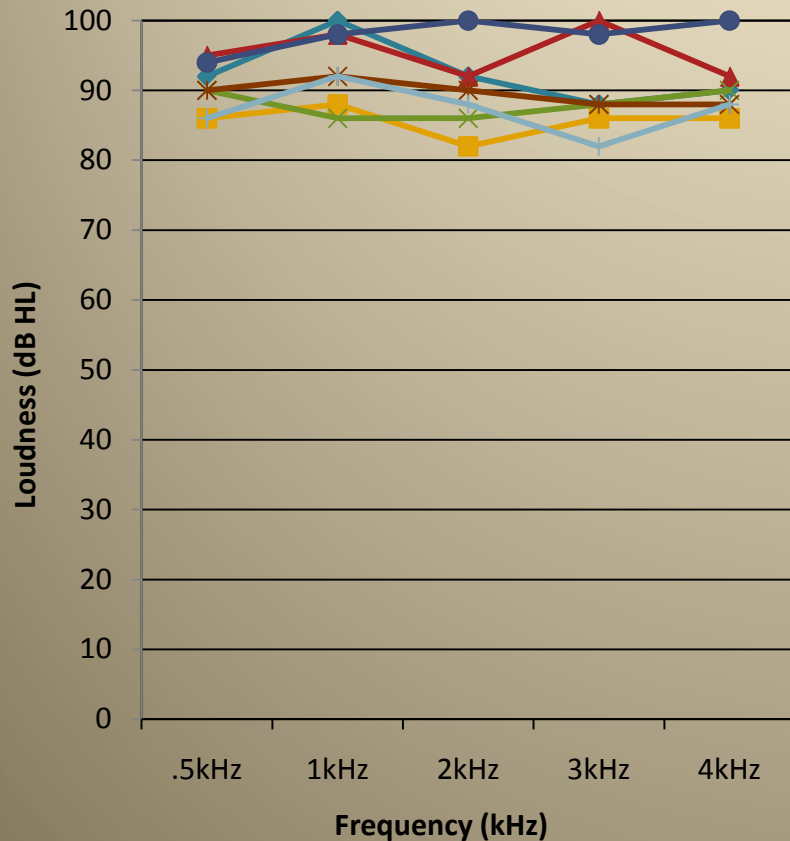


Right Ear

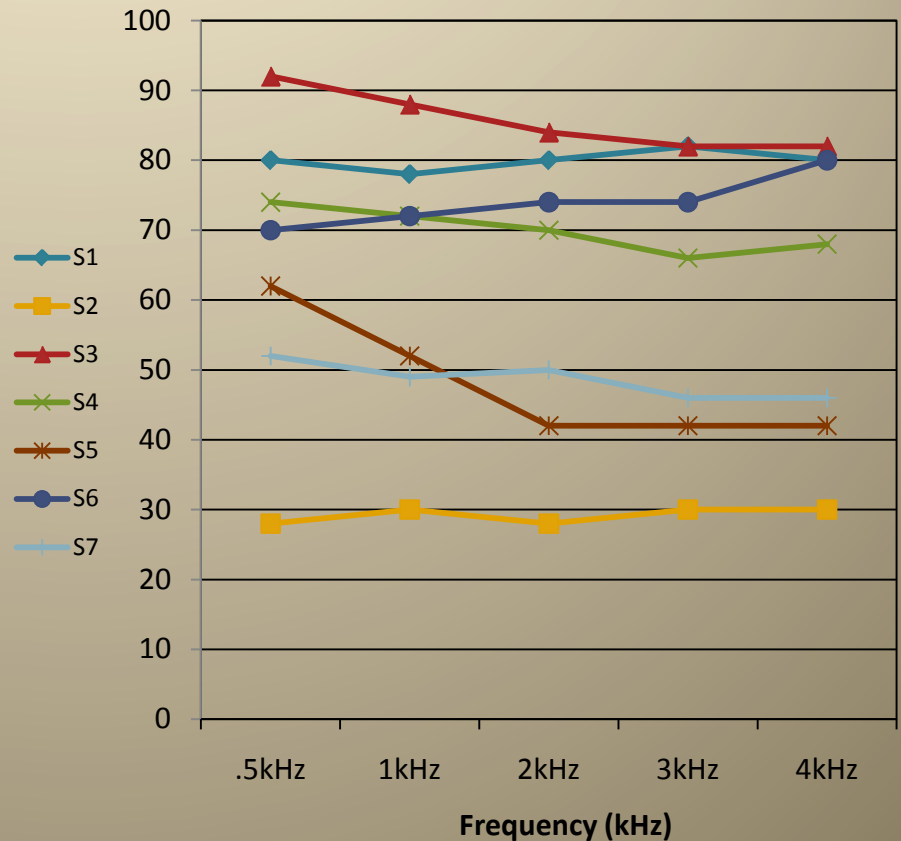


Loudness Discomfort Levels (LDLs)-Left Ear

Normal Subjects

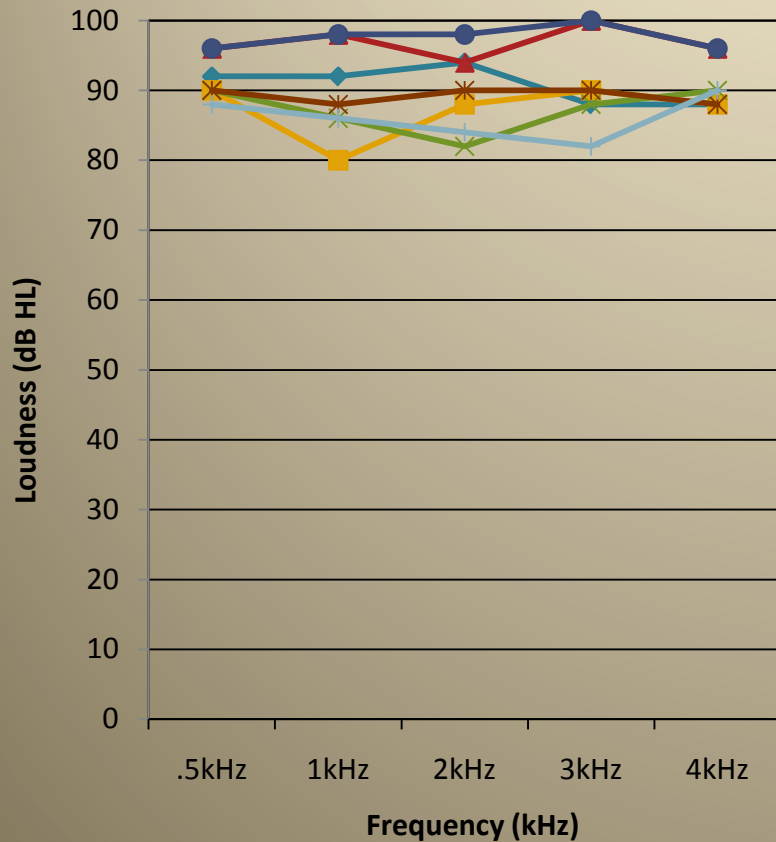


Hyperacusic Subjects

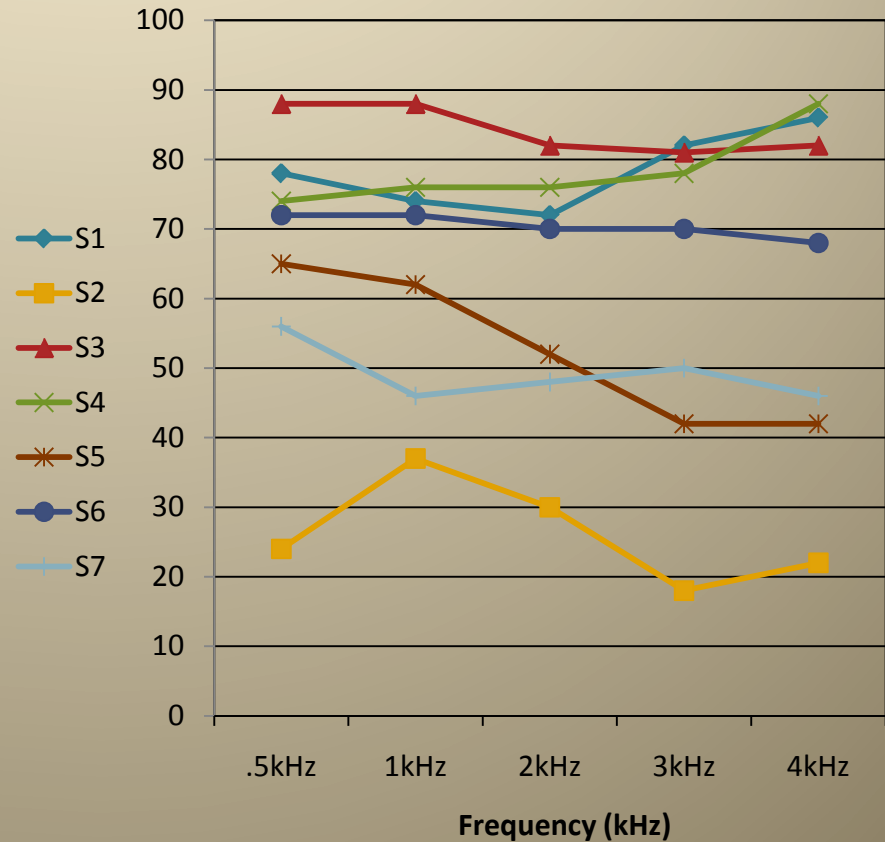


Loudness Discomfort Levels (LDLs)- Right Ear

Normal Subjects

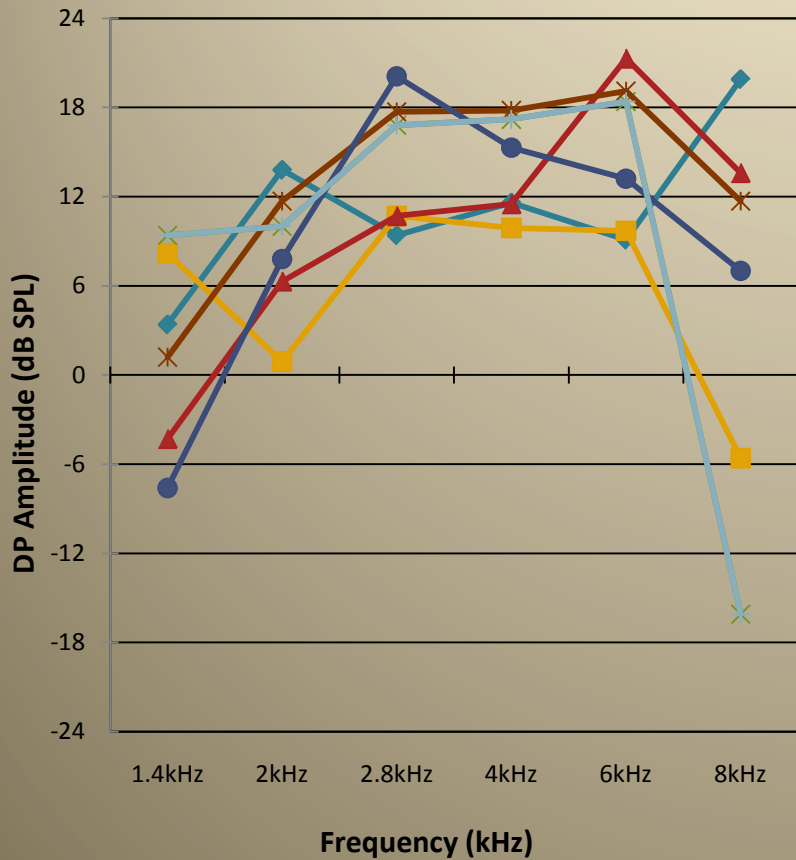


Hyperacusic Subjects

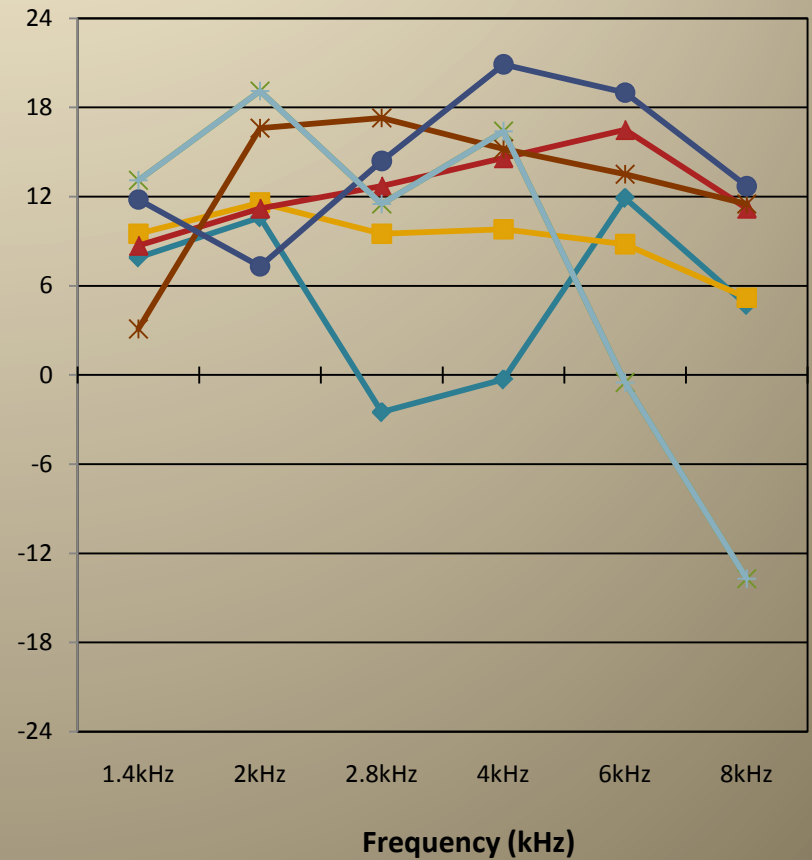


DPOAEs- Normal Subjects

Left Ear

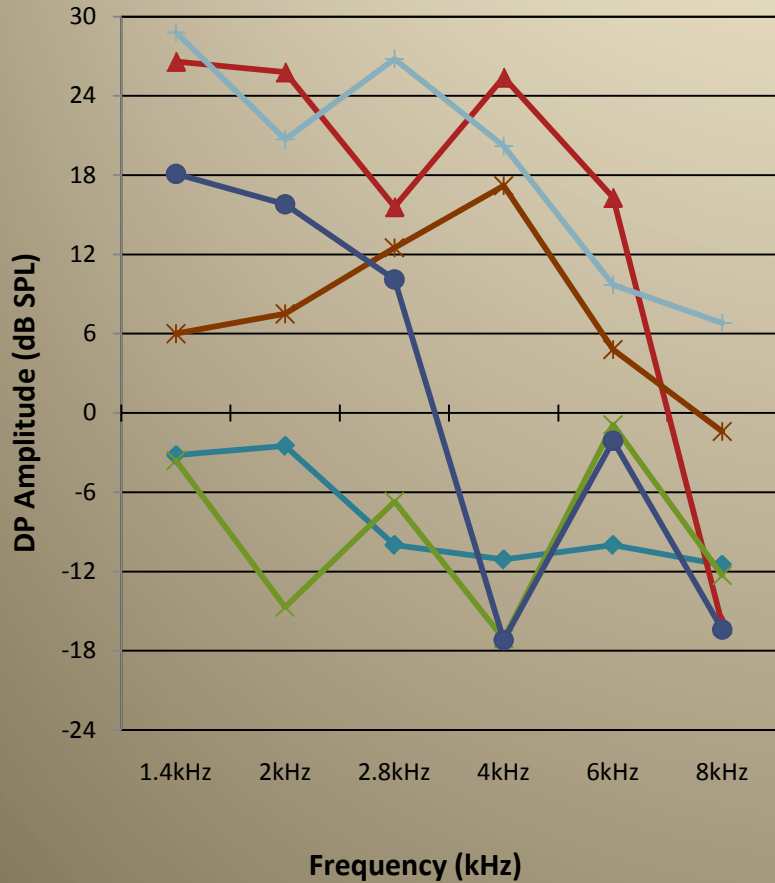


Right Ear

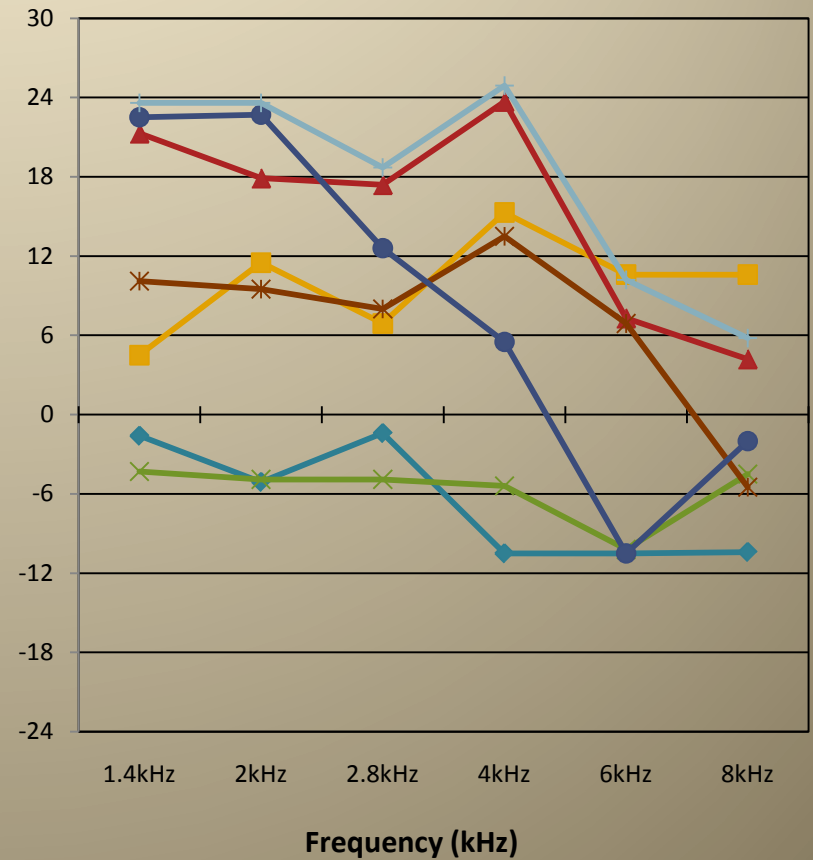


DPOAEs- Hyperacusis Subjects

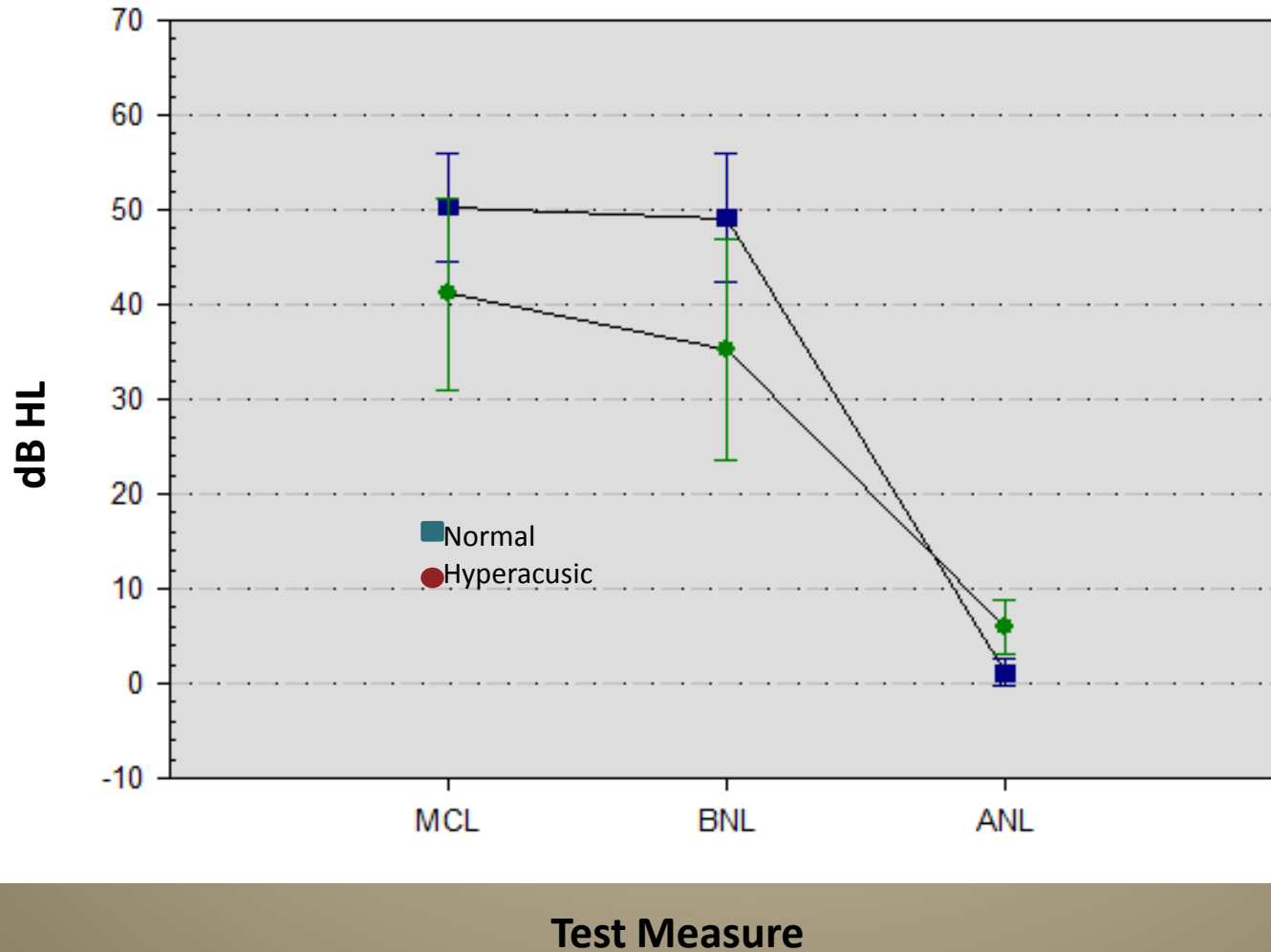
Left Ear



Right Ear



Mean Values for Normal and Hyperacusic Subjects



Error Bars represent 95% confidence intervals

Statistical Analysis

| | Normal | | Hyperacusic | |
|----------------------------|-----------|---------|-------------|---------|
| Measure | Mean | Std Dev | Mean | Std Dev |
| MCL | 50.29 | 6.26 | 45.15 | 10.9 |
| BNL | 49.14 | 7.38 | 35.14 | 12.6 |
| ANL | 1.14** | 1.57 | 6 | 3.1 |
| T Test (ANL) (2-tailed) | T= 3.7004 | dF= 12 | p< 0.01 | |

Statistical analysis using a two tailed T-Test ($p < .01$) showed a significant difference between the ANL for normal subjects vs. hyperacusic subjects.

Hypersensitivity in Autism Spectrum Disorders (ASD)

Our highest ANL of 10 was seen in two subjects. One was a young adult male (S7) diagnosed with Asperger's, who also had the largest amplitude DPOAEs and one of the lowest LDLs of the group.

In 2005, the ANL was evaluated on a group of young adults with ADHD and ADD. These disorders are similar to Autism Spectrum Disorders, such as Asperger's, in that they affect multiple sensory modalities. These disorders have also been associated with difficulty listening and processing auditory information in backgrounds of noise. Researchers found that ANL levels decreased at various presentation levels with the use of medication. The drugs used in the Freyaldenhoven, et.al. (2005) study were stimulant medications which are often used for ADHD and ADD.

Four of the seven hyperacusic subjects in our study were also taking medications, but continued to report abnormal sound sensitivity, however, their drugs were primarily for sleep and anxiety issues. The effect of medication on acceptance of noise levels needs further research regarding the relationship to hyperacusis.

Hypersensitivity in Musicians

The other ANL of 10 was seen in S2, a 52 y.o. female musician with normal hearing, normal DPOAEs but significantly reduced LDLs. In 2007, Hickey and Moore looked at whether music was a more acceptable background sound than speech babble. They found that ANL for music tended to be lower than for speech babble and was not related to the music preference. They concluded that music appeared to be processed differently as a background noise than speech babble.

Music has been found to be very helpful for many people with hyperacusis (Davis and Meltzer, 2009). Our musician however, could not listen to prescribed music and preferred broad band sound, but that too had limited appeal for her.

For this patient, counseling without sound therapy may be the best approach to help her accept and tolerate more sound in her daily life.

Hypersensitivity in Hearing Loss

Subject 4 was a 71 y.o. male with a sloping SNHL who complained of hyperacusis. His ANL was within the normal range (ANL=2), suggesting that his problems reflected recruitment rather than hyperacusis.

This subject would probably benefit from open fit hearing aids with directional mic and DNR (digital noise reduction) but he was reluctant to let go of his definition of hyperacusis believing that hearing aids would make sound louder and worsen his sensitivity. Misconceptions related to the avoidance of sound have been noted by many who work with hyperacusis patients. We cannot emphasize enough how important the role of counseling is in advising our patients.

Discussion

The other four subjects in our study included two with phonophobia (fear of sound) and two with misophonia (dislike of particular sounds). We believe these sound judgments account for the wide range seen in LDLs and ANLs.

Six of the seven subjects in the hyperacusis group used ear protection. The use of ear protection with inappropriate amounts of attenuation can be detrimental to the auditory system. Also, it is important for patients to understand that overuse of ear protection causes an increase in the sensitivity of the auditory system due to decreased auditory input (Jastreboff 2000).

Of interest, all of our hyperacusis subjects noted other sensitivities, mostly to light although a couple mentioned sensitivity to touch.

Discussion

The ANL has been used to predict hearing aid success based on one's willingness to listen to speech in background noise. Researchers differentiate this task from word recognition/discrimination in noise and show that this process of loudness acceptance takes place in a different part of the auditory nervous system.

The ANL may be mediated by non-peripheral factors beyond the level of the superior olivary complex where binaural processing initially occurs within the central auditory nervous system (Harkrider and Smith 2005) and may be due in part to cortical inhibition (Harkrider and Tampas 2006).

The ANL has been shown to be of value in describing differences among listeners related to acceptance of hearing aids and may also be useful as a measure of acceptance of background noise on individuals who are sensitive to sound.

Conclusions

The results from this study, while preliminary, suggest that the ANL can be used as a measure of hyperacusis. By providing other tests to evaluate sound sensitivity we hope to have a more concise definition of hyperacusis relative to other conditions such as phonophobia and misophonia.

- This would enable health care professionals to provide patients with more information and help select appropriate treatment options.
- The ANL may be of use clinically in defining a patient's acceptable noise levels and in addition, be utilized as an outcome measure following treatment.
- Studying acceptable noise levels may be relevant to understanding the processing abilities of those with hyperacusis in everyday complex listening environments.

Future research direction could include:

- Electrophysiological Studies, i.e. ALR to compare cortical responses to the ANL in normal hearing, hearing impaired, and hyperacusis individuals

Acknowledgment

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