Extended high-frequency audiometry and DPOAEs in "normal" hearing noise-exposed young adults

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BACKGROUND

- Noise-induced hearing loss (NIHL) is a permanent hearing loss that remains a hearing health concern despite the implementation of national standards for hearing protection.
- NIHL is often categorized using a high-frequency notch occurring at 3 to 6 kHz in a behavioral audiogram. Recent studies demonstrated that noise exposure can cause auditory neural degeneration, in some cases a loss of up to 50% of the synapses between inner hair cells and cochlear neurons can be detected, even when physiology of the hair cells recovers and hearing thresholds and otoacoustic emissions (OAEs) return to normal (Kujawa & Liberman, 2009). The cochlear synaptopathy is referred to as “hidden hearing loss” because the damage cannot be detected by audiometry until it becomes severe.
- Extended high-frequency audiometry (EHFA) might be an effective tool to diagnose cochlear synaptopathy in humans. The present study investigates EHFA along with extended high-frequency distortion product OAEs (DPOAEs). The study controlled several methodological factors to precisely measure experimental variables, e.g. (1) noise exposure background (NEB) was estimated by a questionnaire (Megerson, 2010). The questionnaire was validated using noise dosimetry to quantify NEB in a young adult population (Megerson, 2010). High NEB obtained with the survey was associated with cochlear synaptopathy (Stamper & Johnson, 2015), (2) EHFA was measured using HDA200 high-frequency headset up to 20 kHz, and (3) DPOAEs were measured using f2/f1 = 1.22 at three primary levels 75/75, 65/55 and 55/40 dB SPL, (4) Supra-threshold auditory functions were measured using QuickSIN and Dichotic Digit Test (DDT).

METHODS

- A sample of 100 human adults (18-30 years) with self-reported normal hearing was collected at the Flagstaff Maintain campus of Northern Arizona University. Individuals with normal otoscopic and immittance findings were referred for further testing. Subjects reporting continuous chronic tinnitus, systemic diseases, neurological or immunological disorders were excluded from the study. Eighty-four participants met the inclusion criteria.
- **Audiometry:** Audiometric thresholds were obtained at 1000 Hz, 2000 Hz, 3000 Hz, 4000 Hz, 6000 Hz and 8000 Hz (GSI-61, Eden Prairie, NM) with ER-3A insert receivers (Etymotic Research. Inc, Elk Grove Village, IL). Hearing thresholds at 10000, 12500, 14000, 16000, 18000 and 20000 Hz were measured with HDA200 headphones, using the modified Hughson-Westlake procedure in 5 dB steps.
- **DPOAEs:** DPOAEs were measured in 33 participants using SmartOAE (version 5.10, Intelligent Hearing System, Florida, USA) connected with ER-10D probe (Etymotic Research. Inc, Elk Grove Village, IL). DPOAEs were measured using F2/F1=1.22 at three primary levels: 75/75, 65/55, 55/40 in 9 data points/octave from 1000 to 16000 Hz.
- **QuickSIN:** QuickSIN test was performed to assess speech perception in noisy listening situations. The test was performed three times, and an average SNR loss was calculated.
- **Dichotic Digit Test (DDT):** DDT (3 digit pairs) were performed to evaluate binaural integration. The test stimuli were presented at 70 dB HL using GSI-61 connected with a computer. The participants were instructed to write all the digits they heard in one run.
- **Noise exposure background (NEB):** NEB was assessed by a self-reported questionnaire developed by Megerson (2010).

Fig 1: Histogram of NEB

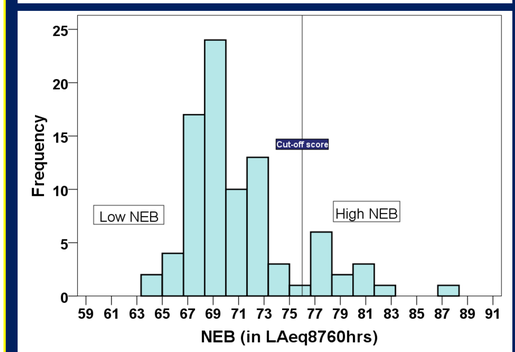


Fig 2: Pearson correlation coefficients for NEB and hearing thresholds

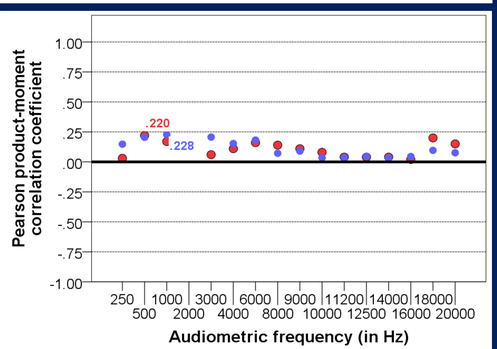


Fig 5: Scatter plot between NEB and DDT score

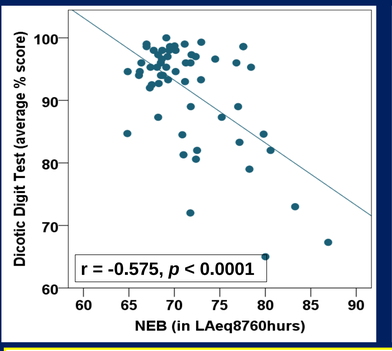
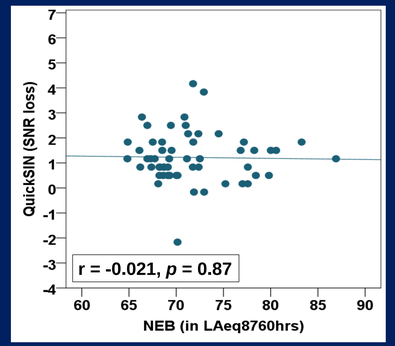


Fig 6: Scatter plot between NEB and QuickSIN



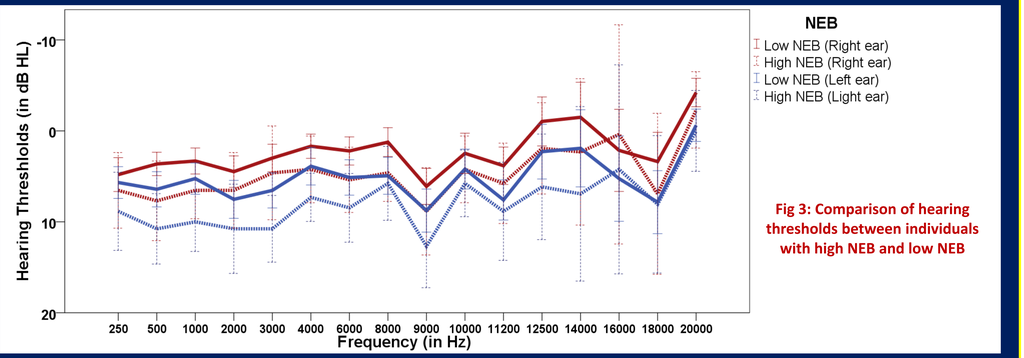


Fig 3: Comparison of hearing thresholds between individuals with high NEB and low NEB

Fig 4a: Comparison of DPOAE amplitudes between individuals with high NEB and low NEB (Right ear)

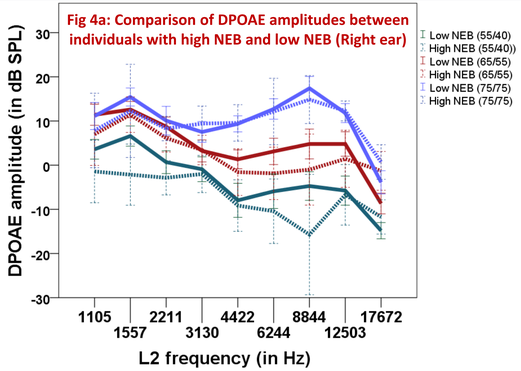
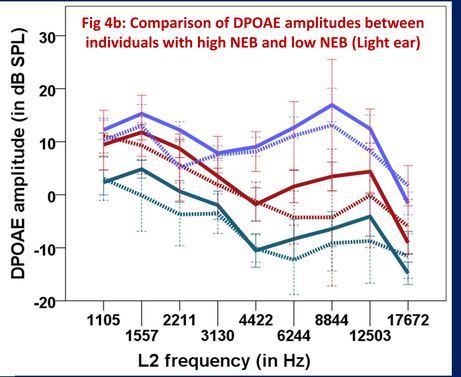


Fig 4b: Comparison of DPOAE amplitudes between individuals with high NEB and low NEB (Light ear)



RESULTS AND DISCUSSION

- Fig. 1 shows a histogram of NEB. A cut-off score of 76 $L_{Aeq8760hours}$ was utilized to identify individuals with high versus low NEB.
- Pearson product-moment correlation coefficients between NEB and hearing thresholds were computed to investigate the relation between NEB and hearing thresholds. The Bonferroni correction was applied to the *p* value of 0.05 to counterpart the problem of multiple comparison. The analysis obtained no significant association between NEB and hearing thresholds at any audiometric frequency (Fig. 2).
- Repeated measure ANOVAs showed no significant difference between hearing thresholds for individuals with high versus low NEB in both ears [Right ear: F(1, 80)=1.93, *p*=0.16; Left ear: F(1, 84)=1.21, *p*=0.27].
- A repeated measure ANOVA revealed that DPOAEs elicited by 55/40 primary levels were significantly lower in individuals with high NEB compared to individuals with low NEB in the right ear [F(1, 30)=4.53, *p*=0.042], but not in the left ear [F(1, 32)=1.91, *p*=0.17]. The repeated measure ANOVAs further revealed that DPOAEs were not significantly different between the groups for 65/55 and 75/75 primary levels (Fig. 4).
- A statistically significant correlation coefficient was obtained between NEB and DDT (r= -0.575, p<0.0001) (Fig. 5), but not between NEB and QuickSIN (r =-0.021, *p*=0.87) (Fig. 6).
- The results suggest that EHFA and DPOAEs might have limited utility in diagnosing cochlear synaptopathy. Binaural hearing skills revealed a promising association with NEB suggesting that a (central) auditory processing test battery might be useful to delineate cochlear synaptopathy in young adults.

MAJOR REFERENCES

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