Peripheral role in temporal processing deficits

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Background

- Older adults often report that speech is audible but unclear, and this lack of clarity may result from age-related degradation in temporal processing[1-3]
- These temporal processing deficits may be attributed to cochlear synaptopathy, the loss of cochlear afferent synapses, and cochlear nerve degeneration with normal thresholds and no hair cell loss[4, 5]
- Decreased neural synchrony associated with synaptopathy and a loss of low-spontaneous rate nerve fibers may lead to a reduction in sustained neural firing, resulting in decreased ability to use temporal duration cues in speech perception.[6]
- Cochlear hair cell and lower-level neural function can be assessed using distortion product otoacoustic emissions (DPOAEs) and auditory brainstem responses (ABRs) to click stimuli presented in quiet and in noise[4, 7-9]
- Here we assessed the role of peripheral function (extended high-frequency pure-tone thresholds, ABR amplitudes and latencies, and high-frequency DPOAEs) in the perception of temporal duration cues[2]

1) Is there an effect of age on peripheral measures of auditory nerve function?
2) Does auditory nerve function play a role in the perception of temporal duration cues?

Method

Participants

- Two groups: young normal hearing (YNH, n=18, avg=21 years) and older normal hearing (ONH, n=28, avg=64 years)
- Scores on the Montreal Cognitive Assessment (MoCA) ≥ 26

Click Auditory Brainstem Response (ABR) Recording

- Stimuli were 100-µs clicks presented monaurally via insert earphones at 80 dB SPL in quiet and white noise conditions at signal-to-noise ratios of +10, +20 and +30 dB
- Minimum of 2000 sweeps were obtained for each condition at a rate of 21.1 Hz over two replicable recordings for each ear
- Responses were recorded using the Intelligent Hearing System SmartEP system

Distortion Product Otoacoustic EmissionTesting (DPOAE)

- DPOAE measured from 1000-14,000 Hz at 2.0 frequencies/octave from each ear
- Input/output functions obtained from the right ear over 16 steps from 1000-14,000 Hz
- Responses were recorded using the Intelligent Hearing System SmartDPOAE system

Identification Functions (Perceptual)

- 2-alternative forced-choice identification task for stimuli along WHEAT-WEED continuum of vowel duration: 93 ms (WHEAT) - 155 ms (WEED)[2]
- All stimuli were low-pass filtered at 4 kHz and presented to the right ear at 75 dB-A

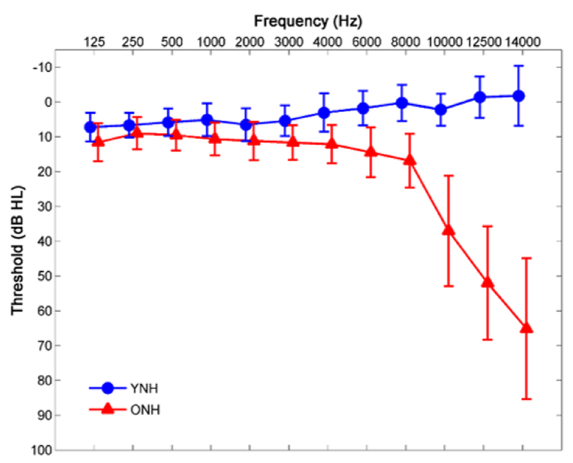
Data Analysis

- Click ABR
  - Offline bandpass filtered from 70-2000 Hz using zero-phase, 6th order Butterworth filter and averaged over 4000 sweeps
  - Automatic peak-picking algorithm in MATLAB was used to identify peak
  - Wave I amplitude and Wave V/I amplitude ratio were calculated using a derived horizontal montage and vertical montage, respectively
- DPOAEs
  - Thresholds were obtained from input-output functions for the F2 frequencies of 7450, 8850, 10500, and 12500 Hz. Threshold was defined as the lowest level at which a consistent SNR ≥ 6 dB was obtained.
- Perceptual
  - Slope and 50% crossover points were calculated from each identification function to indicate the boundary of stimulus categorization

Statistical Analysis

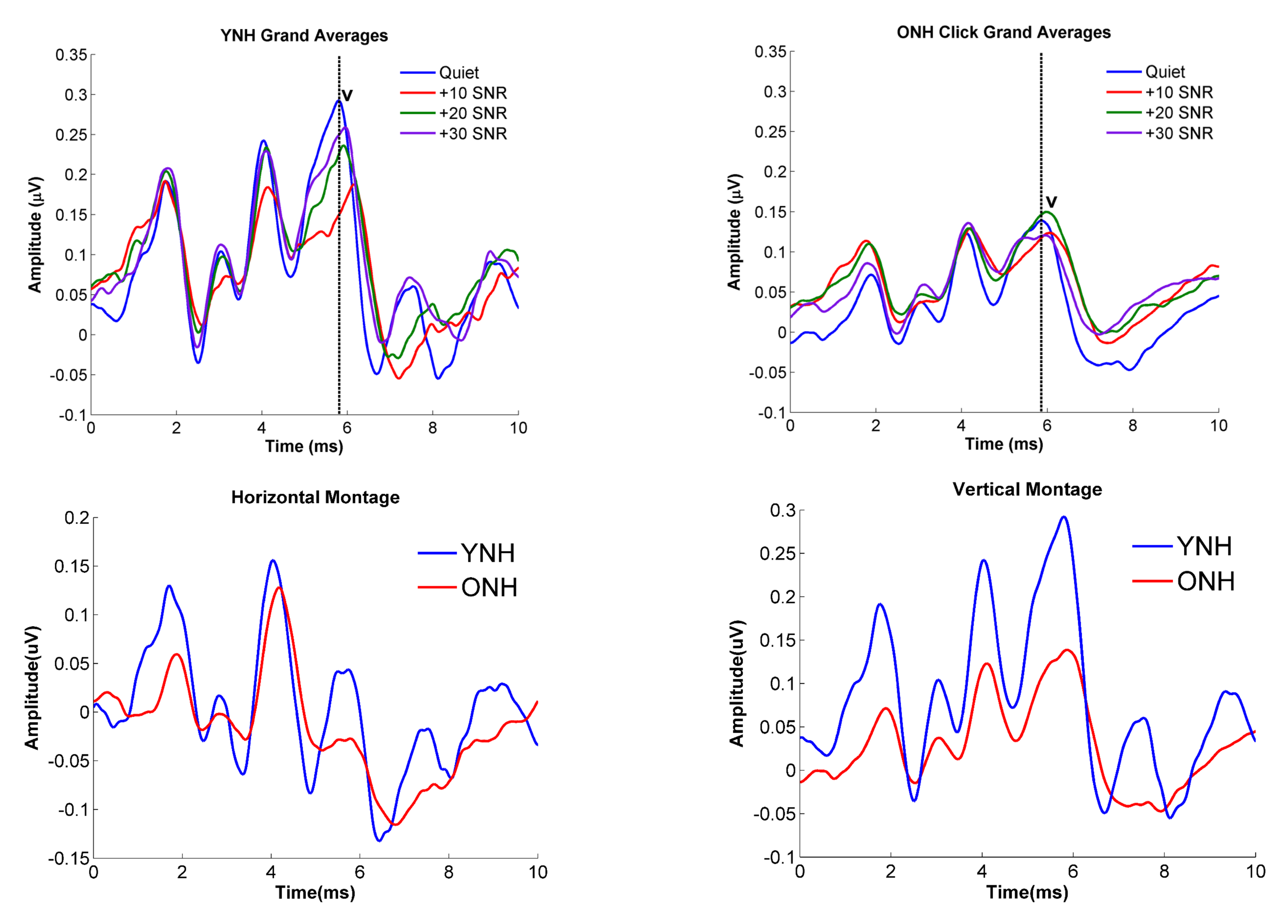
- Independent-samples t-tests were used to compare groups on the following variables: perceptual 50% crossover and slope, ABR Wave I amplitude and ABR Wave V/I ratio, high-frequency (HF) pure-tone average, and HF DPOAE threshold
- Pearson's correlation assessed strength of relationships among peripheral and perceptual variables.

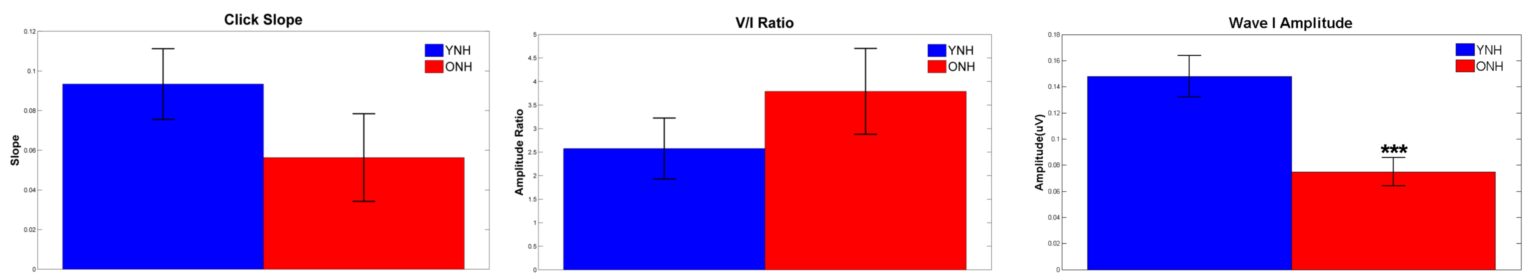
Results: Audiogram



- Even though requirements for thresholds were ≤ 20 dB HL through 4 kHz and ≤ 30 dB HL through 8 kHz (normal hearing), we still found significant group differences at all frequencies above 500 Hz
- Pure-tone averages for 0.5-4 kHz: YNH: 5 dB HL, ONH: 11 dB HL
- High-frequency pure-tone averages for 8-12.5 kHz: YNH: 0 dB HL, ONH: 35 dB HL

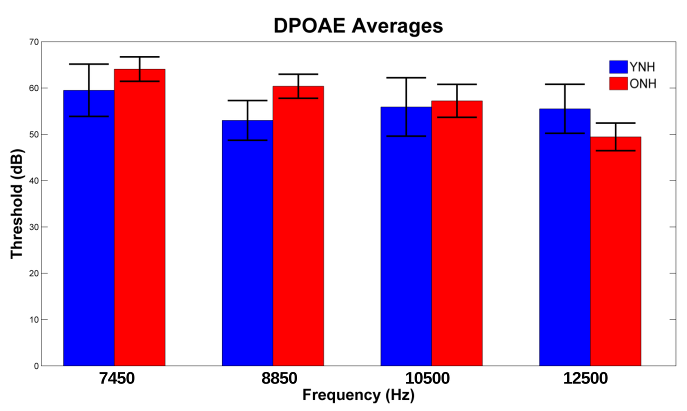
Results: Click ABR

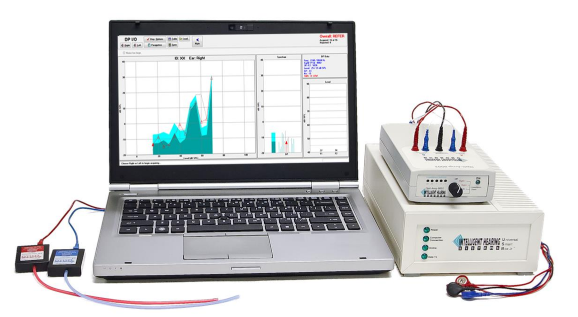




- No significant differences in Click Slope and Wave V/I Ratio were noted at any frequency (all p values > .05)
- Younger adults had significantly higher amplitudes in Wave I than older adults ($p < 0.001$)

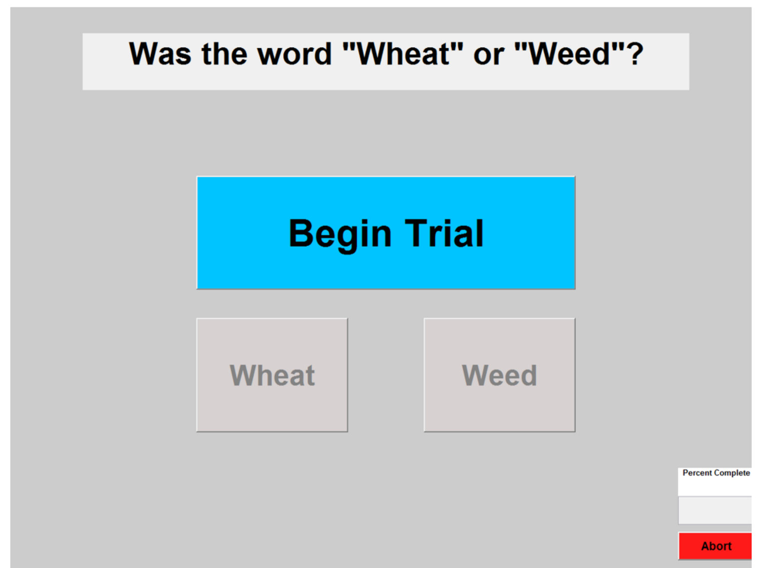
Results: DPOAEs

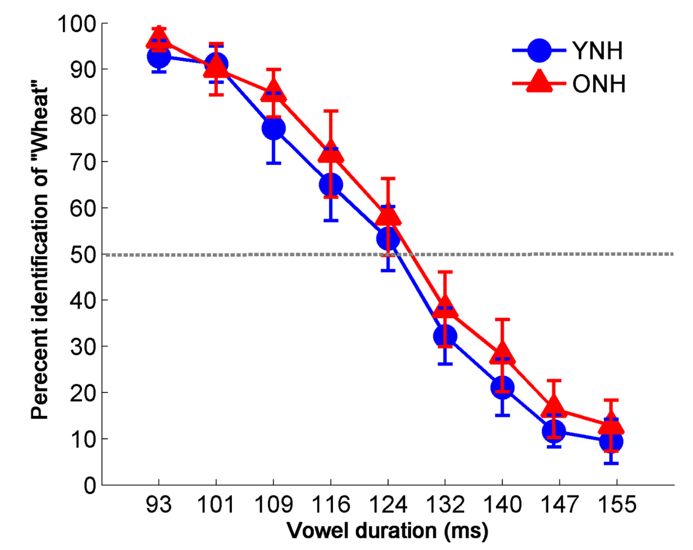




- No significant differences in DPOAE threshold were noted at any frequency (all p values > .05)

Results: Perceptual





- No group differences are observed in the slope or the 50% perceptual crossover (all p values > .05)
- None of the peripheral measures (HF PTA, ABR values and DPOAE thresholds) correlated with the crossover point or slope on the perceptual function

Discussion

- Audiogram
  - Significant group differences highlight the difficulty in equating pure-tone thresholds between younger and older adults. Even with strict recruitment criteria, decreased hearing sensitivity is present in older adults compared to younger adults.
- Click ABR
  - There were no significant group differences in click slope and wave V/I ratio, but younger adults had significantly higher Wave I amplitudes than older adults.
    - Reduced Wave I amplitudes suggest that neural synchrony in older adults may be reduced by cochlear synaptopathy and loss of auditory nerve fibers.
  - The effects of noise in younger adults were consistent with previous studies showing delayed latencies with decreasing SNRs[7,8]. However, the shallower latency slope in older adults may indicate reduced synchrony even in quiet.
- DPOAEs
  - Lack of group differences may reflect equipment calibration limitations and interference from standing waves[10]
- Perceptual
  - No significant group differences were observed for slope or 50% crossover point, but differences may have been observed if we had used sentence instead of word contexts[2,3]

- **Conclusion** – Peripheral measures do not appear to contribute to the variance in perceptual performance based on vowel duration; therefore we believe that higher level auditory or cognitive mechanisms may play a larger role in this perceptual task.

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