Training effects on perception and neural representation of temporal speech cues

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Introduction

- Treatment strategies for age-related hearing loss have historically focused on restoration of audibility.
- However, increased audibility may not compensate for age-related temporal auditory processing deficits.[1-3]
- Reduced auditory temporal processing leads to hearing difficulties in many real world listening situations, including rapid speech and speech in noise.
- Auditory training may allow older individuals to achieve improved temporal processing abilities, and therefore improved communication outcomes.[4]
- Previous auditory training studies have noted improvement in neural auditory function[5] and behavioral response of older individuals.[6]

Can an auditory training paradigm that incorporates discrimination of silent interval durations improve temporal processing in the older individual?

Method

Participants

- Two groups of participants: young normal hearing (YNH, n=14, avg= 22 years) and older normal hearing adults (ONH, n=14, avg= 70 years)
- Scores on the Montreal Cognitive Assessment (MoCA) ≥ 24

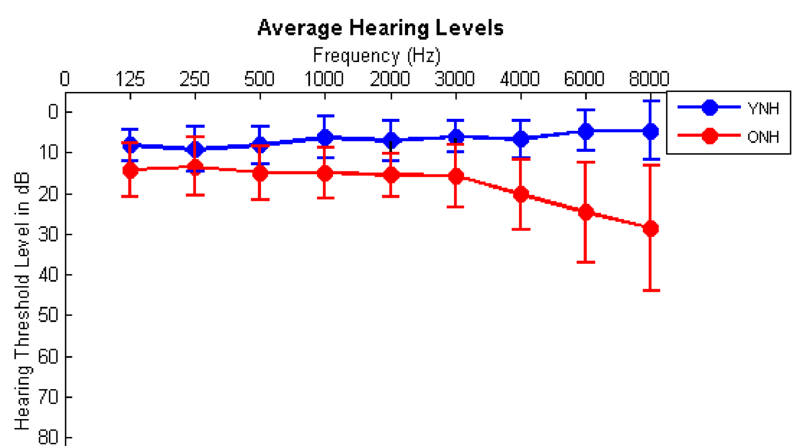


Figure 1: Average thresholds in YNH and ONH

Stimuli

- Contrasting word pair ("dish" and "ditch") presented in a multi-step continuum that varies silence duration preceding the fricative in 10 ms increments
- Steps vary from 0-ms silence duration ("dish") to 60-ms silence duration ("ditch")

FFR

- Rostral brainstem responses were recorded with the Biosemi ActiABR-200 acquisition system and digitized at 16,384 Hz
- Stimuli presented in alternating polarities to right ear at 75 dB SPL
- Minimum of 3000 sweeps obtained for each condition
- Responses offline bandpass filtered from 70-2000 Hz using zero-phase, 4th order Butterworth filter and averaged over 660 ms
- Stimulus-to-response correlation: cross-correlation was performed by shifting the stimulus waveform in time relative to the response, until a maximum correlation was found between the stimulus and the region of the response from 10-300 ms
- Morlet wavelets used to decompose signal from 80-800 Hz to analyze the phase-locking to the temporal envelope (PLF_{ENV}) and 300-1600 Hz to analyze the phase-locking to the temporal fine structure (PLF_{TFS})

Perceptual

- Discrimination task performed at pre- and post-test, along with 9 interval training sessions **(Fig. 5)**
- Identification task performed during pre- and post-test only **(Fig. 4)**

Statistical analyses

- Two-way ANOVAs (between-subject: group (young vs. old); within-subject: test session (pre vs. post)) run on four dependent variables: STR correlations, PLF_{ENV} values, PLF_{TFS} values, and 50% crossover points from identification function

FFR: Time domain

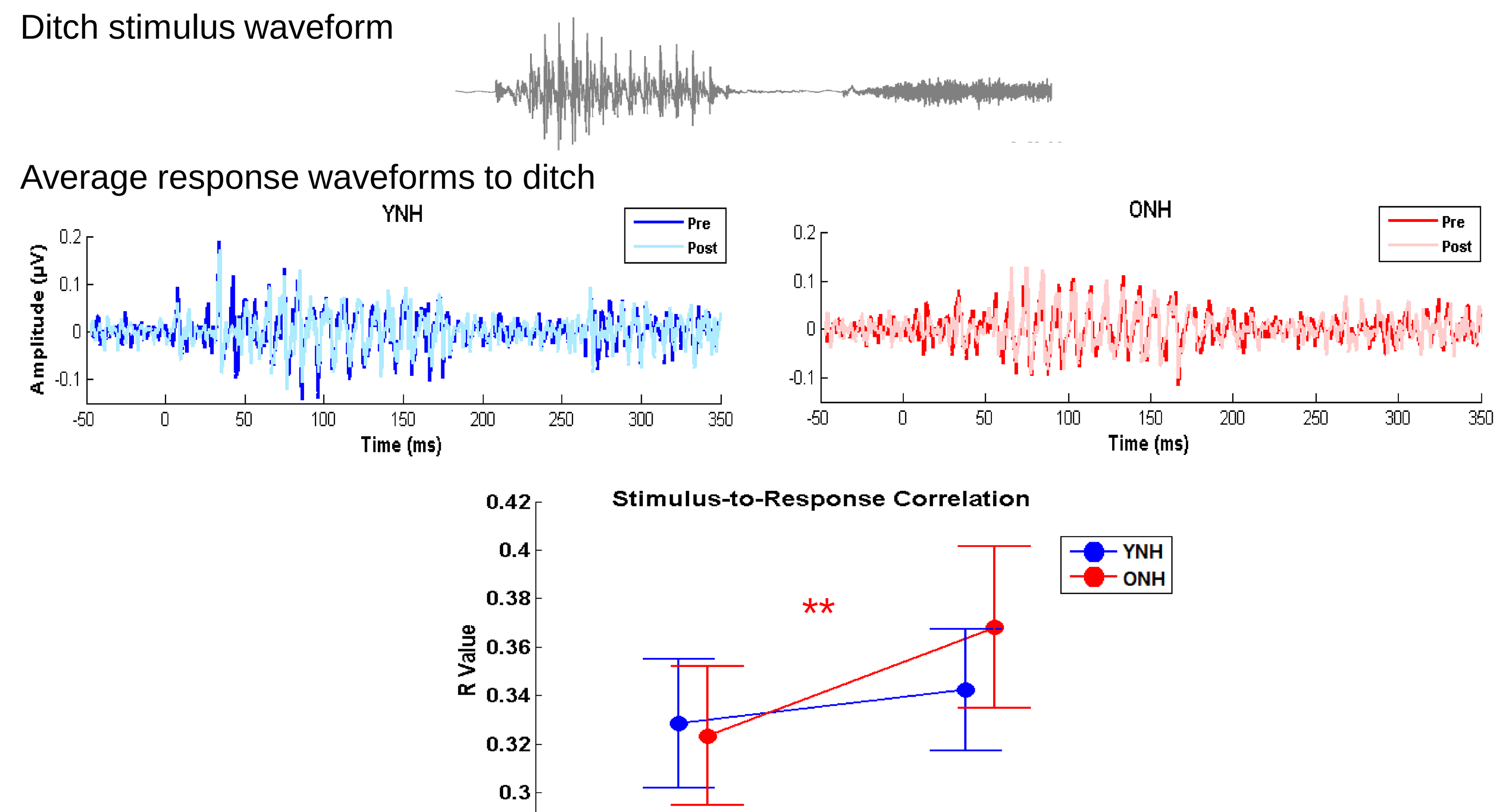
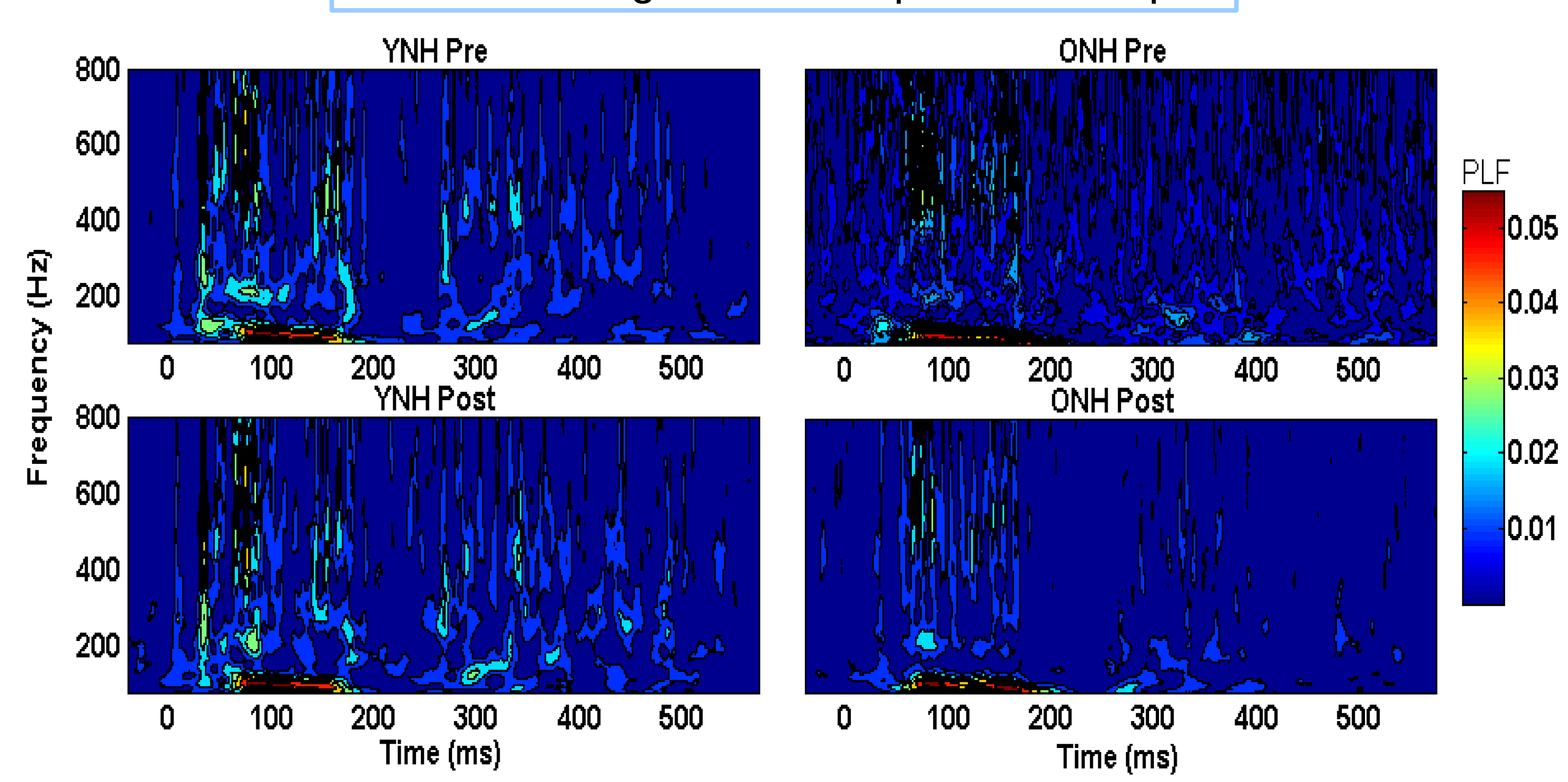


Figure 2

- Response waveforms in YNH and ONH groups mirrored stimulus waveforms
- Training significantly increased overall morphology in ONH ($p < 0.01$) but no training effects noted in the YNH waveforms. Error bars = ± S.E.

FFR: Phase-locking factor

Phase-locking factor: Temporal Envelope



Phase-locking factor: Temporal Fine Structure

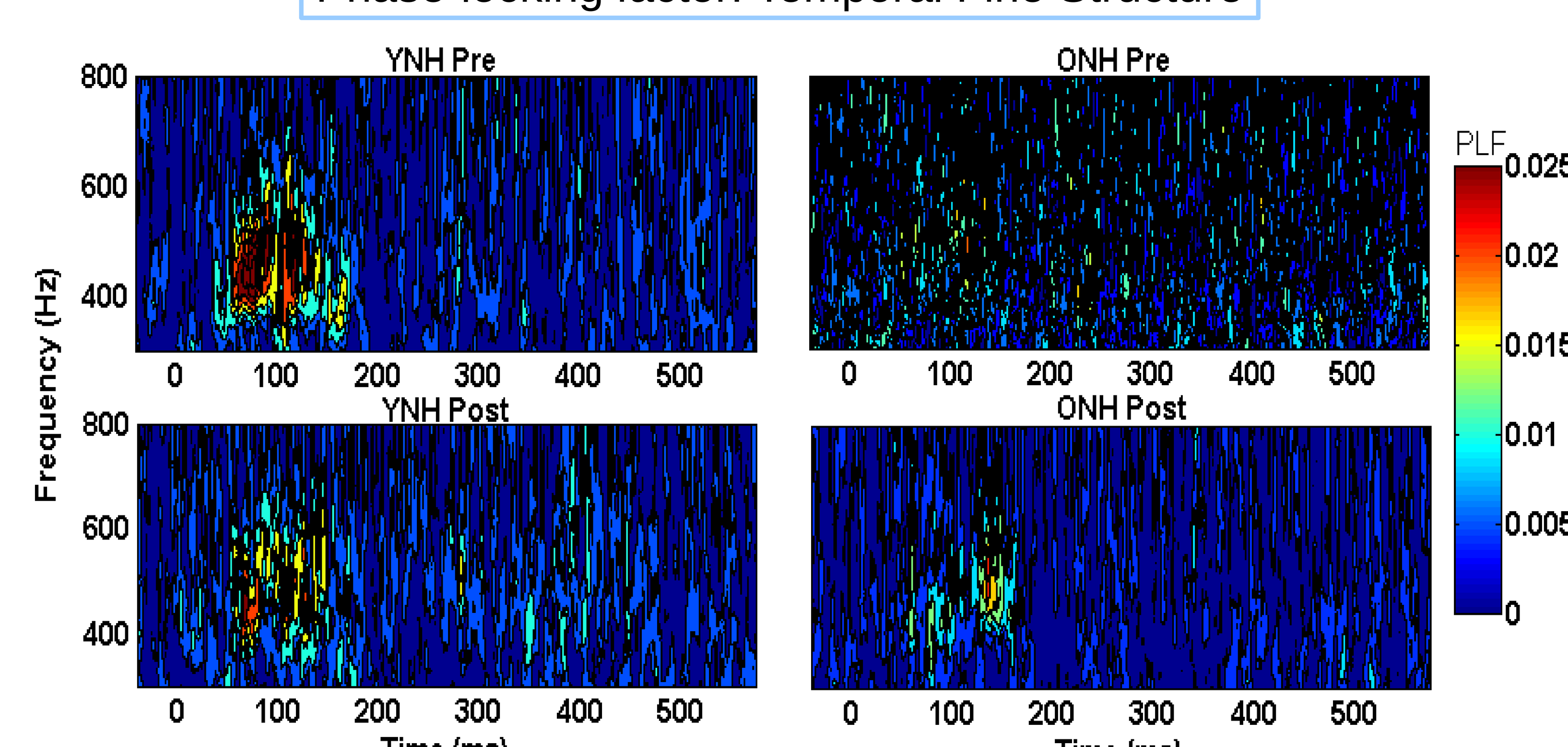


Figure 3

- No training related improvements were noted for phase locking in either group

Perceptual: Identification Functions

Figure 4
Identification task completed during pre- and post-test

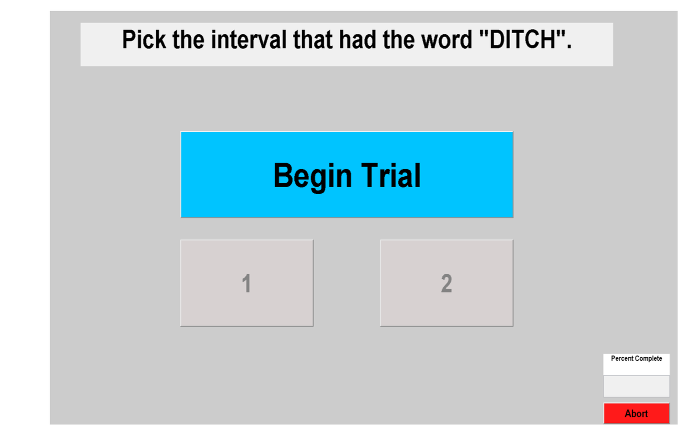


Figure 5
Discrimination task completed for training

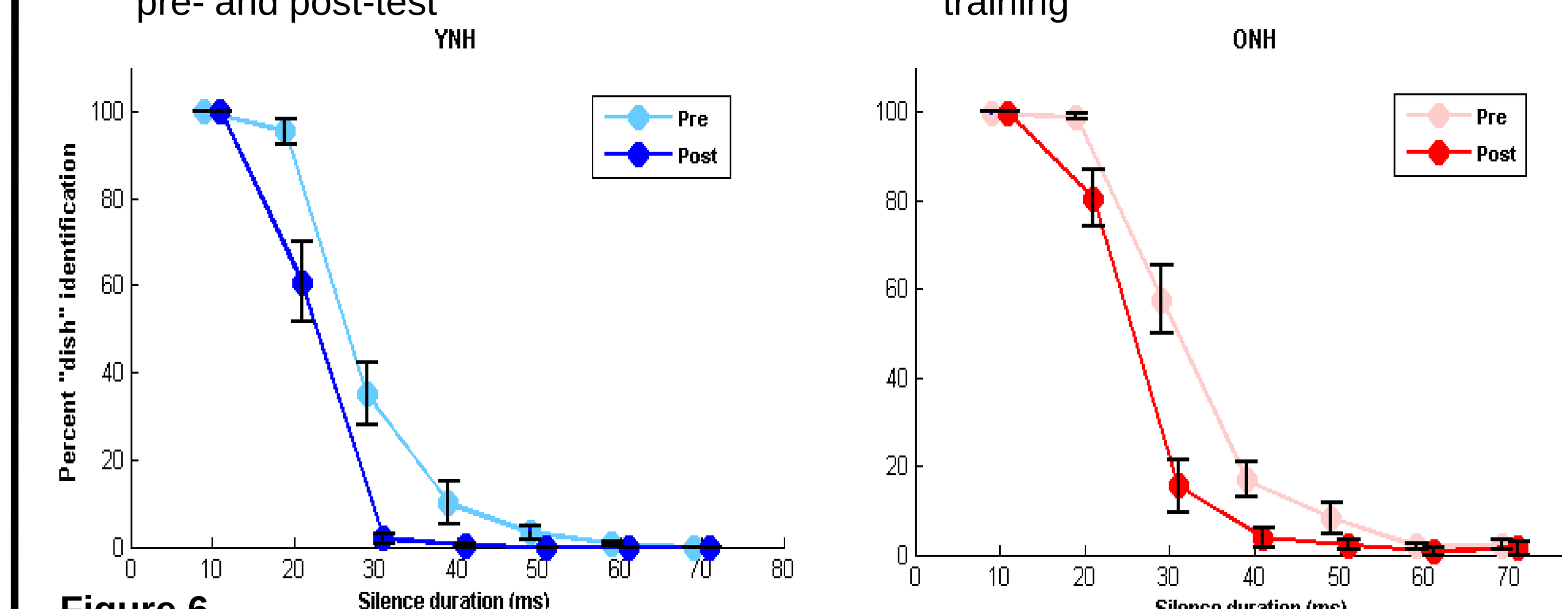


Figure 6

- Main effect of training on the 50% crossover point ($F (1, 26) = 85$, $p < .001$)
- No group × session interaction suggesting that training related changes did not differ between group. Error bars = 1 S.E.
- Changes in neural encoding did not predict changes in behavior ($p > 0.05$)

Discussion

- **Perceptual**: Nine sessions of perceptual training is sufficient to demonstrate behavioral improvement in both ONH and YNH groups **(Fig. 6)**.
- **Neural**: Nine sessions of perceptual training sufficient to demonstrate improvements in waveform morphology in ONH, but not YNH group **(Fig. 2)**.
  - Possible reason for lack of neural change in YNH: midbrain auditory function is already close to optimal (ceiling effect)
  - Possible reasons for lack of correlations between behavioral and neural changes in ONH:
    - Lack of statistical power
    - Changes in higher level auditory encoding were responsible for behavioral changes
    - Changes in cognitive function were responsible for behavioral changes
- **Conclusions**:
  - ONH performance after completion of training is similar to performance of YNH group before training.
  - Age-related temporal processing deficits may be at least partially restored through targeted training strategies.
- **Future steps**: Random assignment of YNH, ONH, and OHI (older hearing impaired) participants to perceptual training or active control training, generalization to other temporal contrasts, and evaluation of retention.

References

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