Effects of Ageing on Spectral-Shaping on Brainstem Differentiation of Consonants

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Introduction & Rationale

Older listeners even with normal hearing (NH) often present with poorer temporal resolution, due to both central and peripheral impairments, thus altering speech spectral cues that distinguish consonants might not be fully captured by the aging auditory system. Specifically, ageing might disturb the encoding of the second formant (F2) transition, an imperative speech cue for identifying place of articulation in stop consonants.

Because discriminating consonants is vital for speech understanding, it is important to understand how the aging brain discriminates among consonant sounds, while including the effects of hearing sensitivity. Factors such as ageing and other than hearing status must be explored to explain performance differences between listeners with NH and those with hearing loss.

Further, it is imperative to understand how the brain processes frequency-related cues that aim to enhance important spectral cues such as the F2 transition. Providing spectrally-shaped gain, by improving audibility of the F2 formant in relation to the rest of the signal, may overcome performance difficulties in NH elders, as opposed to flat frequency-independent amplification. Providing the elders with the latter kind of amplification may increase susceptibility to deterioration effects of upward spread of masking, hence making feature identification even more difficult.

The Purpose of the Study: For the reasons above, this investigation aimed to study the effects of ageing on the brainstem differentiation of contrastive stop consonant; (2) determine whether spectrally-shaped (i.e. frequency-specific) gain can recover potential age-related brainstem alterations, if detected.

Subjects

Eleven older adults (mean = 58.08 years; range = 51 – 72 years; 4 males) with “near-normal” to NH and 16 younger controls (mean = 24.63 years; range = 18 – 33 years; 6 males) with NH participated in this study. For both groups, younger and older adults, average audiometric thresholds for the tested (i.e. right) ear are illustrated in the following figure.

Stimuli

For Behavioral Testing: (Harkrider, et al. 2003) A series of 96 tokens were generated by varying a total of 16 steps (Klatt 1988). The starting frequency of the F2 formant ranged from 900 to 2300 Hz at 100 Hz steps creating the fifteen tokens.

Spectral Shaping (Harkrider et al. 2003)

- Peak latencies and peak amplitudes were identified for 15 speech-ABR peaks
- The major peaks: 2, 3, 4, 5, 7, 8, 10, the minor peaks: 6 (3), 9, and the complex peaks: 4 and 6. Latencies were identified for the first 50 ms of the waveform (i.e. F2 transition duration is 40 ms).

Shaping on Brainstem Differentiation of Consonants

- Consensus Differentiation Score: A- metric analysis (Hornickel et al. 2009) was conducted to generate differentiation scores for major and minor peaks. It was expected that the stimuli with the highest F2 will elicit the earliest responses due to brainstem instincitivity. Hence, the following latency parameters were used: 
  
<table>
<thead>
<tr>
<th>Peak</th>
<th>Matrix</th>
<th>Gain (dB)</th>
</tr>
</thead>
<tbody>
<tr>
<td>F2 (major)</td>
<td>100</td>
<td>Gain (dB)</td>
</tr>
<tr>
<td>F2 (minor)</td>
<td>50</td>
<td>Gain (dB)</td>
</tr>
<tr>
<td>F2 (complex)</td>
<td>50</td>
<td>Gain (dB)</td>
</tr>
</tbody>
</table>

For Electrophysiological Testing:

- 6 examples (2 shaping conditions X 3 phonemes)
- The examples had 900, 1700 and 2300 Hz for their F2 onset frequencies.
- 80 dB SPL (e.g. Hornickel et al. 2009)

Results

Behavioral Testing and Analysis

- 20 blocks (36 tokens each) a total of 600 responses
- Presented randomly
- Mean correct identification of 10/16 tokens in the SmartEP
- Increase the F2 frequency in older adults

Electrophysiological Testing and Analysis

- Speech-ABRs were recorded using Intelligent Hearing Systems NeuroImaging 128 System and Starkey Auditory Research Module
- Stimuli were presented monaurally to the right ear via an insert earphone.
- Vertical Electrode montage: Cz
- Rate: 4500, 4000 sweeps, alternating polarity.
- A total of 6 speech-ABR waveforms [3 phonemes X 2 shaping conditions].

Conclusion

The brainstem changes detected in our older listeners do not seem to influence their behavioral identification of stop consonants. How might these changes impact on the auditory processing of speech perception tasks utilized in this study cannot be teased out using current data.

Further cortical assessments will be needed to evaluate possible decline-compensation patterns.

Discussion

- Normal-hearing older listeners showed robust categorical perception, or better defined categories than younger controls.
- Noticeable brainstem differences were obtained between the two groups (older vs. younger adults): (1) Older listeners showed larger amplitudes for the minor wave “d” than younger adults.
- The amplitude of the negative major peak (5) increased from 80 dB SPL to 100 dB SPL in younger, but not in older adults.

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