Age-related hearing loss: Speech perception problems and speech technology needs

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Hearing Research Lab at UMD

- General focus of lab
- Currently funded research projects:
  - Auditory temporal processes, speech perception, and aging (NIA, NIH; co-investigators are P. Fitzgibbons and G. Yeni-Komshian)
  - Functional hearing evaluation for military occupational specialties (collaboration with D. Brungart at Walter Reed; funded by Creare, Inc.)
  - Multi-site study of the efficacy of speech perception training in hearing aid users (NIDCD, subcontract with Communication Disorders Technology – C. Watson, J. Miller, J. Dubno, M. Leek)
  - Speech processing algorithms for older listeners with hearing loss (collaboration with C. Espy-Wilson; funded by ADVANCE grant via NSF)
Senescent changes in auditory system and cognition

- Decline in peripheral auditory nervous system
  - Reduced ability to detect high frequency information
  - Reduced ability to code rapid signal onsets

- Decline in central auditory nervous system
  - Reduced neural synchrony leading to distorted perception
  - Slowed neural processing
  - Reduced inhibitory mechanisms

- Decline in cognitive function
  - Working memory capacity
  - Selective attention
  - Speed of information processing

Prevalence of age-related hearing loss: approx. 50%
Number affected: 24 million people > 65 yrs with hearing loss today
Impact on speech understanding: noise and rapid speech

- Difficulty recognizing speech in noise
  - Mostly predicted by AI theory (fixed SNR, steady-state noise, single target talker)
  - In adaptive conditions with MT babble, older people have more difficulty in noise than younger people
  - Partly associated with ↓ in cognitive ability

- Difficulty understanding rapid speech
  - Time compression
  - Naturally fast speech

Low probability sentences

Gordon-Salant & Fitzgibbons, 1993
Cole & Gordon-Salant, 2014

Cole & Gordon-Salant, 2014
Gordon-Salant & Fitzgibbons, 1993
Impact on speech understanding: accented English

- Difficulty understanding accented speech in quiet
- Difficulty using cues for speech segregation in noise, with accented talkers

**Sentences**

<table>
<thead>
<tr>
<th>Accent Condition</th>
<th>Percent Correct Recognition</th>
</tr>
</thead>
<tbody>
<tr>
<td>none</td>
<td>100</td>
</tr>
<tr>
<td>mild</td>
<td>90</td>
</tr>
<tr>
<td>moderate</td>
<td>80</td>
</tr>
</tbody>
</table>

**Background Noise Condition**

- Unaccented Talker
- Moderately Accented Talker

**Signal-to-Noise Ratio (dB)**

- NF = native female
- NM = native male
- NFM = native female + male
- NNM = non-native male
- N+NNM = native + non-native male
- SMN = speech-modulated noise

Significant main effects: accent ($p<.01$) and group ($p<.01$)

Gordon-Salant, et al., 2010

Gordon-Salant et al., 2013
Current speech technology:

**Implications**

- **Hearing aid use**: ≈ 25% among older HI people
  - Hearing aids don’t alter the signal in the time domain; continuing difficulty in noisy environments

- **Cochlear implants**: used by increasing proportion of older people
  - High rates of electrode stimulation – probably not beneficial as people age

- **Telephone communications**:
  - Difficulty on telephone – listening to fast speech, accented speech, computer-generated speech

- **Television viewing**:
  - Older people with hearing loss understand 40% of the spoken message (in quiet, even with hearing aids)

**Challenges**

- **Lack of data** on speech understanding performance among older adults:
  - While using the telephone & tv
  - While using assistive hearing technology (including CI’s)
  - Who are native speakers of languages other than English

- **Low use of technology** by older people (Pew Research Center, 2012)

<table>
<thead>
<tr>
<th>Device</th>
<th>GI Generation (age 76+)</th>
<th>All adults (age 18+)</th>
</tr>
</thead>
<tbody>
<tr>
<td>% of adults who own this device</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cell phone</td>
<td>56%</td>
<td>88%</td>
</tr>
<tr>
<td>Desktop</td>
<td>31%</td>
<td>58%</td>
</tr>
<tr>
<td>Laptop</td>
<td>20%</td>
<td>61%</td>
</tr>
<tr>
<td>E-reader</td>
<td>5%</td>
<td>18%</td>
</tr>
<tr>
<td>Tablet</td>
<td>3%</td>
<td>18%</td>
</tr>
</tbody>
</table>
Targeted areas of research for funding

- Development of technology to slow down speech in a wearable device and in telephones that preserves intelligibility and accommodates talker variability;

- Conversion of accented English to more native-like English, in a wearable device or speech-to-text;

- Modifications in cochlear implant technology and hearing aids to accommodate slowed processing and difficulty in noise, and that actually show benefit by older people;

- Efficacious training strategies to facilitate learning/plasticity in older people for adapting to new technologies;

- Acceptability of new devices (including hearing aids and telephone technology) for older people;

- Does advanced speech technology improve quality of life?
Thank you!