Speech perception in individuals with dementia of the Alzheimer’s type (DAT)

Mitchell S. Sommers
Department of Psychology
Washington University
Overview

• Goals of studying speech perception in individuals with DAT
• Theoretical importance
• Characterizing dementia severity
• Sensory abilities and DAT
  – Thresholds
  – SRTs (with and without spectral shaping)
• Cognitive abilities needed for speech perception
  – Lexical discrimination (with and without spectral shaping)
  – Talker normalization (with and without spectral shaping)
• Summary and conclusions
• Clinical implications
Speech Perception and Alzheimer’s disease

• Goals
  – Characterize hearing and speech perception abilities of age-matched individuals who differ in cognitive status
  – Identify possible behavioral indicators distinguishing earliest stages of the disease
    • Importance of early intervention

• Theoretical importance
  – Allows study of how cognitive declines affect speech perception in groups matched for age
  – Use of spectral shaping allows assessment of relationship between sensory and cognitive abilities
    • If spectral shaping improves cognitive abilities needed for speech perception
      – Suggests that processing degraded signal not only impairs perception, but has downstream consequences
    – Example of study by McCoy et al. (2005).
Dementia severity of dementia

- Participants recruited from Washington University ADRC
  - Annual cognitive evaluation
    - Determine dementia status
    - Battery of neuropsychology tests
- Classification of dementia severity
  - Clinical Dementia Rating (CDR)
    - 90-minute interview by board-certified neurologist assessing
      - Memory, orientation, judgment, community affairs, home and hobby, personal care
    - Separate interview with collateral source (family member) assessing changes in these areas
- CDR ratings
  - CDR 0 – Healthy older adults
  - CDR 0.5 – Very mild DAT (similar to current MCI diagnosis)
  - CDR 1 – Mild DAT
  - CDR 2, 3 – Moderate and severe dementia (not tested)
### Participant characteristics

<table>
<thead>
<tr>
<th>Measure</th>
<th>CDR 0 (n=53)</th>
<th>CDR 0.5 (n =47)</th>
<th>CDR 1 (n = 45)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Demographic measures</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age</td>
<td>78.2</td>
<td>75.9</td>
<td>74.3</td>
</tr>
<tr>
<td>Education</td>
<td>13.9</td>
<td>13.3</td>
<td>14.1</td>
</tr>
<tr>
<td><strong>Memory measures</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Digit span forward</td>
<td>6.4</td>
<td>6.4</td>
<td>5.8</td>
</tr>
<tr>
<td>Digit span backward</td>
<td>4.8</td>
<td>4.4*</td>
<td>3.5**</td>
</tr>
<tr>
<td>Paired associates</td>
<td>14.4</td>
<td>9.4*</td>
<td>7.1**</td>
</tr>
<tr>
<td><strong>Processing speed</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Digit-symbol</td>
<td>40.1</td>
<td>36.8*</td>
<td>23.8**</td>
</tr>
<tr>
<td><strong>Language measures</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WAIS vocabulary</td>
<td>53.4</td>
<td>43.7*</td>
<td>35.5**</td>
</tr>
<tr>
<td>Boston naming</td>
<td>53.9</td>
<td>44.6Z*</td>
<td>35.0**</td>
</tr>
</tbody>
</table>

*Significant difference between CDR 0 and CDR 0.5  
**Significant difference between CDR 0.5 and CDR 1
Effects of DAT on pure-tone thresholds
DAT and speech reception thresholds

- **SRTs**
  - Signal-to-noise ratio 50% correct word identification
  - Current study uses 100 words excised from low-predictability SPIN sentences

- **Procedure**
  - First word presented in multi-talker babble at SNR below threshold
  - Increment level in 4-dB steps until word identified correctly
  - Subsequent words presented using simple up-down tracking with 2-dB steps
  - Average SNR values at reversals (used as SRT)

- **Conditions**
  - No spectral shaping
  - Spectral shaping
    - Signal amplified using 1/3 octave band amplification
    - Signal amplified individually so that signal level 15-18 dB above threshold for frequencies up to 4000 Hz
SRTs in healthy older adults and individuals with DAT

![Graph showing SRTs in different CDR statuses with and without spectral shaping]
Lexical Discrimination

- Ability to distinguish similar sounding items (bat, pat)
- Neighborhood activation model (Luce and Pisoni, 1998)
  - Word identification determined by number of similar neighbors
  - Neighbors defined as words differing from a target item by addition, deletion, or substitution of a single phoneme
    - Neighbors of CAT include: KIT, PAT, AT, SCAT
- Correct identification of target item requires
  - Activation of target item AND inhibition of neighbors
- Words differ in size or density of their neighborhoods
  - Hard words (CAT): many similar sounding words (resides in a dense neighborhood), considerable demands on inhibition
  - Easy words (SONG): few similar sounding words (resides in a sparse neighborhood)
Lexical Discrimination in healthy older adults and DAT

- **Age, inhibition, and lexical discrimination**
  - Older adults have deficit in ability to inhibit irrelevant information
  - Sommers (1996) compares young and old identification of easy and hard words
    - Find much bigger age difference for lexically hard words than for easy words
    - Sommers and Danielson (1999) age differences in lexical discrimination due to differences in inhibition

- **DAT and lexical discrimination**
  - Good evidence that DAT produces additional deficits in inhibition
  - Do individual with DAT have greater difficulty than healthy older adults perceiving lexically hard words?
  - Does spectral shaping improve identification of lexically hard words in either healthy old or DAT
Procedure

• Same participants as in SRT study
  – Identify 76 “easy” words (mean neighborhood density = 10.8)
  – Identify 76 “hard” words (mean neighborhood density = 26.4)
  – Average frequency of easy and hard words do not differ
  – All testing done with 6-talker babble and SNR of +2
  – Half of easy and hard words presented with no spectral shaping
  – Half identified following spectral shaping (same as in Experiment 1)
Lexical Discrimination in DAT

Percent correct

NS = not shaped
SS = specially shaped

Easy NS  Easy SS  Hard NS  Hard SS

Shaped - unshaped

Easy  Hard

CDR 0  CDR 0.5  CDR 1
Talker normalization in DAT

• Talker normalization
  – Process of adjusting to different talkers
  – Same word spoken by male, female, child have dramatic acoustic differences
  – Even same word by same person differs acoustically
  – Need to adjust or normalize incoming signal to match representations stored in memory

• Testing for talker normalization
  – Compare conditions with single talker and multi-talkers
  – Single talker – all words spoken by same talker
  – Multiple talker – words spoken by 10 different talkers
    • Talker presented on any given trial varies randomly

• Differences between single and multiple talker conditions
  – Index of normalization costs
Talker normalization and DAT

• Same participants as in earlier studies
• 75 words presented in single talker condition
  – Specific talker used rotated
• 75 words presented in multiple talker condition
  – 5 males and 5 females
  – Talker presented on any given trial selected randomly
• Words presented in 6 talker babble at +2 SNR
Talker normalization and DAT

Percent correct

NS = not shaped
SS = specially shaped

Shaped - unshaped

Single NS | Single SS | Multiple NS | Multiple SS
CDR 0 | CDR 0.5 | CDR 1

Single | Multiple
Summary and conclusion

• DAT, sensory abilities and speech perception
  – No affect of DAT on hearing thresholds
  – DAT have greater difficulty than age and hearing matched older adults understanding speech in noise
    • SRTs increase progressively from CDR 0, CDR 0.5, and CDR 1
    • Also progressive benefit from spectral shaping
      – Greater benefit for CDR 0 than for DAT

• DAT, cognitive abilities and speech perception
  – Lexical discrimination
    • Similar performance and benefits from shaping for easy words
    • CDR 0 and 0.5 show similar declines from easy to hard
    • CDR 1 show even greater declines from easy to hard
    • Systematic decline in benefits of spectral shaping
      – CDR 0 show greatest benefits; CDR 1 least
Summary and conclusion

• DAT, cognitive abilities and speech perception
  – Talker normalization
    • Similar performance and benefits from shaping for single talkers
    • Systematic decline from single to multiple talkers
    • CDR 0 exhibit large benefits from spectral shaping
    • Relatively small benefits of shaping for DAT patients
Clinical implications

• DAT patients do benefit from spectral shaping to improve audibility
  – Hearing aids likely to have benefits both for patients and caregivers

• Spectral shaping has some benefit for DAT patients but less than for age-matched healthy controls
  – Other possible strategies
    • Avoid noisy situations for communicating important information
      – SRT results suggest increased susceptibility to noise in DAT
    • Spoken communication by single person likely to be most effective
      – Multiple talker situations (e.g., family gatherings) likely to be very problematic for DAT individuals

• Early identification of DAT patients
  – Changes in SRTs and talker normalization may provide additional cues to changes in cognitive status
  – Currently incorporated into annual assessment at ADRC
Support and acknowledgments

• Collaborators
  – Washington University ADRC
  – John Morris, MD
  – Stephanie Danielson

• Support
  – Brookdale Foundation
  – NIA