Audition and Cognition in Adults with Hearing Loss

Sarah Campbell, MS, CCC-SLP
scamp3@uky.edu

Anne Olson, PhD, CCC-A
aolso2@uky.edu
Disclosures

• The authors have no financial or non-financial relationships relevant to the content of the presentation to disclose.
Background

• Widespread evidence linking cognitive ability and hearing (Gatehouse, Naylor et al. 2003; Humes 2007; Lunner and Sundewall-Thoren 2007; Rudner, Foo et al. 2007)

• Working memory and understanding speech

• Working memory
  ◦ Temporary storage mechanism that we actively manipulate while solving complex tasks
  ◦ Multi-component system
    • Phonological loop
    • Visuospatial sketch pad
    • Central executive function
Working Memory

- Preserved working memory important in understanding speech and language
  - Daneman and Carpenter (1980)
    - Correlation between verbal working memory (reading span test) and language and reading comprehension
  - Caplan and Waters (1999)
    - Suggest a specialization of the verbal working memory system
      - Fraction assigned to sentence syntactic interpretation
      - Fraction assigned to sentence meaning
Importance in Hearing Loss

- National Health and Nutritional Examination Survey (Lin, 2011)
  - N= 605 adults with HL (age 60-69)
  - > hearing loss associated w/ poorer non-verbal cognitive ability (DSST)
    - Hypothesized increased cognitive load while listening
  - HA use positively associated w/ higher cognitive function
Factors affecting working memory

- Other aspects of cognition
- Speech and language processing
- Age related declines
- Presentation mode
- Audibility
  - Hearing loss
  - Amplification
  - Perception of effort
Study Purpose

To investigate the effect of hearing loss in adults on working memory performance

- Considering ability to understand speech in noise
- Considering perceived listening effort
Hypotheses

Persons with greater hearing loss will demonstrate poorer working memory ability than persons with less severe hearing loss.

Persons with higher listening effort scores will demonstrate poorer working memory ability.
Participants

- **Inclusion Criteria**
  - Ages 50-80
  - Bilateral mild-severe sensorineural hearing loss
  - Bilateral hearing aid users for at least 1 month
  - Adequate vision and motor skills to complete computer task

- **Exclusion Criteria**
  - Conductive hearing loss
  - Asymmetric sensorineural hearing loss
  - H/o neurological or psychological disorder
## Participants

- **N=29**

<table>
<thead>
<tr>
<th>Gender</th>
<th>11 female; 18 male</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean age (SD)</td>
<td>66.93 (7.34)</td>
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<tr>
<td>Mean years of education (SD)</td>
<td>17.89 (3.32)</td>
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<tr>
<td>Mean duration of hearing aid use (range)</td>
<td>6.58 years (range 1 month-52 years)</td>
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<tr>
<td>Mean pure tone threshold (SD)</td>
<td>43.28 dB (14.06)</td>
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</tbody>
</table>
Measures

- **Quick Speech in Noise (Quick SIN)**
  - Sentence task

- **Speech, Spatial, and Qualities (SSQ)**
  - Questionnaire (Listening Effort)

- **Reading Span Test (RSPAN)**
  - Visual, dual task, automated assessment that reflects working memory (WM)

- **Administration**
  - Counterbalanced order
  - Aided condition
Quick SIN (Killion et al, 2004)

- Sentence recognition task in noise
- Scoring in # of decibels that speech is above background noise for listeners to obtain 50% of words in sentences
- 6 sentence lists were averaged for overall dB SNR

Smaller signal to noise ratio (SNR) is better
Speech, Spatial and Qualities (SSQ) (Gatehouse and Noble, 2004)

- Self-assessment designed to reflect dynamic real world listening conditions encountered by most listeners
- Visual Analog scale 1-10
  - 3 questions re: Listening Effort
    - Do you have to concentrate very much when listening to someone?
    - Do you have to put in a lot of effort to hear what is being said in conversation with others?
    - Can you easily ignore other sounds when trying to listen to something?
The girl carried an umbrella during the rain shower.
Is this sentence correct?
The door likes to play the saxophone.
Is this sentence correct?

TRUE  FALSE
The socks were happy to sing to the yellow.
Is this sentence correct?

TRUE  FALSE
Select the letters in the order presented. Use the blank button to fill in forgotten letters.
You recalled 3 letters correctly out of 3.

You made 0 sentence error(s) for this set.
# RSPAN Scores

<table>
<thead>
<tr>
<th>RSPAN sub-score</th>
<th>Description</th>
<th>Min Score</th>
<th>Max Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Absolute Score</td>
<td><strong>Perfectly recalled sets</strong>: letters were correctly recalled, and recalled in correct order.</td>
<td>0</td>
<td>75</td>
</tr>
<tr>
<td>Total Score</td>
<td><strong>Number of sets where letters were correctly recalled</strong> (regardless of order)</td>
<td>0</td>
<td>75</td>
</tr>
<tr>
<td>Speed Errors</td>
<td>Number of <strong>sentence presentations that participant was unable to answer</strong> as a result of time limits</td>
<td>0</td>
<td>75</td>
</tr>
<tr>
<td>Accuracy Errors</td>
<td>Number of <strong>sentences that participant incorrectly judged to be true or false</strong></td>
<td>0</td>
<td>75</td>
</tr>
<tr>
<td>Total Errors</td>
<td>Sum of the Speed and Accuracy Errors</td>
<td>0</td>
<td>150</td>
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</table>
Data Analysis

- Group comparisons based on severity of hearing loss (average of both ears)
  - Mild group = PTA < 40 dB HL
  - Moderate-severe group = PTA > 40 dB HL
- Independent t-tests for group differences
- Correlations among demographic variables
## Results

<table>
<thead>
<tr>
<th>Measures</th>
<th>Mild (n=13)</th>
<th>Moderate to Severe (n=17)</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>66.0 (7.1)</td>
<td>67.1 (7.4)</td>
<td>.66</td>
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<tr>
<td>Degree of hearing loss (dB HL)</td>
<td>30.5 (8.8)</td>
<td>52.6 (7.9)</td>
<td>.000*</td>
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<tr>
<td>Years of Education (years)</td>
<td>19.2 (2.8)</td>
<td>17.1 (3.6)</td>
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<td>Duration of HL (years)</td>
<td>10.8 (9.1)</td>
<td>20.9 (14.1)</td>
<td>.055</td>
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<tr>
<td>Duration of HA use (years)</td>
<td>3.0 (4.4)</td>
<td>9.2 (14.2)</td>
<td>.14</td>
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<td>QSIN (dB SNR - aided)</td>
<td>5.1 (2.7)</td>
<td>7.0 (3.5)</td>
<td>.073</td>
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<tr>
<td>SSQ (Listening effort - aided)</td>
<td>4.02 (2.09)</td>
<td>4.06 (2.0)</td>
<td>.968</td>
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</table>
# Results

<table>
<thead>
<tr>
<th>Group</th>
<th>Mild ( n=13 )</th>
<th>Moderate to Severe ( n=16 )</th>
<th>( p ) value</th>
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<tbody>
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<td>RSPAN Sub-scores</td>
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<td>RSPAN Absolute Score</td>
<td>21.2 (14.8)</td>
<td>23.8 (15.3)</td>
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<td>RSPAN Total Score</td>
<td>39.5 (20.5)</td>
<td>44.3 (16.0)</td>
<td>.494</td>
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</tbody>
</table>
Results – R-SPAN

RSPAN Letter Recall by Group

Number of correct letters recalled

Mild
Moderate -Severe

Absolute Score
Total Score
## Results

<table>
<thead>
<tr>
<th>RSPAN Sub-scores</th>
<th>Mild (n=13)</th>
<th>Moderate to Severe (n=16)</th>
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<td>4.3 (5.07)</td>
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<td>10.3 (24.3)</td>
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<td>RSPAN Total Errors</td>
<td>7.6 (7.8)</td>
<td>3.1 (2.0)</td>
<td>.035*</td>
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Results: R-SPAN

RSPAN Errors by Group

- Speed Errors
- Accuracy Errors
- Total Errors

Number of Errors

Mild
Moderate - Severe
### Correlations

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<tr>
<th></th>
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<th>YrEduc</th>
<th>durationHL</th>
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<th>PerfectRC</th>
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* Correlation is significant at the 0.05 level (2-tailed)
Discussion

- Previous research has shown that WM affected by:
  - Age
  - Hearing loss

- Participants with greater hearing loss exhibited a trend for better performance on RSPAN:
  - Significantly fewer errors w/ > hearing loss

- May relate to cross modal learning effects with sensory deprivation

- Use of amplification, years of education may preserve working memory
Limitations

- RSPAN norms only on healthy young adults
- Participants highly educated
- Small sample size
- No control for visual acuity
Future directions

- Clinical use of automated cognitive assessments such as RSPAN
  - Long and difficult task
  - Need to be faster to administer
- RSPAN validity
- Role of amplification in preservation of working memory
References

QUESTIONS?

?????