Top-Down Processing in the Older Adult

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Nature of the Problem for Older Adults

• Common complaint: “Can hear speech, but can’t understand it.”

• Generally accepted that as people advance in age beyond age 60, speech-understanding problems will be encountered increasingly.

• The reasons for these difficulties, however, are less well understood and accepted.
Why do older adults have speech-understanding difficulties?
Three Primary Hypotheses
[From CHABA (1988), Humes (1996)]

• PERIPHERAL hypothesis
  – simple, audibility version
  – “multiple distortion” version
    • hearing loss AND deficits in suprathreshold processing of sound
  – prevalence: hearing loss, 35-40%

• CENTRAL AUDITORY (CAPD) hypothesis
  – prevalence: 0-50% ???

• COGNITIVE hypothesis
  – prevalence: MCI, 3-18%; age-related decline higher

• Can also be COMBINATIONS of these
Schematic of Normal Auditory System

Complex Acoustic Speech Signal

Peripheral Transduction and Encoding

Neural Transmission and Feature Extraction

Information Processing, Labeling, Storage and Retrieval

Sound Wave

Auditory Periphery

Brainstem Pathways

Cortex

Peripheral Hypothesis (cochlea; aud nerve)

Central Auditory Hypothesis

Cognitive Hypothesis
Peripheral Hypothesis

- Well known that as people age, they demonstrate increasing amounts of sensorineural hearing loss in the high frequencies, typically attributable to underlying cochlear pathology.
Peripheral Hypothesis Example:
Humes (2005) Speech Recognition in Older Adults

- Speech at 90 dB SPL
- Individual Differences

Graph:
- N = 249
- r = -0.74
- Speech at 90 dB SPL
- Percent Correct vs. HFPTA in dB HL
Findings from Several Studies of Individual Differences

- 65-90% of the systematic variance in speech-understanding performance explained by (or correlated with) hearing loss
  - van Rooij & Plomp (1990, 1991)
  - Helfer & Wilber (1990), Helfer (1993)
  - Divenyi & Haupt (1997a, 1997b, 1997c)
  - Dubno & Ahlstrom (1997), Dubno et al. (1997) and Dubno, Ahlstrom & Horwitz (1999)
What about AIDED speech understanding?

10-15 dB above threshold (Cochlear pathology still present)
What about AIDED speech understanding in older adults?

• Can older brain make full use of the speech information *once audibility has been restored*?
  
  – In general, correlations between AIDED speech-understanding performance of older adults and…
    
    • ...*hearing loss* are weak ($r < 0.2$)
    
    • ...*cognition* are moderate ($0.4 < r < 0.7$)
      
      – especially in fluctuating speech-like backgrounds or competing speech
Cognition & Aging

MOTHER GOOSE & GRIMM by Mike Peters

WHAT IS THE WORST PART OF GETTING OLD?

MEMORY LOSS ... AND... THAT... OTHER THING.
Cognitive Factors & Aging

• Age-related changes in cognitive function:
  – Memory (primarily working memory)
  – Speed of Processing
  – Attention and Inhibition of Distracting Information
  – Executive Function
  – Use of Context, Verbal Knowledge, Information
Aging and Cognition
From Salthouse (2010)
N = ~1,600 to 6,500
Central Auditory Hypothesis

1. Sound Wave
2. Auditory Periphery
3. Brainstem Pathways
4. Cortex

AUDITORY Pathways and Centers ONLY
At Least Two Forms of “Central Auditory” Deficits or Lesions

• From studies of central-auditory anatomy and physiology with laboratory animals (mainly, mice—CBA, C57)
  – True age-related changes in central-auditory anatomy or physiology independent of peripheral hearing loss (CEBA)
  – Changes in the auditory portions of the CNS due to the presence of a peripheral age-related hearing loss (CEPP)
Older animals apparently have “speech understanding problems” too.
Human Evidence for “Central Presbycusis”: Not Compelling to Date

Review

Central Presbycusis: A Review and Evaluation of the Evidence

DOI: 10.3766/jaaa.23.8.5

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Abstract

Background: The authors reviewed the evidence regarding the existence of age-related declines in central auditory processes and the consequences of any such declines for everyday communication.

Purpose: This report summarizes the review process and presents its findings.

Data Collection and Analysis: The authors reviewed 165 articles germane to central presbycusis. Of the 165 articles, 132 articles with a focus on human behavioral measures for either speech or nonspeech
What support is there for Higher-Level Auditory-Processing Problems in Older Humans?

• Primarily comes from clinical “prevalence” studies in older adults and *UNAIDED listening*

• Potential problems in these studies
  – tests frequently made use of speech and peripheral hearing loss and cognition can impact performance
  – tests included in battery have often been of questionable reliability
  – application of a “parallel battery with loose criterion”
  – no validation of tests in target population
Recent IU Study of AIDED Speech Understanding in 98 Older Adults
Spectral Shaping Applied--SPIN

[Graph showing sound level (dB SPL) against 1/3-OB center frequency (Hz) with lines labeled SPIN, LTASS, Older-thr, LTASS-shaped, YNH-thr.]
Characteristics of the 98 Older Adults

**Right Ear**
- **N = 98**
- **FREQUENCY (Hz)**: 250, 500, 1000, 2000, 4000, 8000
- **HEARING LEVEL in dB HL (re: ANSI, 2004)**: 0, 20, 40, 60, 80, 100
- **Median**
- **Interquartile Range**

**Left Ear**
- **N = 98**
- **FREQUENCY (Hz)**: 250, 500, 1000, 2000, 4000, 8000
- **HEARING LEVEL in dB HL (re: ANSI, 2004)**: 0, 20, 40, 60, 80, 100
- **Median**
- **Interquartile Range**

**AGE:**
- M = 69.2 y, 60-86 y
- 50 females;
- 91 right ears tested;
- 91 not current HA users (88 never)
Multiple-Regression Analysis

- Independent Variables
  - Age
  - TRT
  - ESI
  - Cognitive Function
    - Composite of 6 measures
  - Modulation Detection
  - Dichotic Masked Threshold
  - Stream Segregation
  - Informational (Multi-Burst) Masking
  - Hearing Loss

- Dependent Variable
  - Speech Understanding
    - Composite of 7 separate measures

- Z Scores
- Factor Scores
Mult Reg Results

Variables NOT Entering:
- Mod Detection
- Stream Seg
- Age

AIDED Speech Understanding: 59.5%

ESI: 14.9%
Cog: 11.4%
Info. Mask: 10.0%
TRT: 9.6%
H Loss: 8.8%
Dich. Mask: 4.8%
Summary

• Overviewed Hypotheses About the Nature of the Speech-Understanding Problems of Older Adults and the Evidence in Support of Each

  – Peripheral Hypothesis
    
  – Central-Auditory Hypothesis
    
  – Cognitive Hypothesis

  Primary factor for UNAIDED listening difficulties of older adults

  Due to a number of difficulties, unclear as to role of CAPD in the listening difficulties of older adults

  MAY be major factor for AIDED listening difficulties of older adults
Acknowledgements

• NIA R01-AG008293, NIA R01-AG022334
• Colleagues: Dana Kinney, Gary Kidd, Jenny Lentz
• Postdocs: Dan Fogerty, Vidya Krull
• Au.D. and UG RAs: Ellie Barlow, Sara Brown, Megan Chaney, Hannah Fehlberg, Tera Quigley
Text Recognition Threshold (TRT)
Zekveld (2007): Moderate correlation with speech in interrupted noise

Very Few Tests of CAPD Have Established the Modality Specificity of the “Central Auditory” Measurements
A Quick Test (AQT)

Older adults worse than young adults
Sentence Span Task

All trees are plants (T/F)
M (hold in memory)
A human has a tail (T/F)
C (hold in memory)

Recall all letters (4 – 8 sentence / letter pairs)
Memory Updating

Example with 3 frames:

- **STUDY**
  - 3
  - 4
  - 2
  - -4
  - -1

- **UPDATING**
  - -2
  - 1

- **RECALL**
  - type responses, in this case: 1 (left frame), 3 (right frame), & 6 (middle frame)

- time
Spatial Short-Term Memory