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Foundational Aspects of Hearing and Aging: A Research Update

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Learning Objectives

- 1) Describe how age-related changes in sensory and cognitive abilities affect speech perception in older adults
- 2) Identify current theories of spoken word recognition and explain how they account for age differences in speech understanding
- 3) List the clinical implications of age-related changes in sensory and cognitive abilities as they apply to understanding speech.
Age-related changes in hearing

What are the causes of age-related hearing loss
What are the causes of age-related hearing loss

Hair cell loss and aging

Hair cells in apical region encode low frequencies

Hair cells in basal region encode high frequencies

Aging is associated with a basal (high frequency) to apical (low frequency) loss of hair cells
Consequences of age-related hearing loss

- Impaired speech perception
- Age declines are even larger for degraded listening conditions
  - With background noise
    - Poorest performance is when background noise is other speech (restaurants)
    - Can lead to social isolation
  - At faster speaking rates
  - Accented speech

Simulate hearing loss using low-pass filtering
- Similar to what sloping high-frequency hearing loss would produce

Severe hearing loss	Mild hearing loss

Mild and severe with background noise

Severe loss with background noise	Mild hearing loss with background noise

Effects of background talkers and noise
It isn’t all hearing loss

- Speech perception deficits observed even in older adults with clinically normal thresholds
- Speech deficits remain even with amplification to correct hearing loss
- Speech perception worse in patients with Alzheimer’s disease compared with healthy older adults even when they are matched for hearing thresholds
- Can’t explain why have difficulty with fast speech
  - True even if fast speech is louder than regular speed

Aging also associated with cognitive declines

- Speech specific cognitive abilities
  - Talker normalization – 3 instances of word CAT

- Need to adjust for differences due to vocal tract size and shape
- Would be particularly important in conversations with more than one person
  - Can test by comparing performance with lists of words
    - All spoken by same talker
    - Spoken by multiple talkers

continued
Single vs. multiple talkers

- Compare speech perception in
  - Young adults (YA)
  - Older adults with clinically normal thresholds (NHO)
  - Older adults with hearing loss (HIO)
- Set SNR individually to equate performance in single talker condition
Age-related declines in general cognitive abilities

- Executive functions
  - Attentional control
    - Ability to inhibit activated but no longer relevant information

- Becomes critical in light of current models of spoken word recognition
  - Most current models are activation-competition models
  - Hear spoken word activates that word and similar sounding words
    - Hear CAT, activates CAT, CAB, KIT,
    - Need to reduce activation on competitors (CAB, KIT) using attentional control

- Words differ in how much attentional control needed
  - CAT - similar to many other words (HARD)
  - SONG – Relatively fewer words sound similar (EASY)

Compare young, normal-hearing older, hearing-impaired older

![Graph showing percent correct for NHY, NHO, and HIO conditions with easy and hard categories.](image)
General cognitive declines II: Age-related general slowing

- Older adults are slower at information processing
  - Observed even for simple reaction time tasks
- Are deficits with fast rate speech due to general slowing?
  - Can improve speech perception in older adults by inserting short pauses (but still keeping fast rate speech)
  - Pauses give older adults time to catch up

Clinical implications I: Context

- One way to compensate for hearing loss is to use context to fill in missing information

- Older adults have extensive experience with language
- Hearing loss occurs gradually so can learn to use context
- Maybe they will benefit more than young from having semantic context
Listening comprehension

- So far have seen
  - Older adults are significantly poorer than young at identifying single words, especially in noise
  - Can compensate in part by using context
- Context would be particularly important for understanding longer discourse (stories, lectures)
  - How does the ability to understand discourse change across the lifespan?
Effects of age on auditory discourse comprehension

- Participants
  - 70 participants in each of seven decades
    - 18-29; 30-39; 40-49; 50-59; 60-69; 70-79; > 80
  - Mean education level similar across age groups
  - Age appropriate hearing loss

- Two measures of discourse comprehension
  - Brown, Carlsen, Carstens (BCC) Listening Comprehension Test
    - One passage about 10 minutes
    - 21 questions assessing recall and integration
  - Lectures, Interviews, Spoken Narratives (LISN)
    - Hear six spoken passages (two each of lecture, interview, spoken narrative) in free field
    - Answer 6 questions for each passage (2 information, 2 integration, 2 inference)

Comprehension scores as a function of age
Clinical implications II: Amplification

- **Hearing aids**
  - Designed to compensate for age-related hearing loss
  - Can be highly effective in improving speech perception
    - Especially if well fit
    - Especially in quiet listening situations (e.g., watching TV)
  - Less effective in:
    - Noisy environments – amplify signal and background noise
    - Overcoming obstacles not due to hearing loss
      - Fast speaking rates
  - Currently, only about 20% of qualified (based on hearing) individuals obtain hearing aids
    - About 40% of those who do get an aid aren’t using it regularly one year after purchase

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Satisfaction with medical devices

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<th>Survey 2001</th>
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<tr>
<td>Hearing aids</td>
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Obstacles to hearing aid benefits

- Most hearing aids amplify sound
  - Designed to overcome hearing loss
  - Don't distinguish between speech and background noise
  - Especially bad for parties or other times when background noise is speech
- Loudness recruitment
  - Abnormal growth of loudness resulting from hearing loss
Clinical implications III: Alternatives and supplements to amplification (part 1)

- Auditory-visual speech perception (both see and hear the talker)
  - Lipreading can provide complementary cues for speech perception
    - Place of articulation easy to see on the lips even in very noisy environments
      - /ba/ vs. /da/
  - Hearing loss causes increased reliance on lipreading
  - Older adults acquire hearing loss gradually
    - Can learn to use lipreading over time
  - Typically easier to correct age related changes in vision than hearing

Auditory-only vs. Auditory-visual

![Graph showing percent correct for syllables, words, and sentences for Young and Old groups in auditory and auditory-visual modalities.](image)
Clinical implications III: Alternatives and supplements to amplification (part 2)

- Auditory Training
  - To develop a patient’s ability to recognize speech using the auditory signal and to interpret auditory experiences.
  - Training helps patients use their residual hearing to their maximum capability.
  - Typically 20-30 hours of training on a variety of tasks

Example activity 1: 4-choice discrimination

Hear two words
- Can be same or different words (e.g., putt-butt)
- Determine which of 4 pictures corresponds to the order of the words heard
Example activity 2 – Fill-in-the-Blank

- Identification Task
  - Hear a sentence in clear
  - Asked to listen to 4 possible endings in noise
  - Select the most appropriate ending

Benefits of auditory training
Summary and review

- **Learning objective 1**
  - Understand how age-related changes in sensory and cognitive abilities affect speech perception in older adults
    - Aging associated with sloping high frequency hearing loss due to loss of hair cells
    - Aging associated with reduced ability to adjust to differences in talkers
    - Aging associated with impaired executive functions
      - Results in difficulty understanding words that sound like many other words

- **Learning objective 2**
  - Understand current theories of spoken word recognition and how they account for age differences in speech understanding
    - Current theories suggest that hearing a word results in many potential candidates
      - CAT will activate KIT, HAT, CAB...
    - Older adults have difficulty inhibiting the candidates
    - Results in confusing word that was spoken with other similar sounding words
    - Older adults are slower at information processing making it more difficult to understand fast speaking rates
Learning objective 3

- Understand the clinical implications of age-related changes in sensory and cognitive abilities as they apply to understanding speech.
  - Amplification can provide improved speech perception, especially in quiet environments
  - Less effective in noisy environments
  - Older adults can benefit from using context as a supplement to amplification
  - Older adults can benefit from both seeing and hearing a talker compared with listening alone
  - Older adults can benefit from auditory training which teaches them how to maximize their residual hearing

Questions?