Aging and Speech Communication: The Role of Auditory Processing

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Disclosure Statement

Larry E. Humes

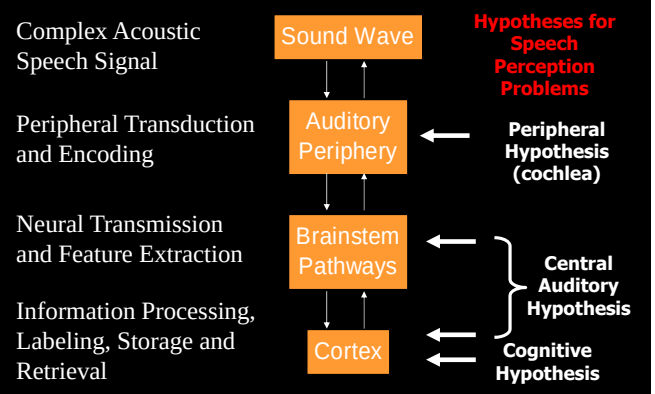
Financial: Salary from NIH.

Non-financial: Larry Humes has a number of publications directly related to the content of this course.

Overview of Talk

- Brief Overview of Hypotheses for the Speech-Understanding Problems of Older Adults for Unaided and Aided Listening
  - Peripheral Hypothesis
  - Central-Auditory Hypothesis
  - Cognitive Hypothesis
- New Data from the "Test Battery Study"
  - Collaborators: Gary Kidd & Jenny Lentz
  - Focus on AIDED Results in 98 Older Adults

Schematic of Normal Auditory System



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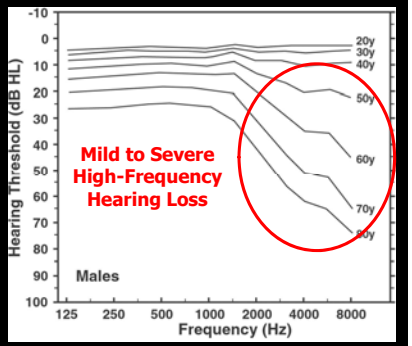
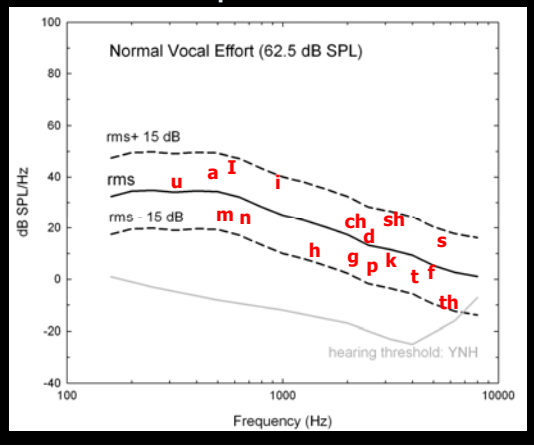
Peripheral Hypothesis--simple version

- Well known that as people age, they demonstrate increasing amounts of sensorineural hearing loss in the high frequencies, typically attributable to underlying cochlear pathology



Consequences of the Peripheral Hypothesis for Speech Understanding



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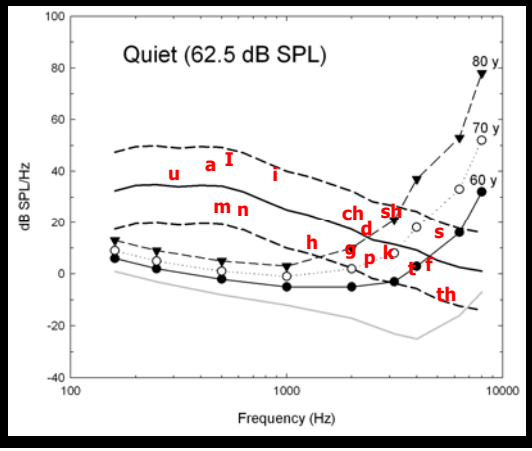
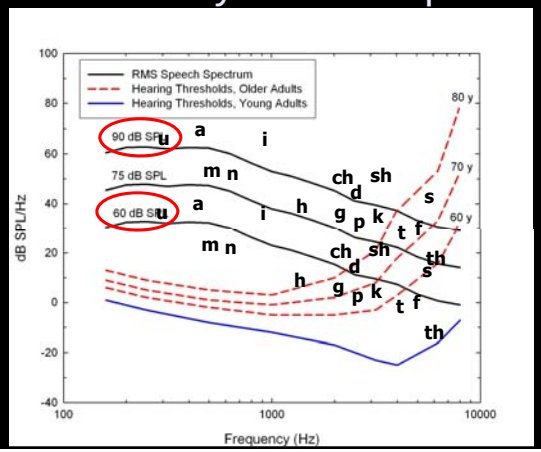
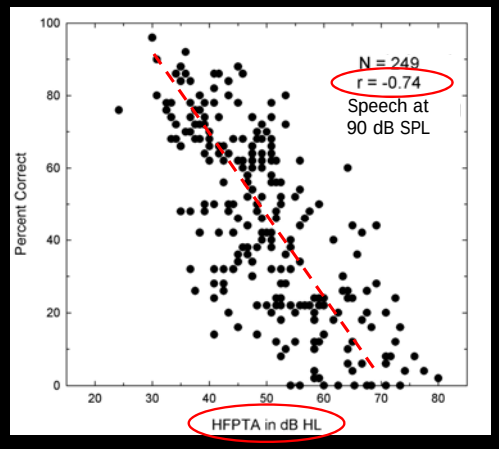


Use of High SPL Alone Does NOT Ensure Fully Audible Speech



Peripheral Hypothesis Example:

Humes (2005) Speech Recognition in Older Adults



Findings from Several Studies of Individual Differenc

- 65-90% of the systematic va ech-understanding performa ed by (or correlated with) hea
  - van Rooij & Pl
  - Helfer & K lfer (1993)
  - Hu 990), Humes and Christopherson (2002), Humes (2005)
  - (1991), Jerger & Chmiel (1997)
  - n-Salant & Fitzgibbons (1993, 1997)
  - Olvenyi & Haupt (1997a, 1997b, 1997c)
  - Dubno & Ahlstrom (1997), Dubno et al. (1997) and Dubno, Ahlstrom & Horwitz (1999)

Support for the Peripheral Hypothesis for *UNAIDED* listening

Peripheral Hypothesis Example:

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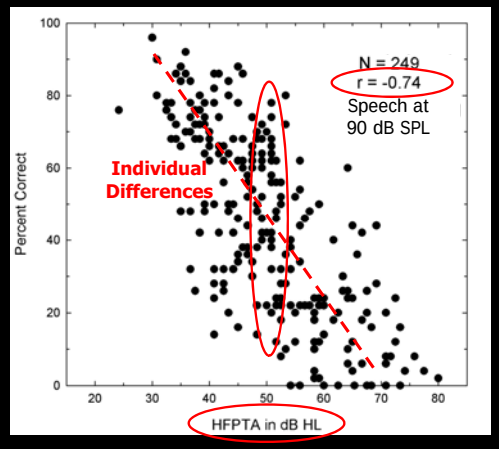
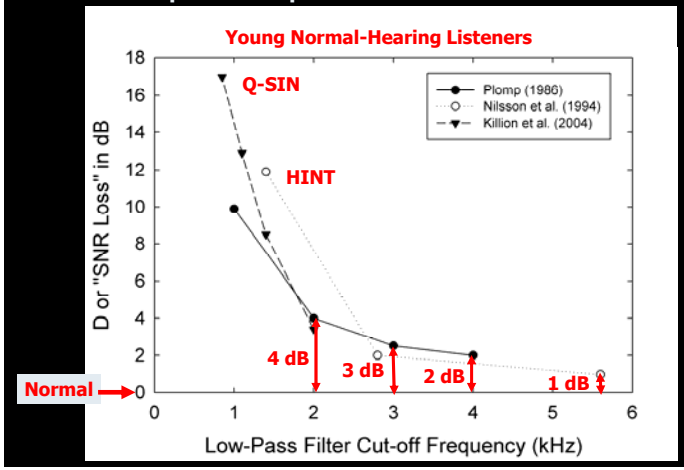
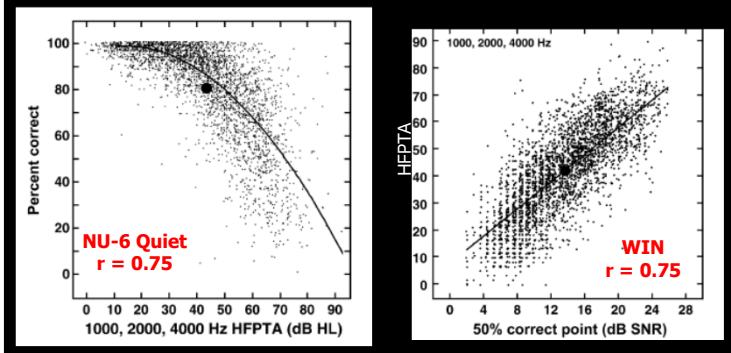


Are high frequencies important for adaptive speech-in-noise tests?



Wilson (2011) N = ~3,200

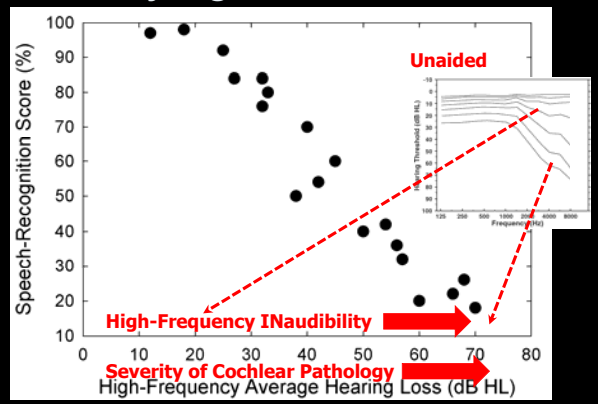


Support for the Peripheral Hypothesis, but which Version?

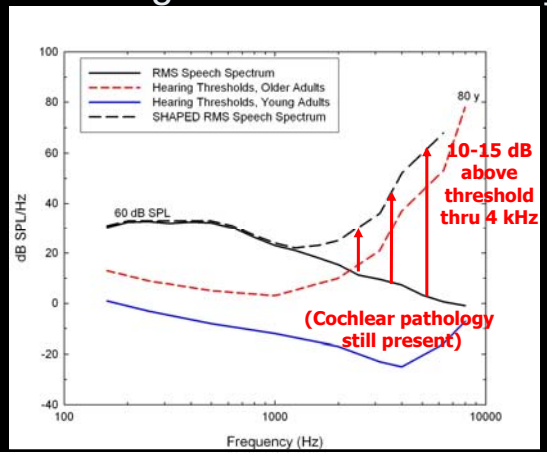
Interpreting Correlations with HFAVG Hearing Loss

- Audibility
  - Similar to LPF or earplug that eliminates high frequency speech sounds
- Severity of Underlying Cochlear Pathology
  - Higher hearing thresholds in SNHL mean more severe underlying cochlear pathology
- How can these two possibilities be sorted out or disentangled?

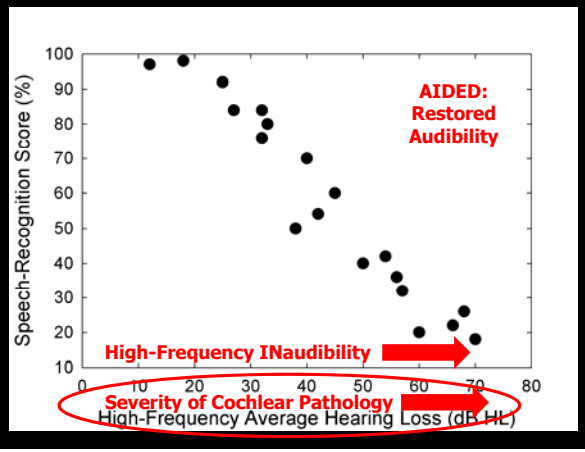
Covariation of Inaudibility and Underlying Cochlear Pathology



Spectrally Shaped Speech: Minimizing the Role of Audibility



Covariation of Inaudibility and Underlying Cochlear Pathology Remedied



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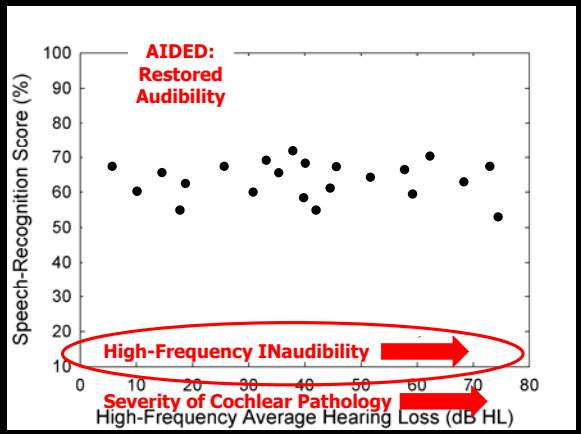
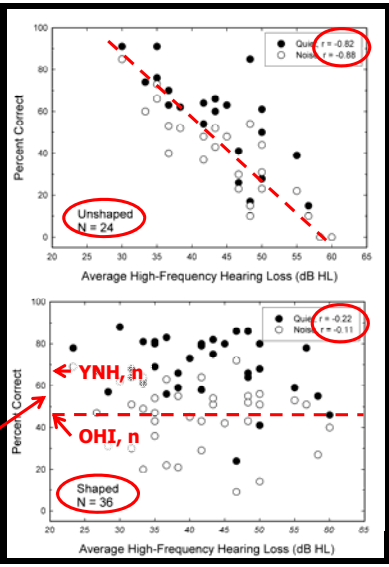


Amos & Humes (2007)

Correlations **Consistent with SIMPLE Peripheral Hypothesis, *but* = Audibility ≠ Performance**



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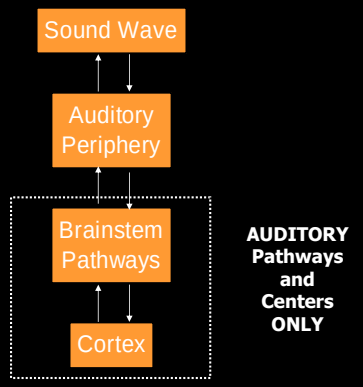
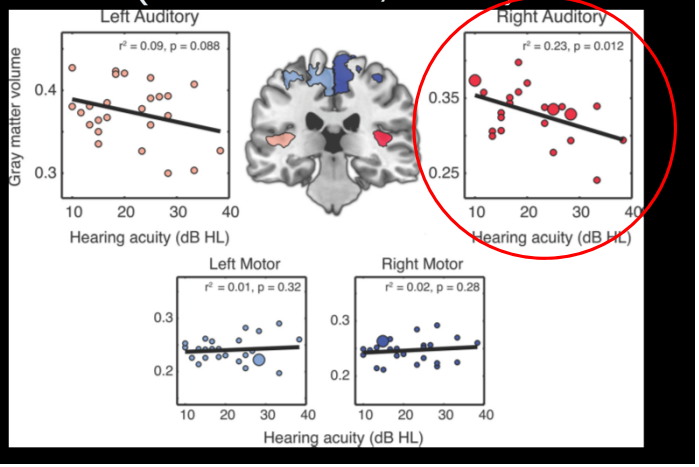
Central Auditory Hypothesis



At Least Two Forms of "Central Auditory" Deficits or Lesions

- From studies of central-auditory anatomy and physiology **<u>with laboratory animals</u>** (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)

CEPP in Humans (Peele et al., 2011)



What support is there for (C)APD Hypothesis in Older **Humans**?

- Primarily comes from clinical "prevalence" studies in older adults and ***UNAIDED listening***

- Potential problems in these studies

Four problems

  - tests frequently made use of speech and peripheral hearing loss 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

Problem #4: Test-Battery ***Validation*** in Older Adults

- Peripheral Hearing Loss Can C nd Speech-Based Measur Auditory Proces

- Co ts Can Confound Mea es of Central-Auditory Processing

Central Auditory System: "Caught in the Middle"

"Caught in the Middle"--An Illustration

- Jerger, Jerger, Oliver & Pirozzolo (1989)
  - 130 older adults
  - Completed neurocognitive test battery
  - Completed "CAPD" test battery
    - Dichotic Sentence Identification (DSI)
    - Synthetic Sentence Identification (SSI)
    - Speech Perception in Noise (SPIN)
    - Phonetically Balanced (PB) words
  - "Diagnosed" as normal/abnormal COG,CAP

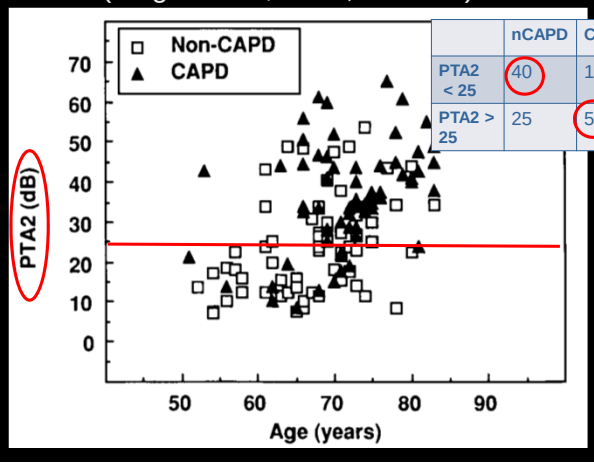
Influence of Cognitive Function on CAPD

		Central Auditory Status	
		Normal	Abnormal
Cognitive Status	Normal	47 (36%)	30 (23%)
	Abnormal	18 (14%)	35 (27%)

54% of those with CAPD had abnormal Cognitive Status

Influence of Hearing Loss on CAPD

(Jerger et al., 1989; N = 130)



	nCAPD	CAPD
PTA2 < 25	40	12
PTA2 > 25	25	53

Jerger, Jerger & Pirozzolo (1991)

N = 200

Correlations of Spe… with Hearin… …ained)

Performance on the "CAPD" test battery clearly impacted by both peripheral hearing loss and cognitive function

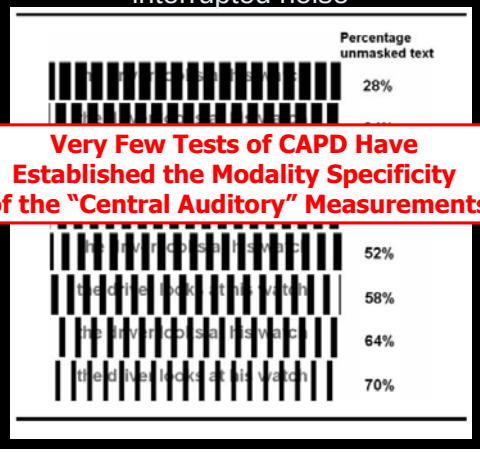
		…N PH	SPIN PL	PB
-…	-0.65	-0.73	-0.78	-0.76
(30%)	(42%)	(54%)	(61%)	(58%)

Modality Specificity Is Important for Tests of "Central Auditory" Processing

- Example: Temporally interrupted speech or speech in interrupted noise
  - Much contemporary interest in temporally distorted or degraded speech as a measure of auditory processing sensitive to aging
  - Visual analog available and being used now in ARL: TRT

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

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- Potential proble…
  - tests fr… …n and peripheral h… …rmance
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Little STRONG evidence to date, with the possible exception of measures of auditory temporal processing

Human Evidence for "Central Presbycusis": Not Compelling to Date

J Am Acad Audiol 23:635–666 (2012)

Review

Central Presbycusis: A Review and Evaluation of the Evidence

DOI: 10.3766/jaaa.23.8.5

Larry E. Humes*
Judy R. Dubno†
Sandra Gordon-Salant‡
Jennifer J. Lister§
Anthony T. Cacace**
Karen J. Cruickshanks††
George A. Gates‡‡
Richard H. Wilson§§
Arthur Wingfield***

Abstract

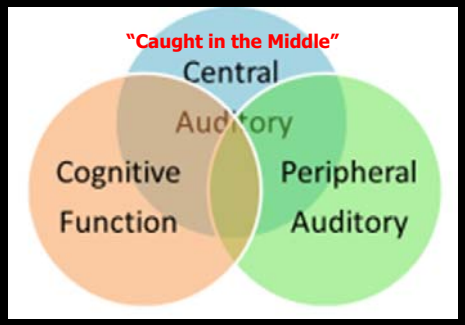
Background: The authors reviewed the evidence regarding the existence of age-related declines in central auditory processes and the consequences of any such declines for everyday communication.

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

SUMMARY

Establishing Central Auditory Problems in Older Adults is Often Challenging due to Concomitant Peripheral and Cognitive Problems



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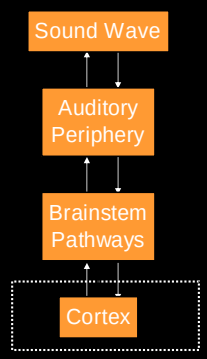
Cognitive Hypothesis

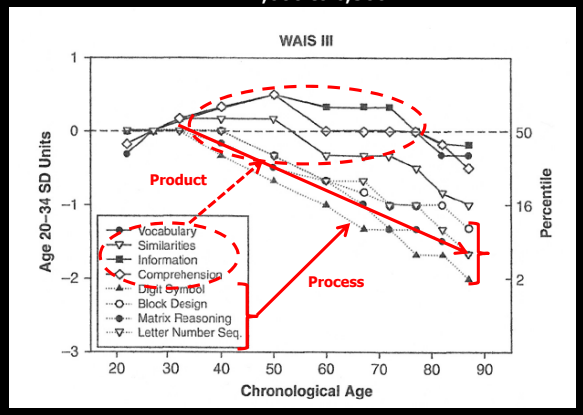


Cognitive Factors & Aging

- 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



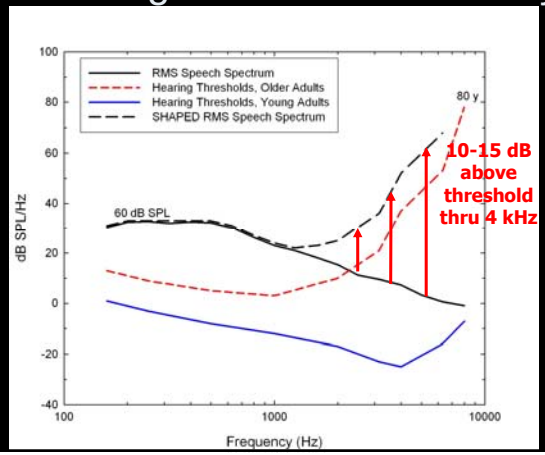
Role of Cognitive Factors in Speech-Understanding of Older Adults?

- Typical finding in studies that have included cognitive variables as predictors of UNAIDED speech-understanding in older adults:
  - Hearing loss, 60-90% of systematic variance
  - Cognitive factors, additional 5-15% of variance
    - Most apparent in competing speech, including dichotic measures of speech understanding
    - Wide range of cognitive factors considered to date

What about AIDED speech understanding in older adults?

- Can older brain make full use of the speech information *once audibility has* been *restored*?

"AIDED"=Spectrally Shaped Speech: Minimizing the Role of Audibility



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 various cognitive measures have been greater than for unaided performance.
    - Especially in fluctuating speech-like backgrounds or competing speech
    - Account for 15-50% of the variance

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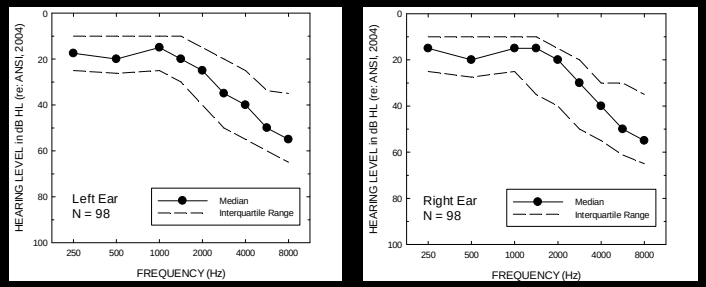
Characteristics of the 98 Older Adults



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

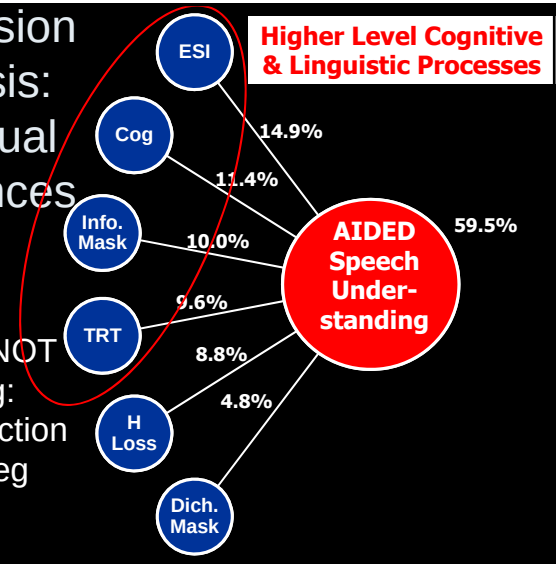
Mult-Reg & Dominance Analysis

- Regression analysis performed
  - Independent Variables
    - Age
    - TRT
    - ESI
    - Cognitive Function
    - Modulation Detection
    - Dichotic Masked Threshold
    - Stream Segregation
    - Informational (Multi-Burst) Masking
    - Hearing Loss
  - Dependent Measures
    - Speech Understanding

Z Scores

Factor Scores

Regression Analysis: Individual Differences



Variables NOT Entering:

- Mod Detection
- Stream Seg
- Age

Summary of New IU Study

- For "objective" (SPIN, CRM) measures of aided speech-understanding in this group of 98 older adults, about 60% of the total variance could be accounted for by the psychoacoustic and cognitive predictors included in this study.
- Of the systematic variance, ESI accounted for about 25%, cognitive factors accounted for about 20%, and TRT, Info Masking, and Hearing Loss each about 15%.

General Summary

- Overviewed Hypotheses About the Nature of the Speech-Understanding Problems of Older Adults and the Evidence in Support of Each
  - Peripheral Hypothesis **Primary factor for UNAIDED listening difficulties of older adults**
  - Central-Auditory Hypot **Due to a number of difficulties, unclear as to role of CAPD in the listening difficulties of older adults**
  - Cognitive Hypothesis **MAY be major factor for AIDED listening difficulties of older adults**

Acknowledgments

- Work supported by NIA R01-AG008293
- We thank Dana Kinney, Charles Brand, Tera Quigley, Megan Chaney, and Sara Brown for their assistance with data collection