Auditory dysfunction and remediation associated with everyday listening of older adults

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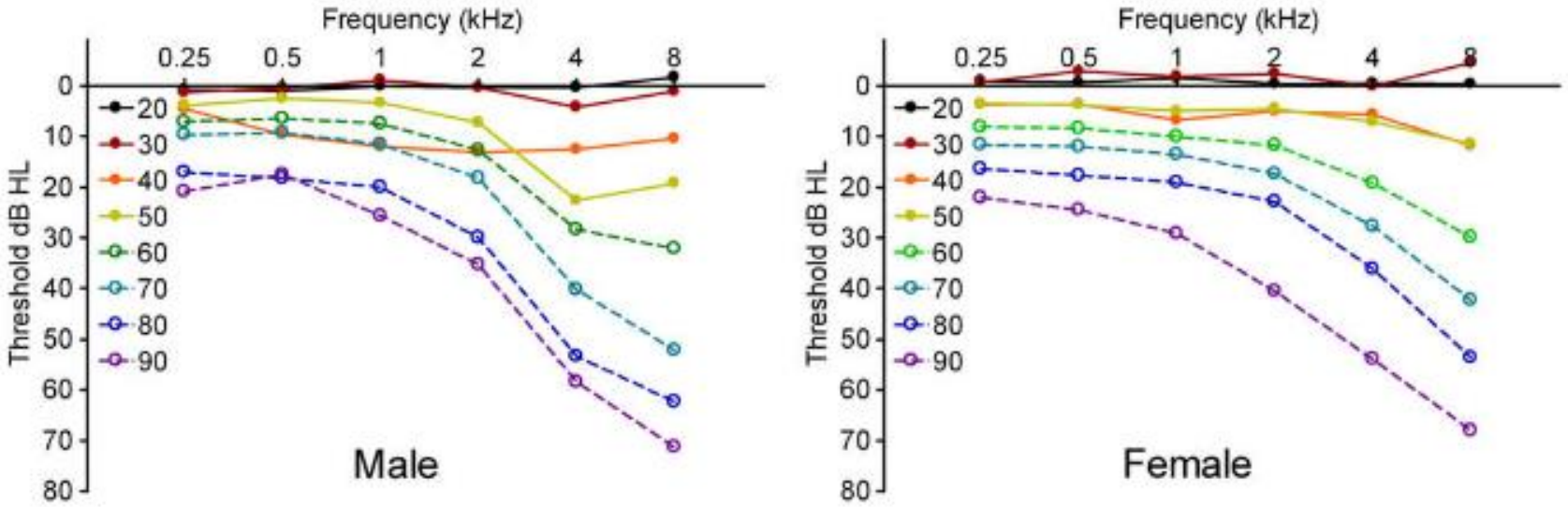
PRESBYCUSIS AND AUDITORY DYSFUNCTION

Typical peripheral auditory changes with age

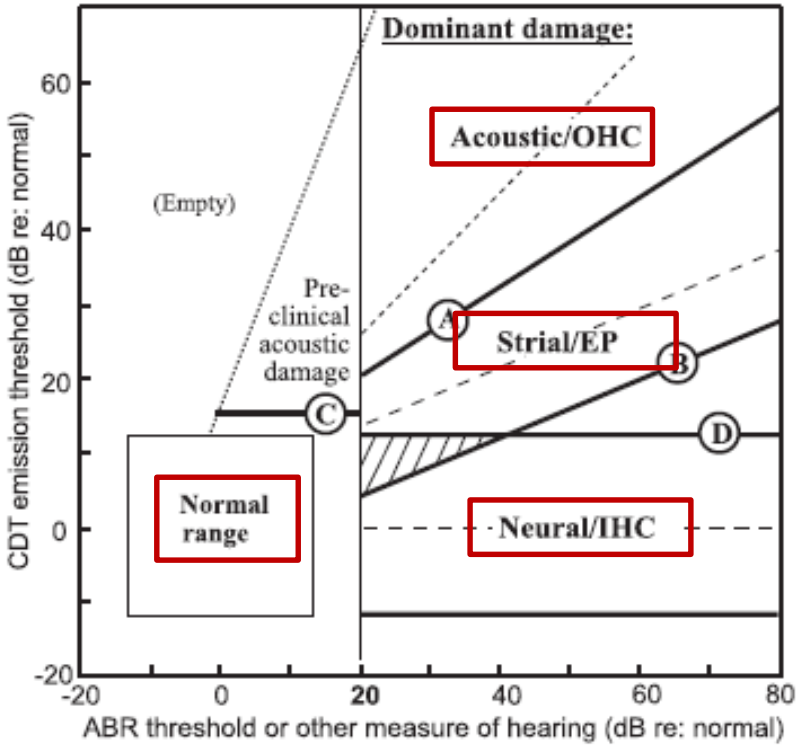
- Progressive loss of sensitivity from high to low frequency

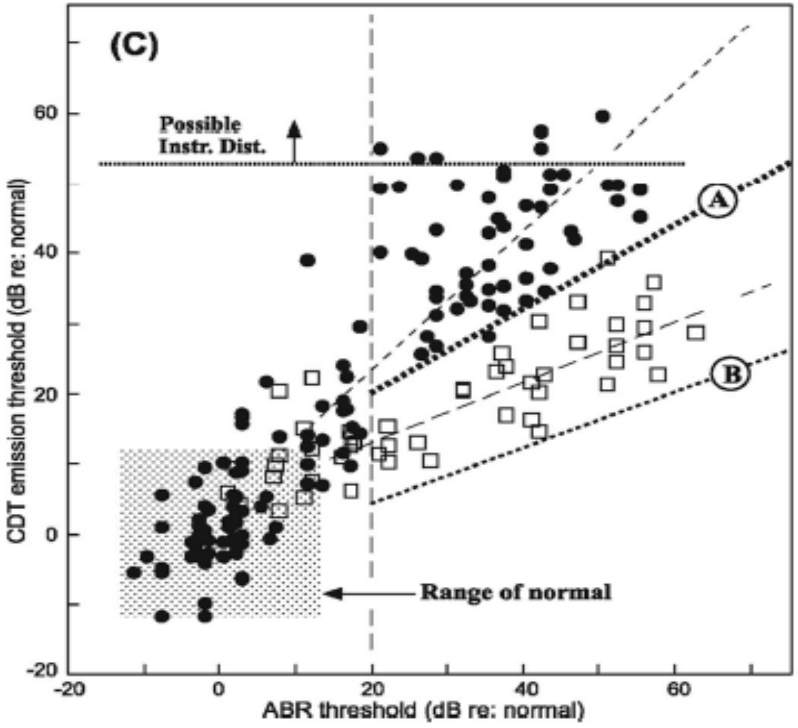


Adapted from Allen & Eddins (2010)

Classic Presbycusic Sub-Types

- Schuknecht's Classifications (1974, 1994)
  - Sensory (OHCs)
  - Strial (Reduction in EP)
  - Neural (VIIIth nerve degeneration)
  - Cochlear Conductive (BM structure)

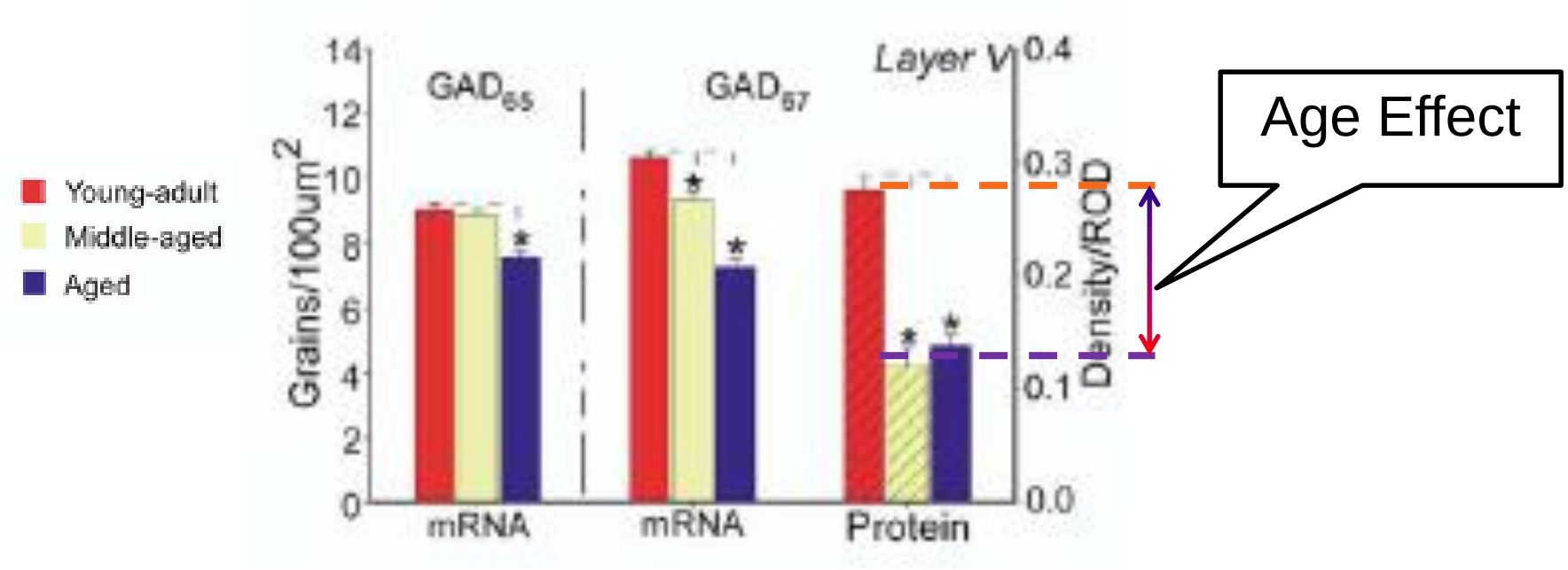




Mills et al. (2006)

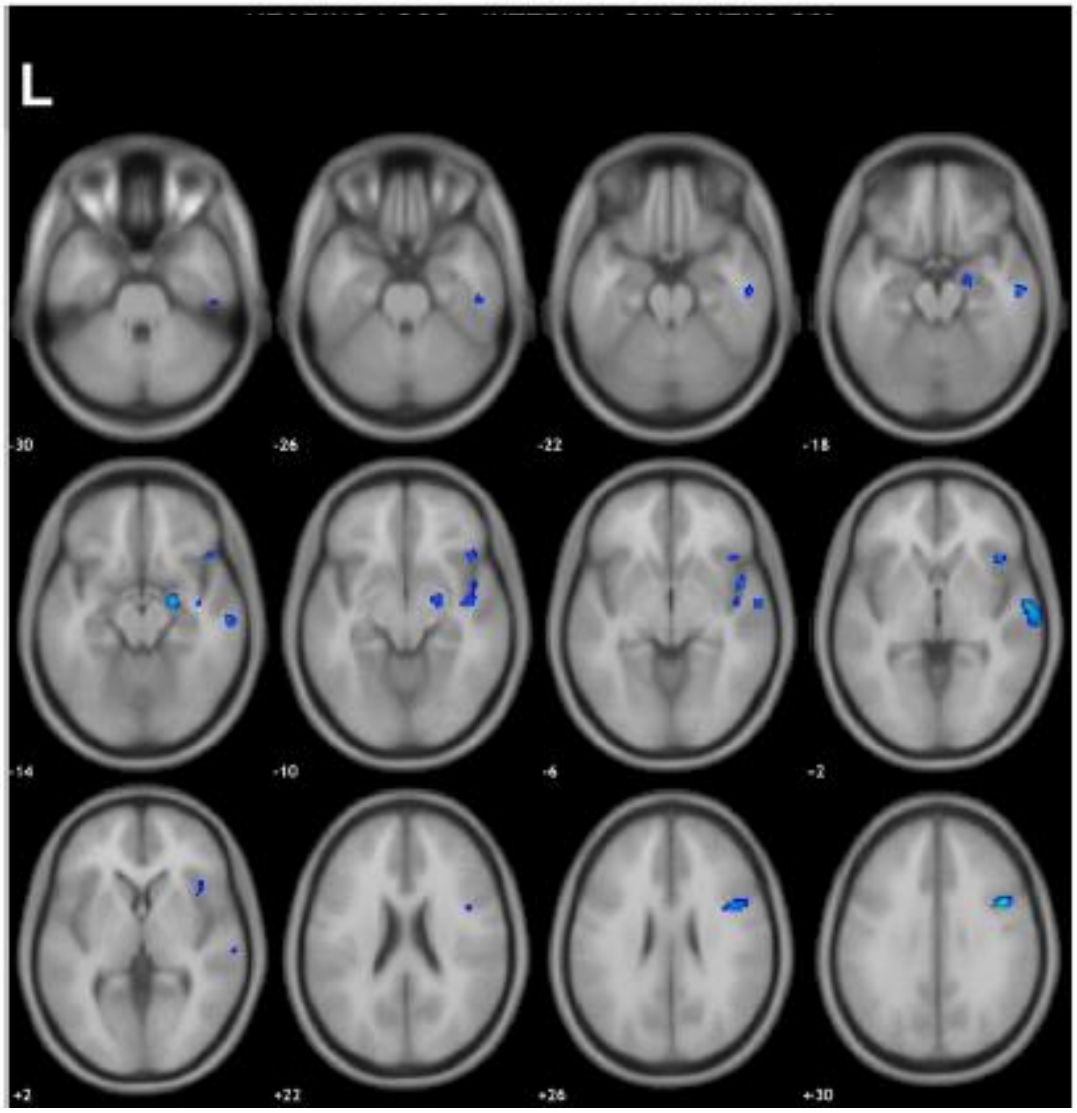
Central auditory changes with age

- Central changes in inhibitory neurotransmitters (GABA)

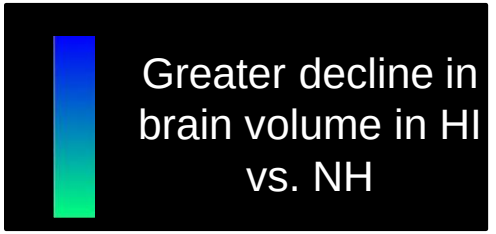


Adapted from Ling et al. (2005)

Changes in central auditory structure with age and hearing loss



Older adults (56-86 yrs) with hearing loss (n=51) show faster decline in right temporal lobe gray matter volume than those with normal hearing (n= 75).



Adapted from Lin et al. (2014)

Presbycusis and Auditory Dysfunction

- Peripheral auditory dysfunction
  - Stria, OHC, IHC changes
- Central auditory dysfunction
  - Inhibition/excitation, timing, tuning, cortical networks
- Peripherally induced central dysfunction
  - Consequences of sound deprivation and altered input
- Cognitive, attention, memory, and pan-sensory changes

REMEDIATION TARGETS

Identify deficits

MECHANISMS & BIOMARKERS

Understanding
Outcomes measures

FOCUSED REHABILITATION

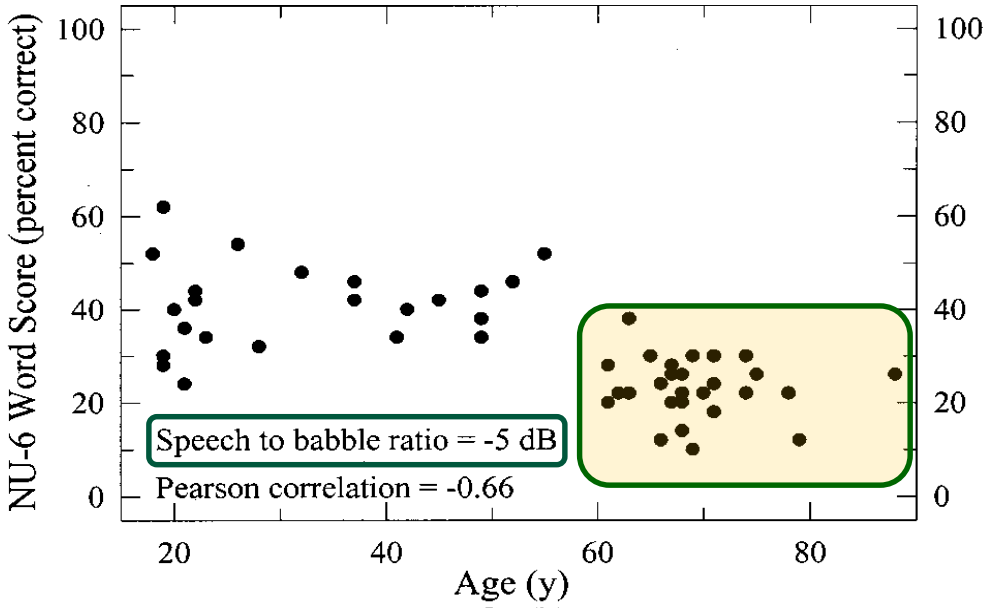
Treatment that targets specific deficits

Audiblity & loudness perception

- Typical aging is accompanied by SNHL
  - Thresholds are substantially increased
  - Uncomfortable loudness level is minimally increased
    - Reduced dynamic range
  - Loudness growth is abnormally steep
    - Loss of normal compressive nonlinearity
  - Little is known about loudness coding and aging *per se*
    - *Eddins, Eddins, Formby: Stay tuned…*

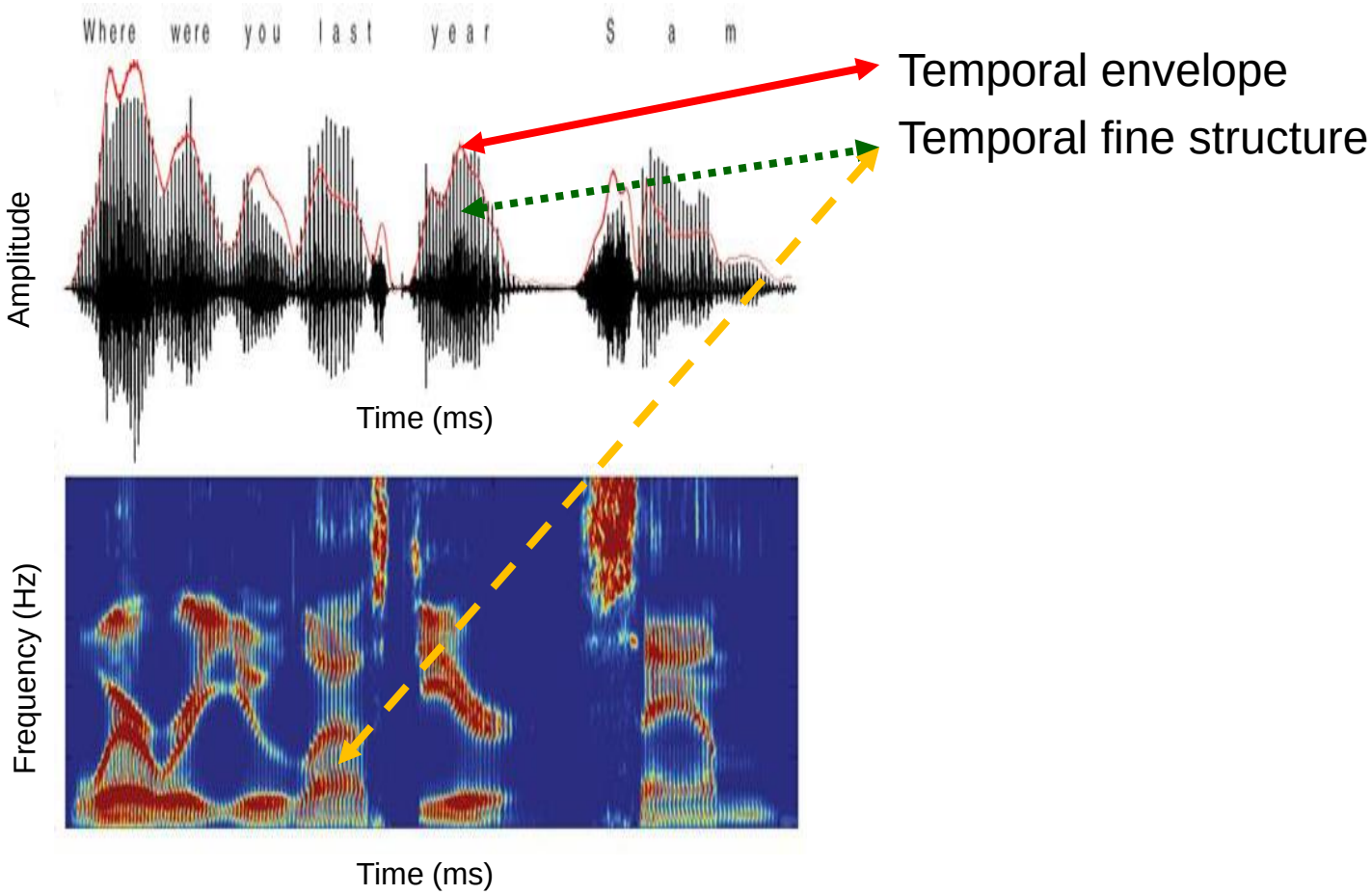
Progressive deterioration of speech in noise

- Top communication complaint in older persons
- Top communication complaint among HI
- Common complaint among blast injured, TBI



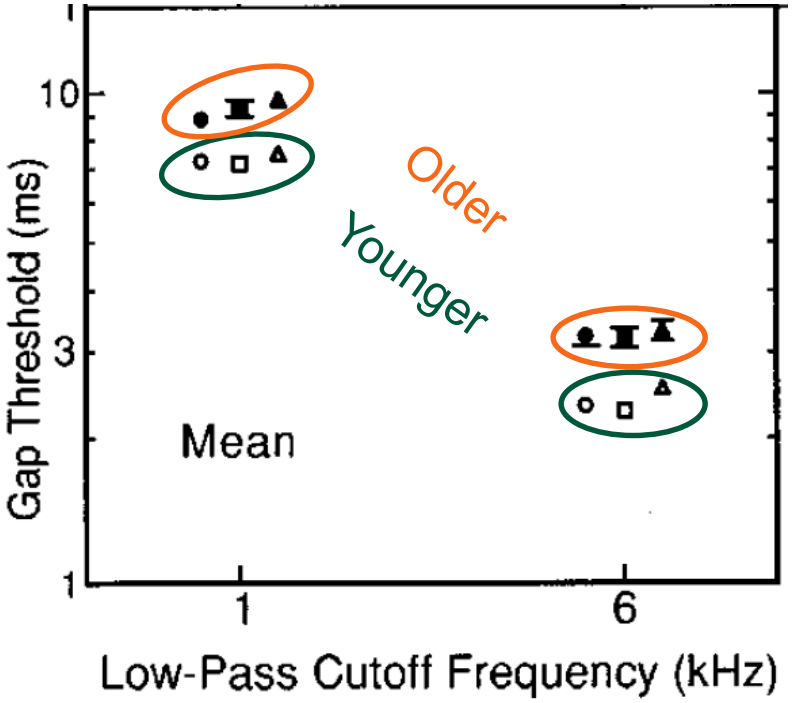
Adapted from Snell & Frisina (2002)

Temporal processing with age: Acoustics

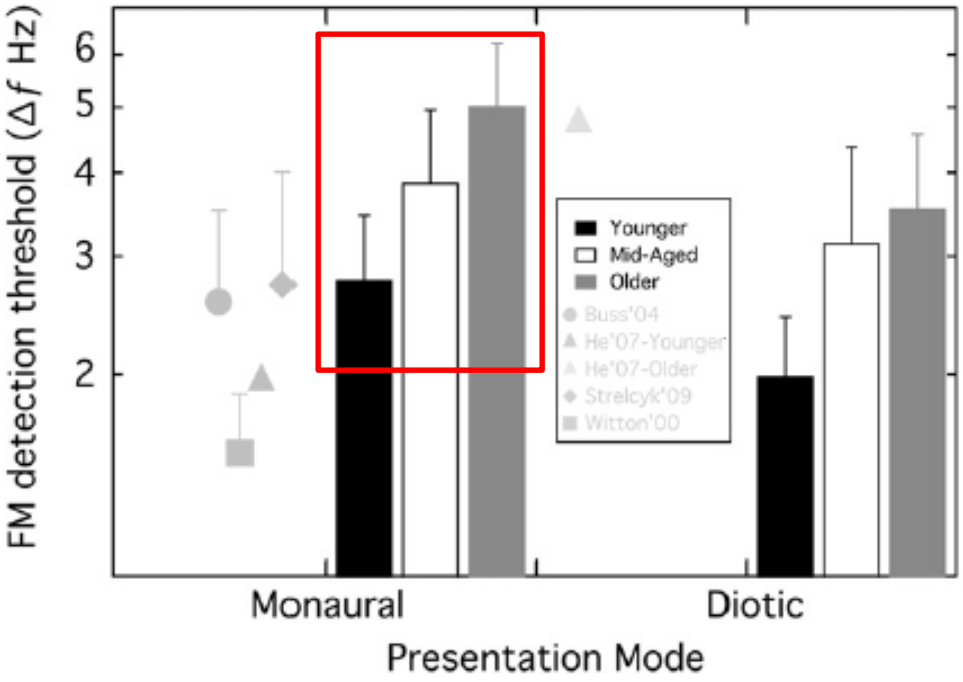


Temporal processing with age: Behavior

- Temporal gap detection
  Low-pass filtered noise
- Temporal Fine Structure
  FM detection (2 Hz), f_c ~500 Hz



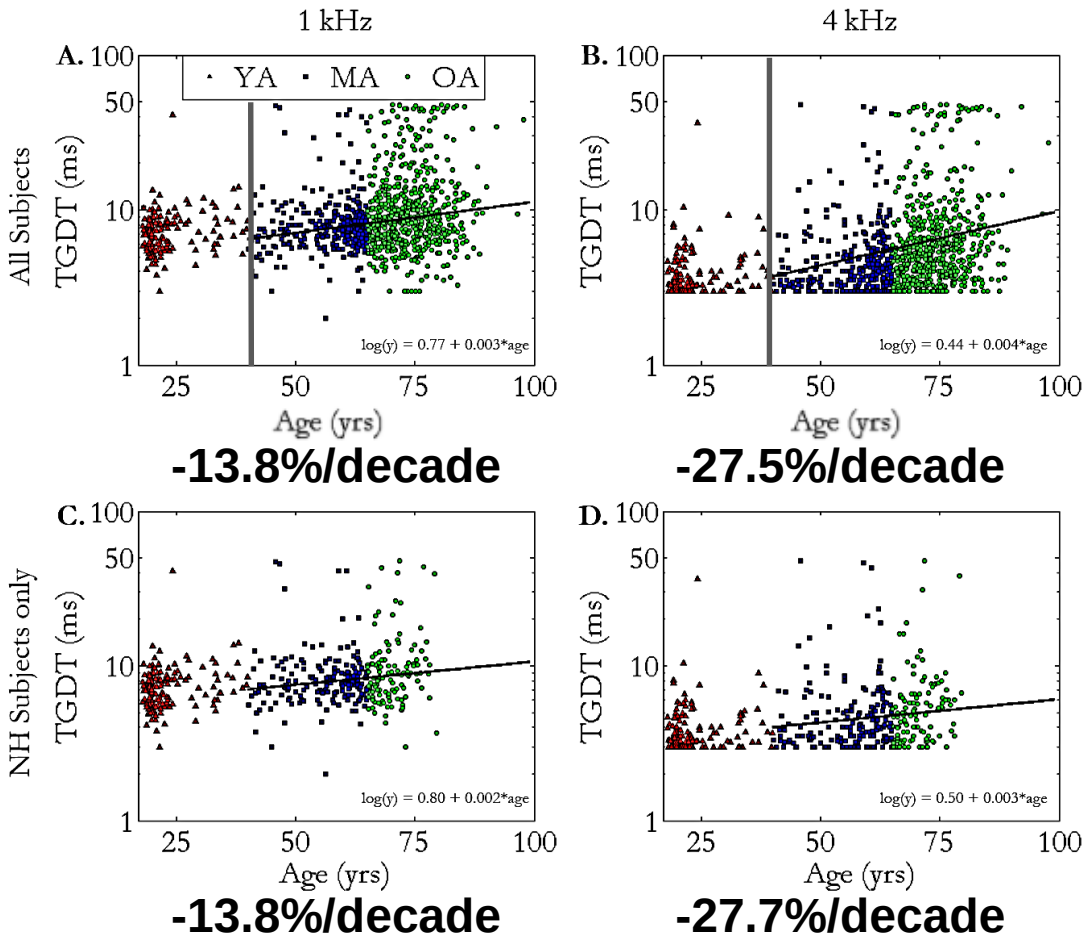
Adapted from Snell (1997)



Adapted from Grose & Mamo (2012)

Rate of decline in temporal processing with age

- Temporal gap detection (n = 1071)



-1.1 ms/decade

n = 427

Rapid progressive decline in auditory temporal acuity after age 40:

Adapted from Ozmeral et al.(In Review)

REMEDIATION TARGET

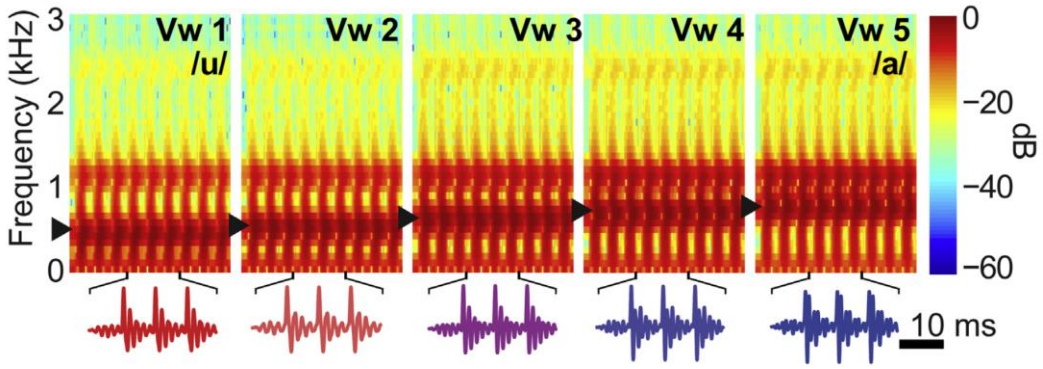
Temporal processing deficit

MECHANISMS & BIOMARKERS

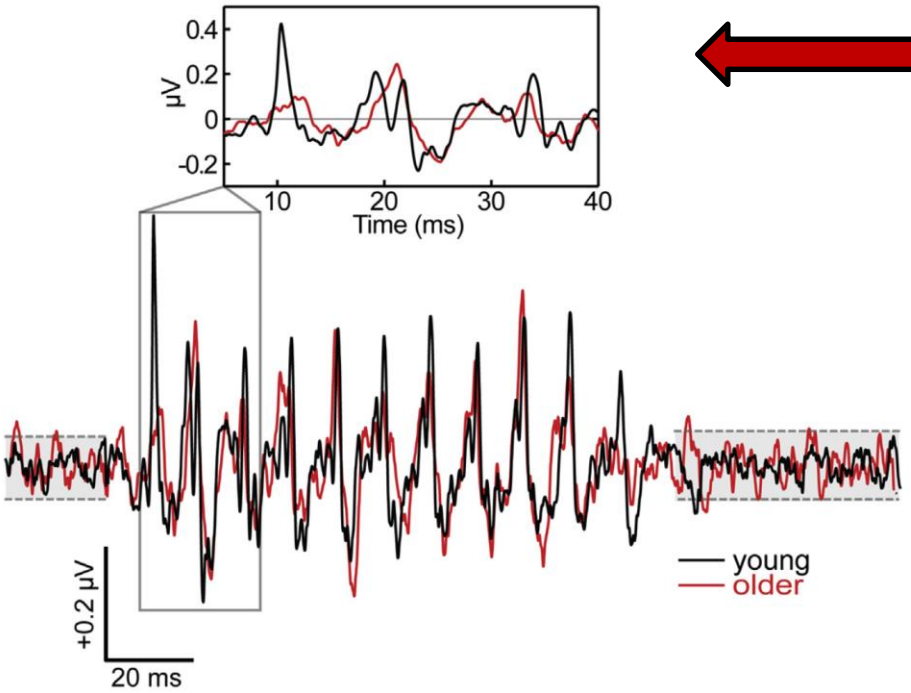
Behavioral and Electrophysiology

- Gain insight into neural bases of deficits
- Characterize biomarkers of deficit
- Objective benchmarks for remediation

Temporal processing deficits in subcortical measures

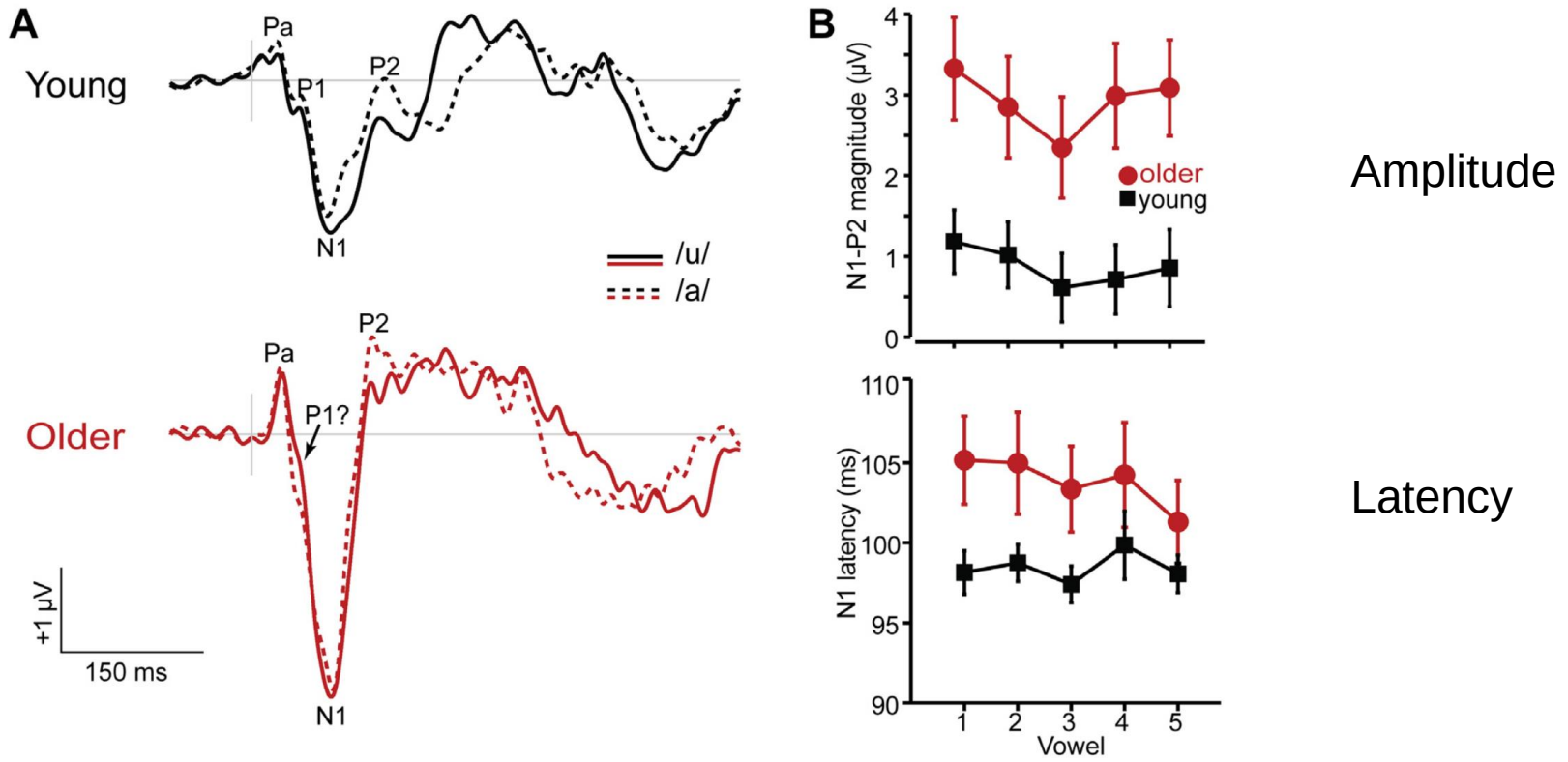


Bidelman et al., 2014



- Age-related deficits in temporal coding of speech in *brainstem ERPs.*
- Consistent with aging effects reported by others (e.g., Anderson et al., 2012; Clinard & Tremblay, 2013; Vander Werff & Burns, 2011)

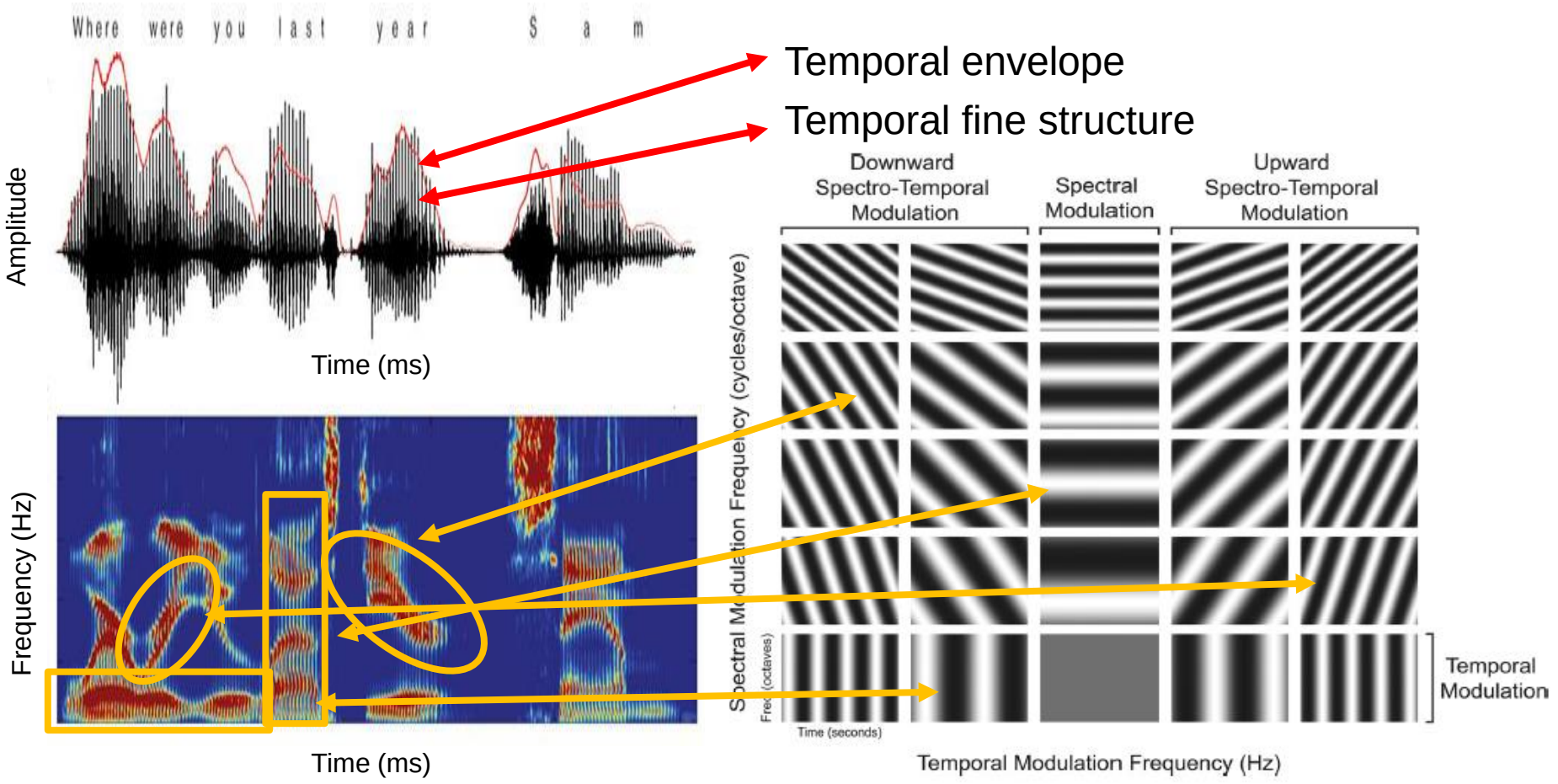
Temporal processing deficits in cortical measures



Bidelman et al., 2014

- Cortical ERPs show enhanced amplitudes but *prolonged latencies.*

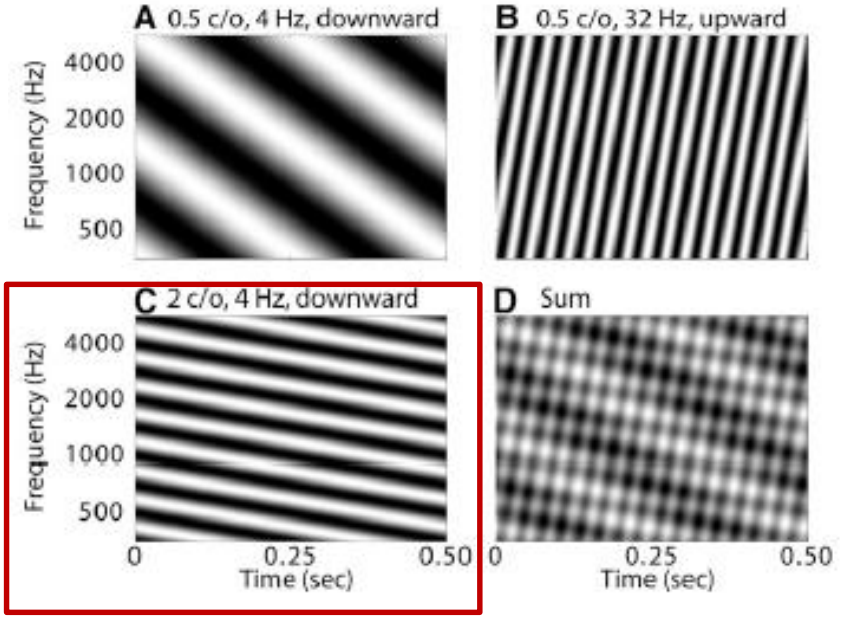
Spectro-temporal processing: Acoustics

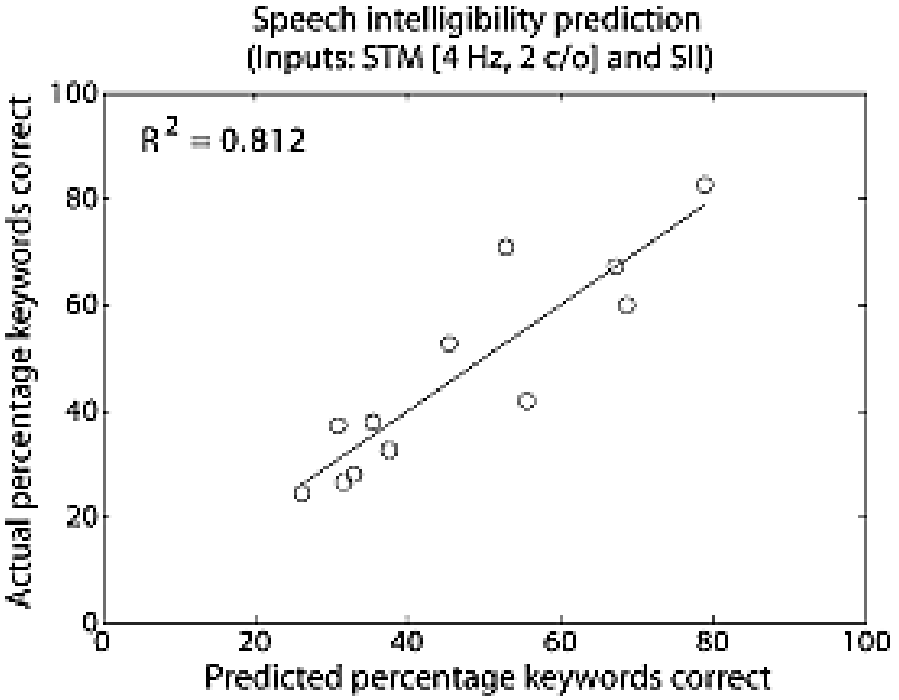


Spectro-temporal processing and age

- Spectro-temporal response fields (Walton & Brimijoin, 2008)

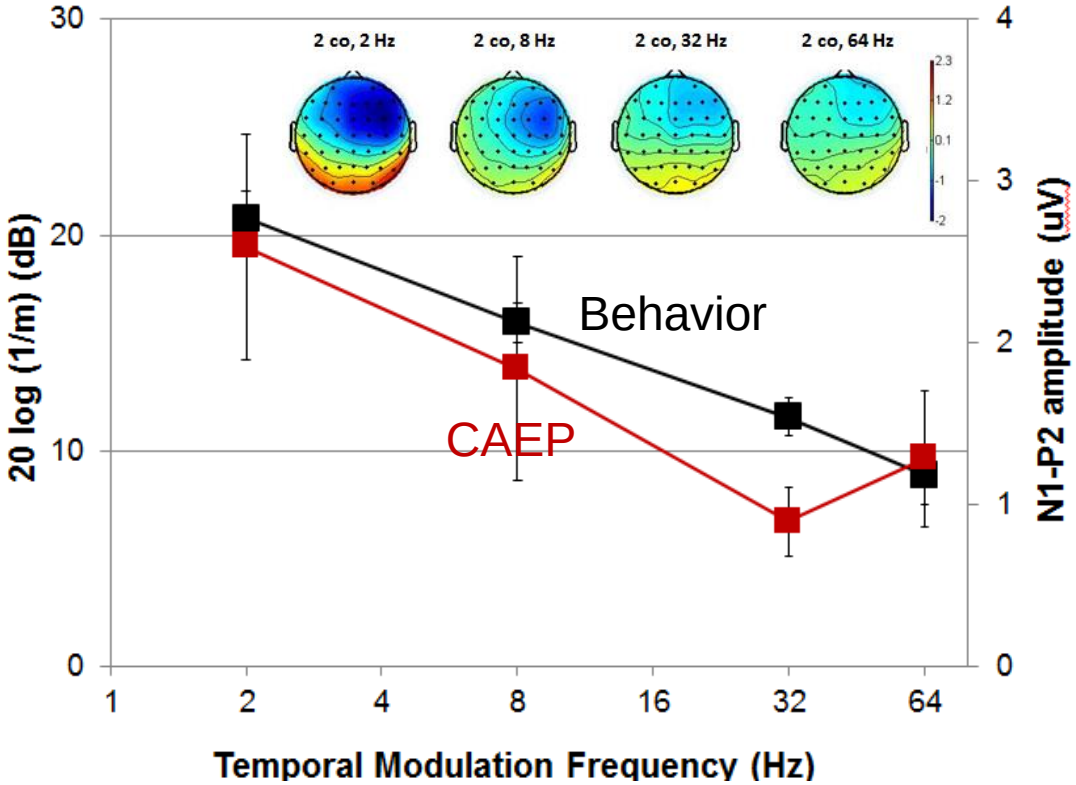
- Spectro-temporal modulation detection (2 c/o & 4 Hz) correlated with sentence intelligibility in noise in MNH (44 yrs) and OHI (76 yrs) (Bernstein et al., 2013)



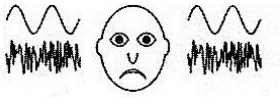


Spectro-temporal processing and age

- STM Behavior & CAEP
  - 10 YNH Ss
  - 10 ONH Ss
  - 10 OHI Ss
  - Many conditions!



Binaural processing changes with age

BMLD Binaural Configuration	
NoSo	
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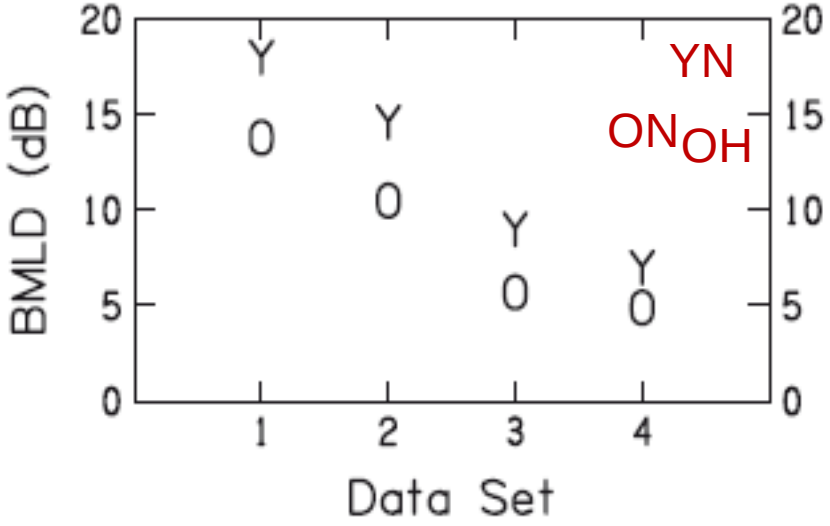
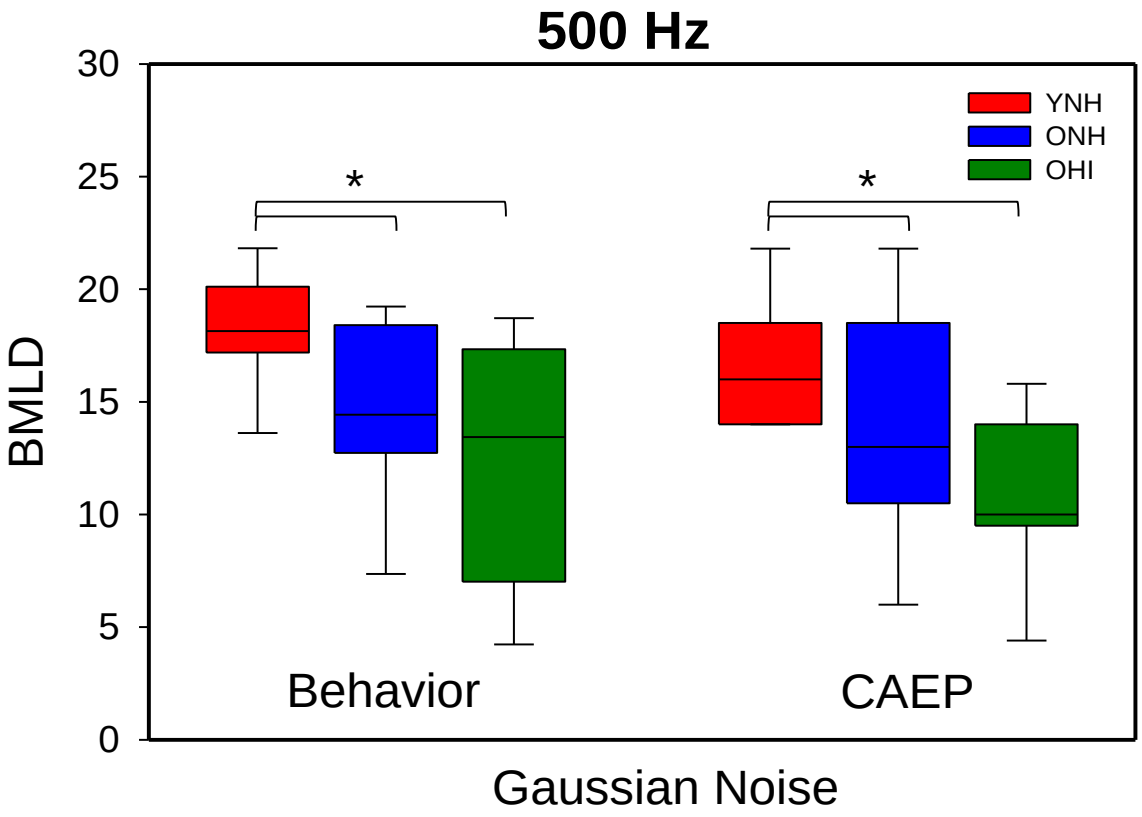


1 Grose et al. (1994)
2 Pichora-Fuller & Schneider (1991)
3 Grose et al. (1994)
4 Strouse et al. (1998)
5 Eddins & Eddins (2015)

Adapted from Eddins & Hall (2010)

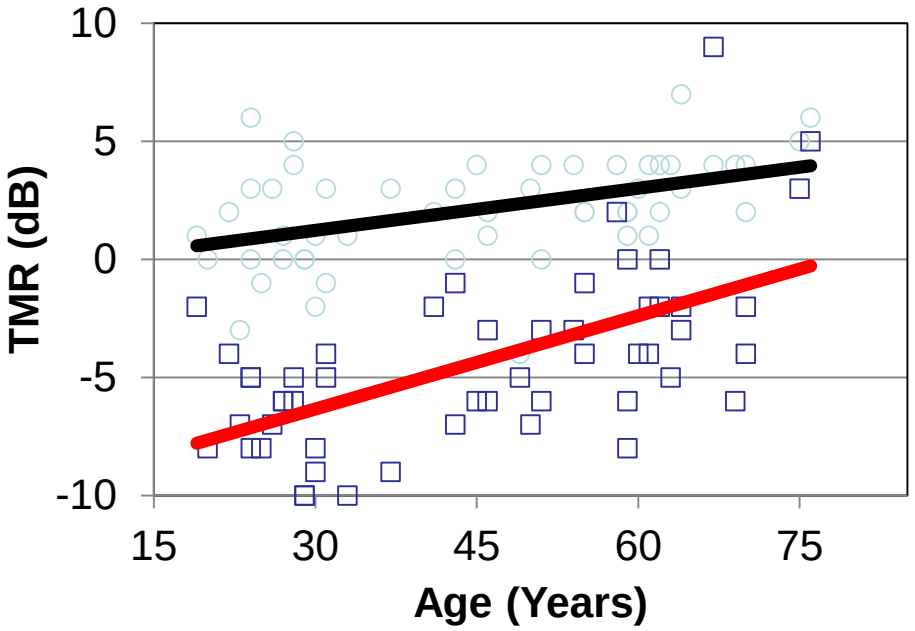
Binaural temporal processing changes with age



CAEPs as a biomarker of binaural fine structure coding.

Progressive decline of speech in competition
Speech spatial release (SSR)

- Greater TMR with age when T and M are colocated



- Spatial separation of T and M results in a spatial release advantage that declines with age

Adapted from Gallun et al.(2013)

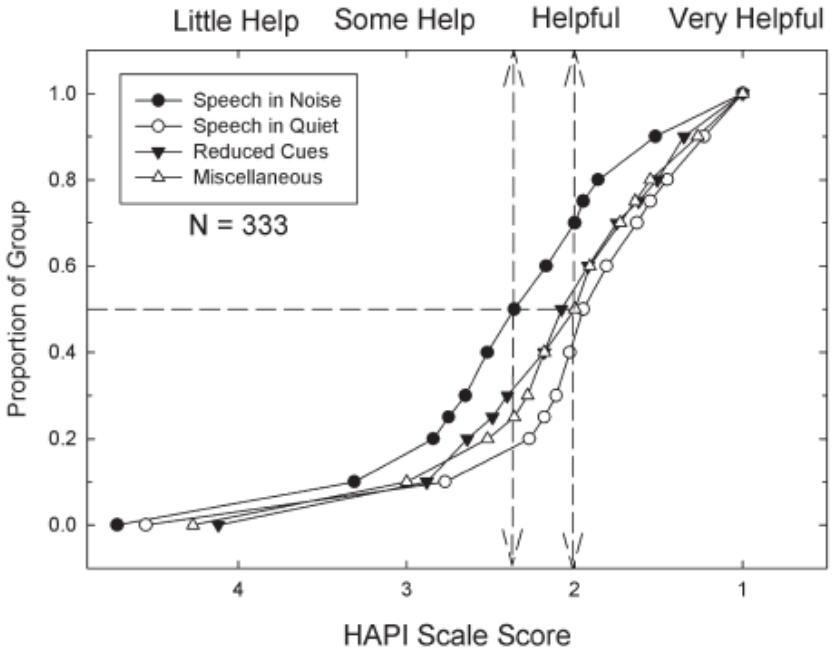
Tinnitus and aging
– perception of phantom sounds

- Incidence increases with age
- Prevalence peaks between 60 and 69 years at 14% (Shargorodsky et al., 2010)
- Very likely to be under-reported
- Impacts sleep, stress, psychological well-being, quality of life, and in severe cases, the will to live.
- Limited consideration in the context of presbycusis

MODERN REMEDIATION STRATEGIES

Amplification & AR

- With hearing loss, proper amplification can improve
  - Audibility & loudness perception
  - Speech perception in quiet
  - Speech perception in background competition
  - Perceived benefit (e.g., HAPI)



Greater improvement when combined with additional aural rehabilitation

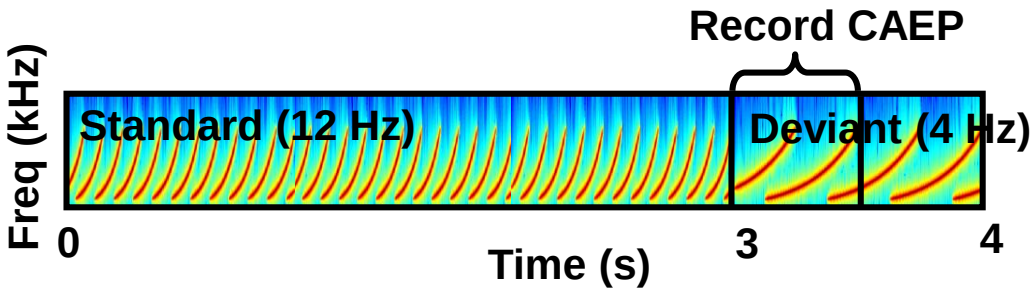
Humes et al. (2009)

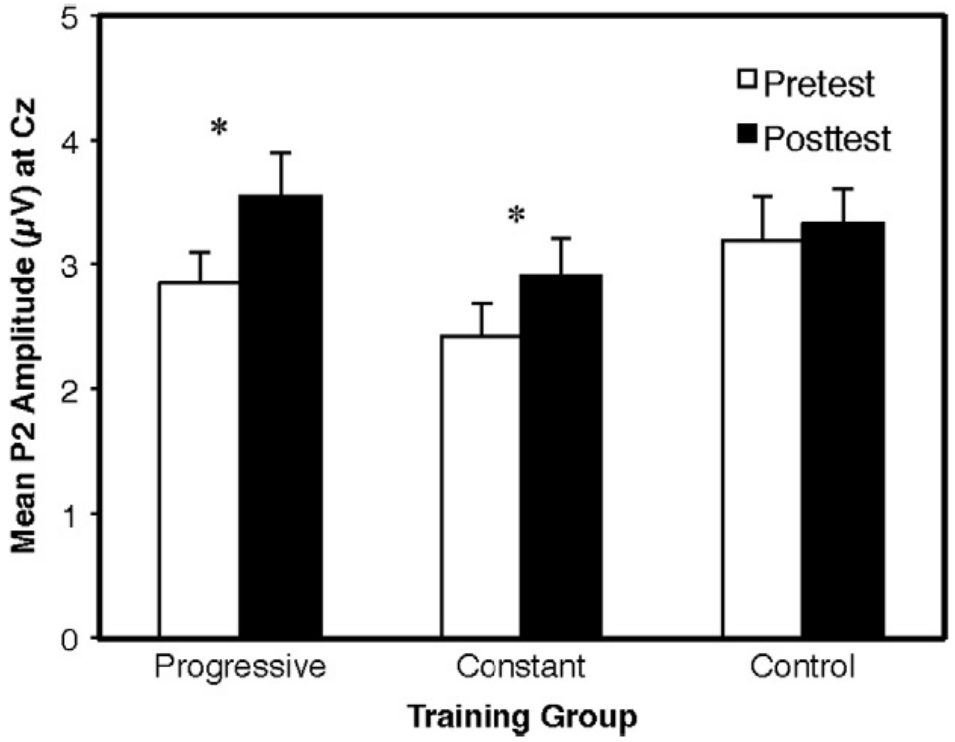
EMERGING REMEDIATION APPROACHES

Auditory Training: Physiological markers

- Discrimination of FM sweeps using constant or progressive training paradigms – measured CAEPs pre & post-training
- Significant changes in CAEP amplitudes

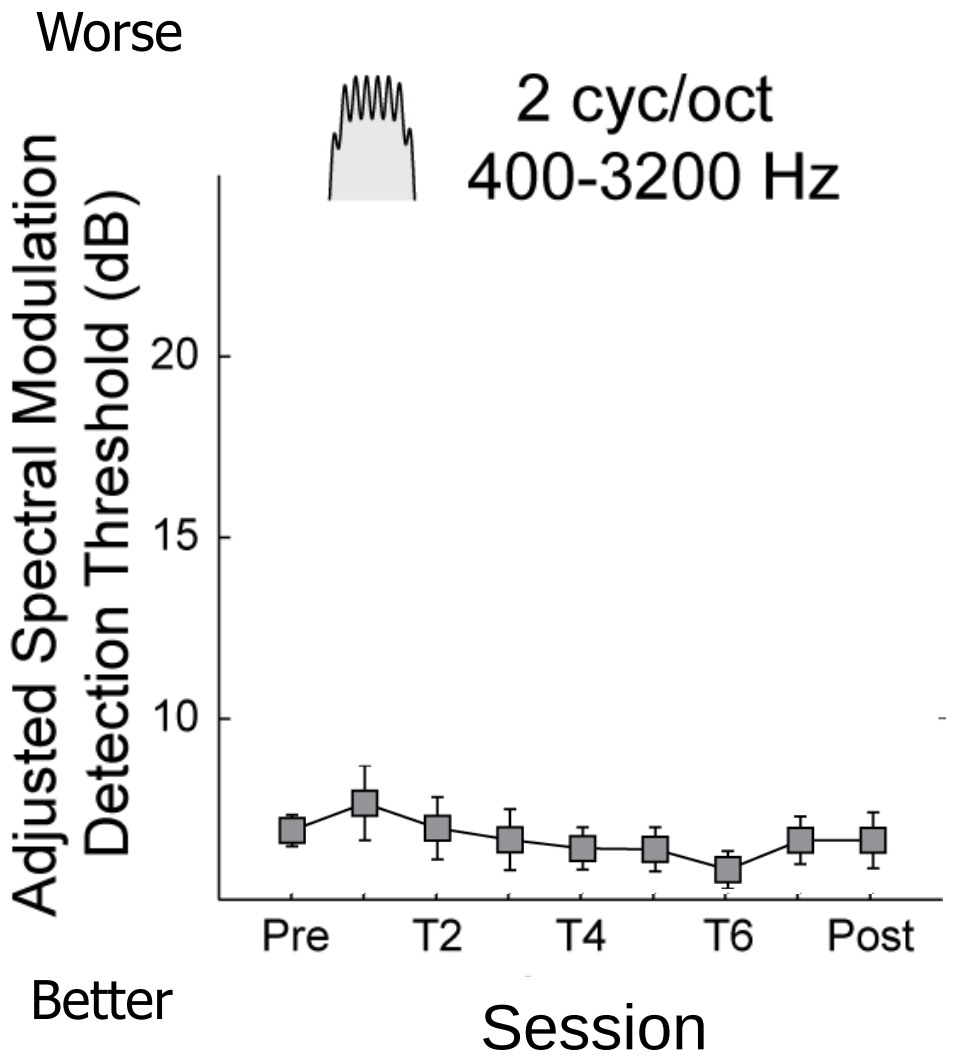
- **Would training with older adults lead to similar improvements?**





Orduna, Liu, Church, Eddins, Mercado (2012)

Perceptual Learning: Age *and* Hearing Loss



Do the influences that govern perceptual learning in older and younger adults?

If so, should training differ?

Sabin, Clark, Eddins, and Wright (2013)

Passive Treatments

- Pharmacology
  - Antioxidant therapy
  - Hormone modulation (e.g., Aldosterone)
  - Targeted modulation of cellular processes
  - Targeted modulation of neurotransmitters

- Augmented Acoustic Environments
  - Amplification → acclimatization
  - Sound generators → perceptual changes
    - Hyperacusis
    - Tinnitus

ALTERNATE SERVICE DELIVERY

Diagnostic Testing…

- Auditory Periphery – Cochlea to Auditory Brainstem
  - PT/ART/OAE/ABR
- "Central" auditory system – Well beyond AI
  - CAP battery
    - Largely speech-based
    - Involves many "neural networks"

- *Brainstem to Auditory Cortex*
  - Target temporal envelope, STM, Mon/Bin TFS, Streaming

PART

- Efficient psychophysics (rapid)
- Remediation targets (broader measures)
- Automated tests (resources)
- Portable (e.g., tablet computer)
- Profile of auditory dysfunction (norms, interpretation)

Portable Audiology

- Tele-Audiology
  - Asynchronous (e.g., send ABR results for interpretation)
  - Synchronous (e.g., remote testing)
  - Hybrid (e.g., remote testing and data sharing)
- Autonomous service delivery
  - Kiosks
  - Mobile apps
- Portable & automated tools
  - Testing (e.g.,AMTAS™, PART, NIH-Toolbox)
  - Fitting/Optimization (e.g., ISPS, SoundPoint)
  - Aural Rehabilitation
    - Education
    - Awareness
    - Training (gamification)
    - Treatment (e.g., sound therapy)

Summary

Hallmarks of age-related auditory dysfunction:

- Audibility
- Tuning
- Compression
- Temporal processing deficits
- Spectro-temporal processing deficits
- Spatial-temporal processing deficits
- Others

Emerging approaches to remediation

- Target specific perceptual deficits
- Make use of big data to find solutions to deficit patterns
- Capitalize on mechanisms of central auditory plasticity
- Pharmacological treatments for hearing deficits
- Alternative service delivery

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Thank you!
Questions or comments?

Auditory & Speech Sciences Laboratory (ca. 2015)

Job Opening: Full-time Research Audiologist