Optimizing outcomes with electric and acoustic stimulation (EAS): speech understanding, music perception, and auditory cortical activation

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A Sound Foundation Through Early Amplification

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DISCLOSURES

Member of Audiology Advisory Board for:

- Advanced Bionics
- Cochlear Americas
- Frequency Therapeutics

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Adrian Taylor, AuD

Bilateral CI = standard of care treatment for bilateral severe-to-profound SNHL

e.g., Balkany et al. 2008; Papsin & Gordon, 2008; Peters et al., 2010; Ramsden et al., 2012

What amount of acoustic hearing is beneficial in a bimodal hearing configuration?

2 primary theories of bimodal benefit:

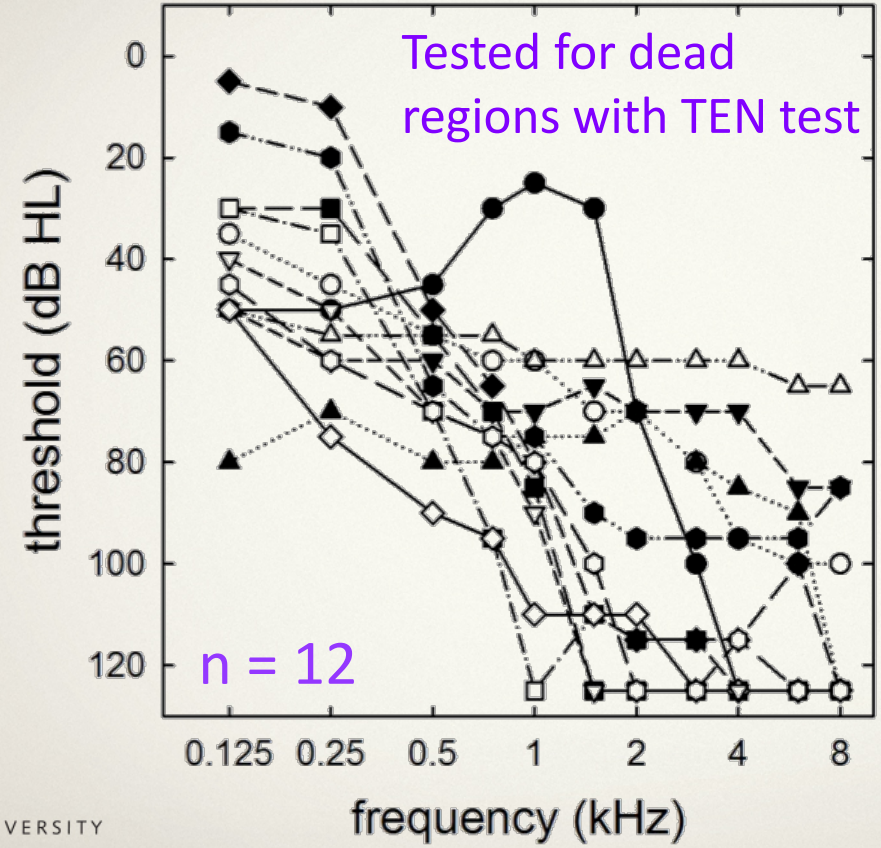
1) Segregation

- LF acoustic cues (e.g., F0 periodicity) → allow for comparison across the ears to form *perceptual streams* to separate the target from the background noise (e.g., Kong *et al*. 2005; Chang *et al*. 2006; Qin & Oxenham 2006)

2) Glimpsing

- spectral-dependent SNR varies over time, allowing for target to be "glimpsed" so that SNR modulations over time → better perception LF target (e.g., Kong & Carolyn 2007; Li & Loizou 2008; Brown & Bacon 2009)

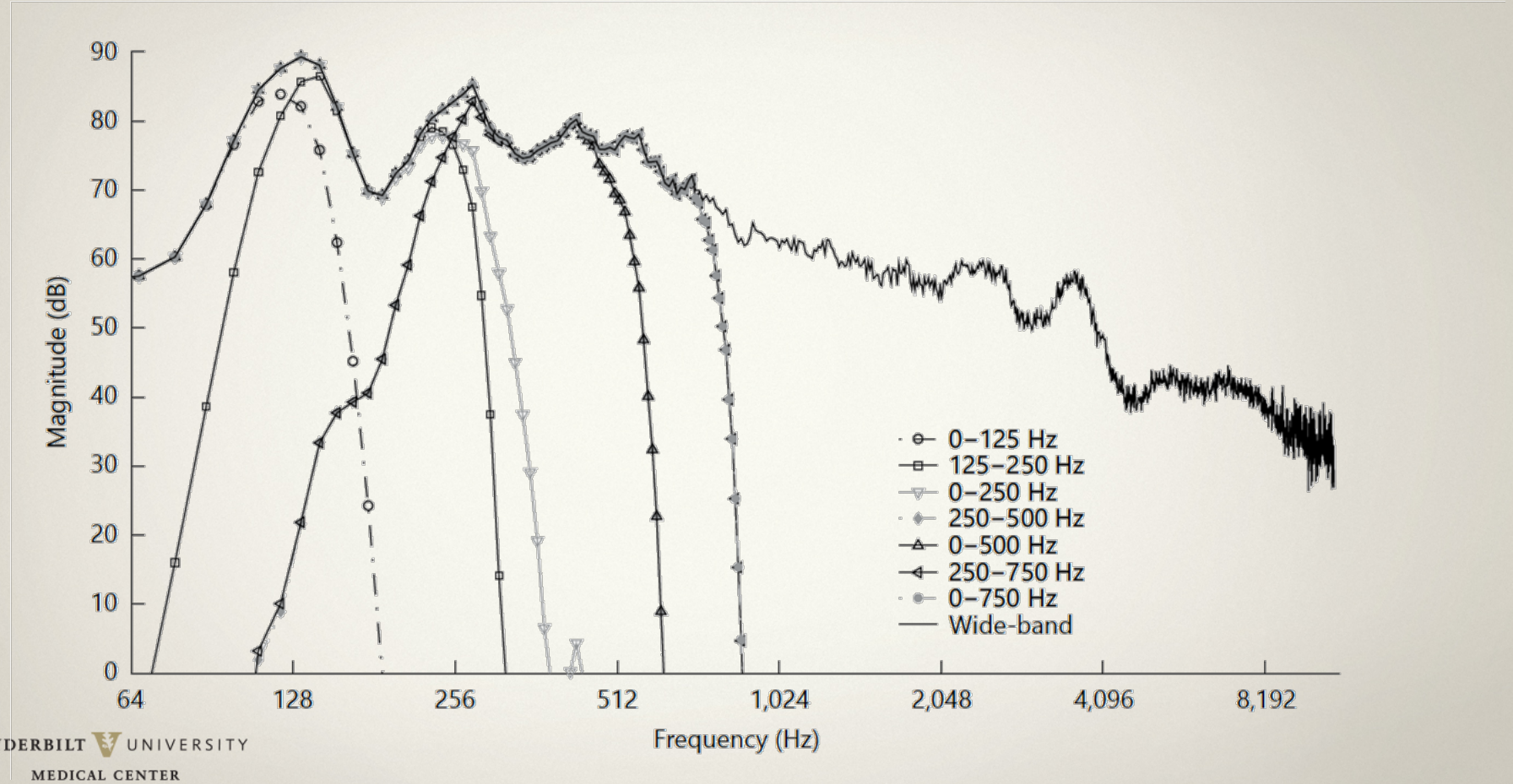
Sheffield & Gifford (2014). Audiol Neurotol, 19:151–163



Presentation level in non-CI ear →

65 dBA signal + NAL-NL1 amplification

Sheffield & Gifford (2014). Audiol Neurotol, 19:151–163



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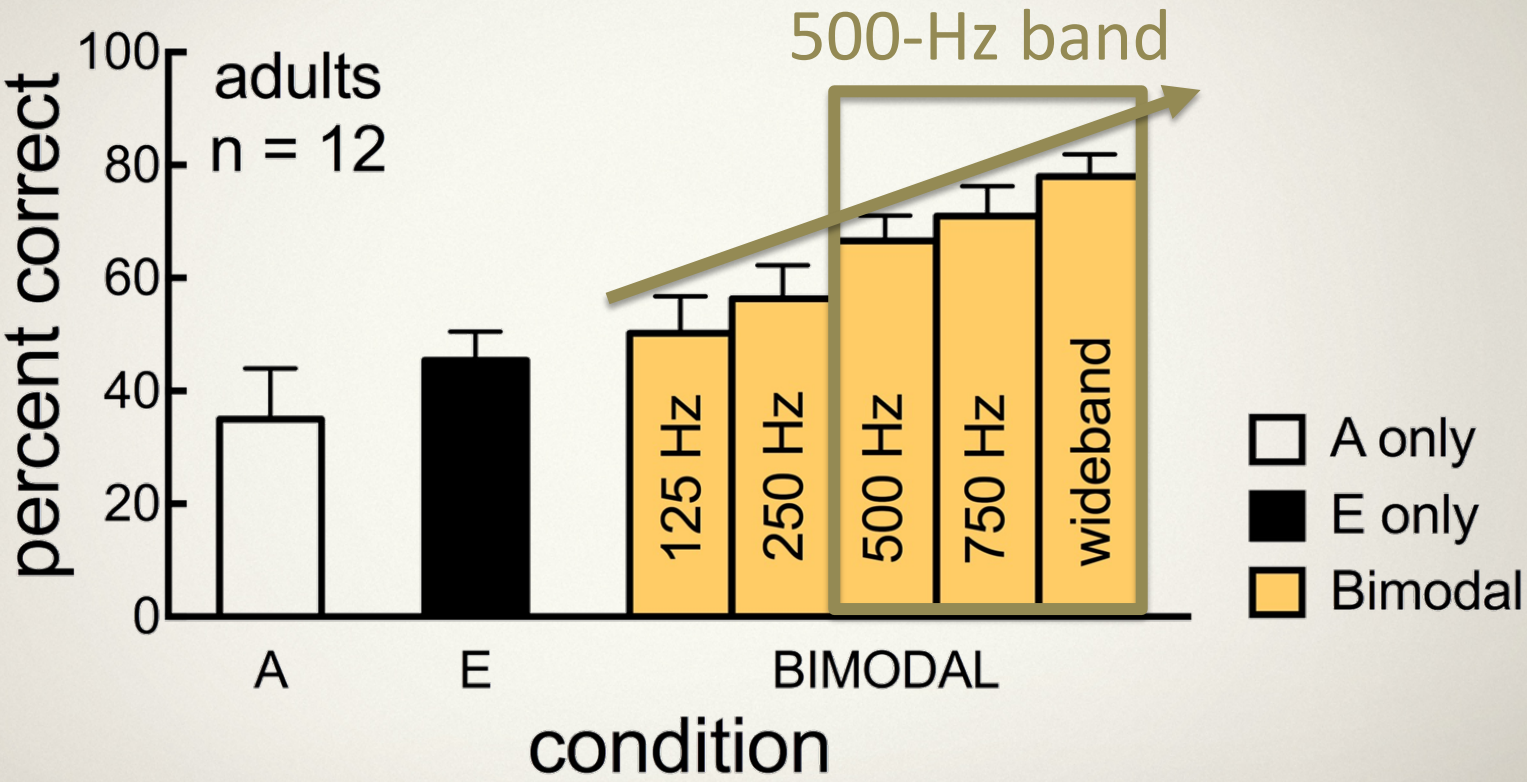
Sheffield & Gifford (2014). Audiol Neurotol, 19:151–163



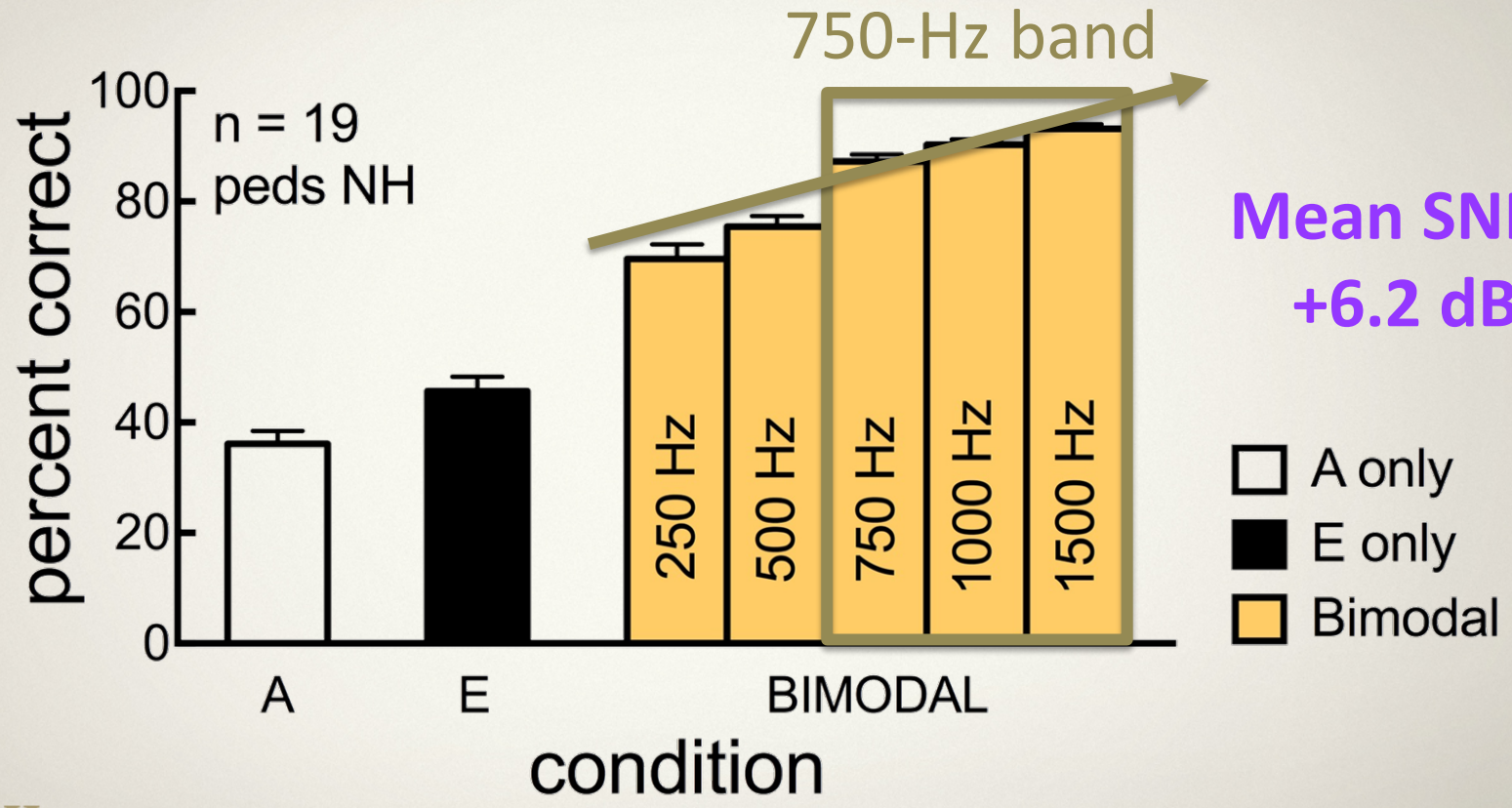
Sheffield et al. (2016). Ear Hear. 37: 282–288.

- Children (n = 19) & adults (n = 10) w/ normal hearing
- Mean age = 9.2 years
    - Range 6 to 12 years
- CI simulations (e.g., Litvak et al., 2007)
- Bimodal simulations: 90 dB/oct
    - <250, <500, <750, <1000, and <1500 Hz
- BabyBio sentences at variable SNR
    - SNR → ~50% for “CI-only” condition
    - Mean = 6.6 dB

Hypotheses

- Children will need a broader acoustic BW for bimodal benefit than adults.
    - Adults are better able to combine top-down and bottom-up processing.
    - Stelmachowicz et al., 2000, 2001, 2004, 2007; Pitmann et al., 2005
- Bimodal benefit will increase with increasing BW for children, as with adults.

Sheffield et al. (2016). Ear Hear. 37: 282–288.

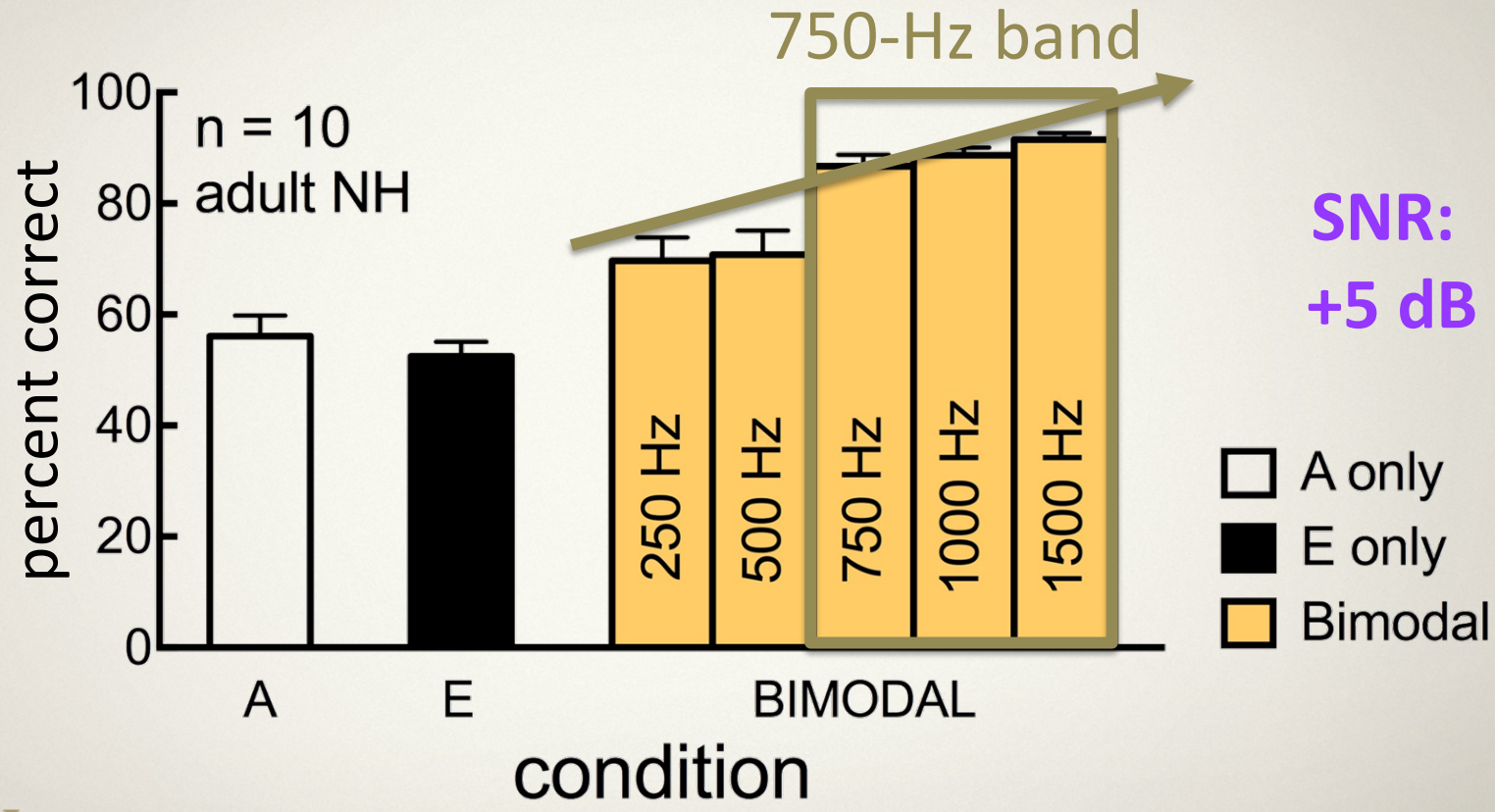


Mean SNR: +6.2 dB

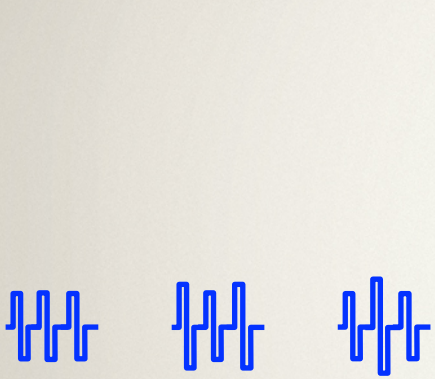
Sheffield et al. (2016). Ear Hear. 37: 282–288.

n = 10
adult NH

Sheffield et al. (2016). Ear Hear. 37: 282–288.

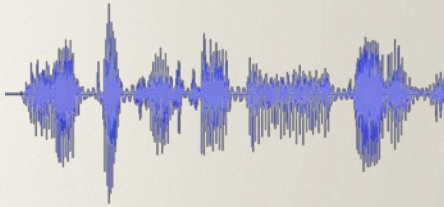


SIMULATIONS



NH

NH



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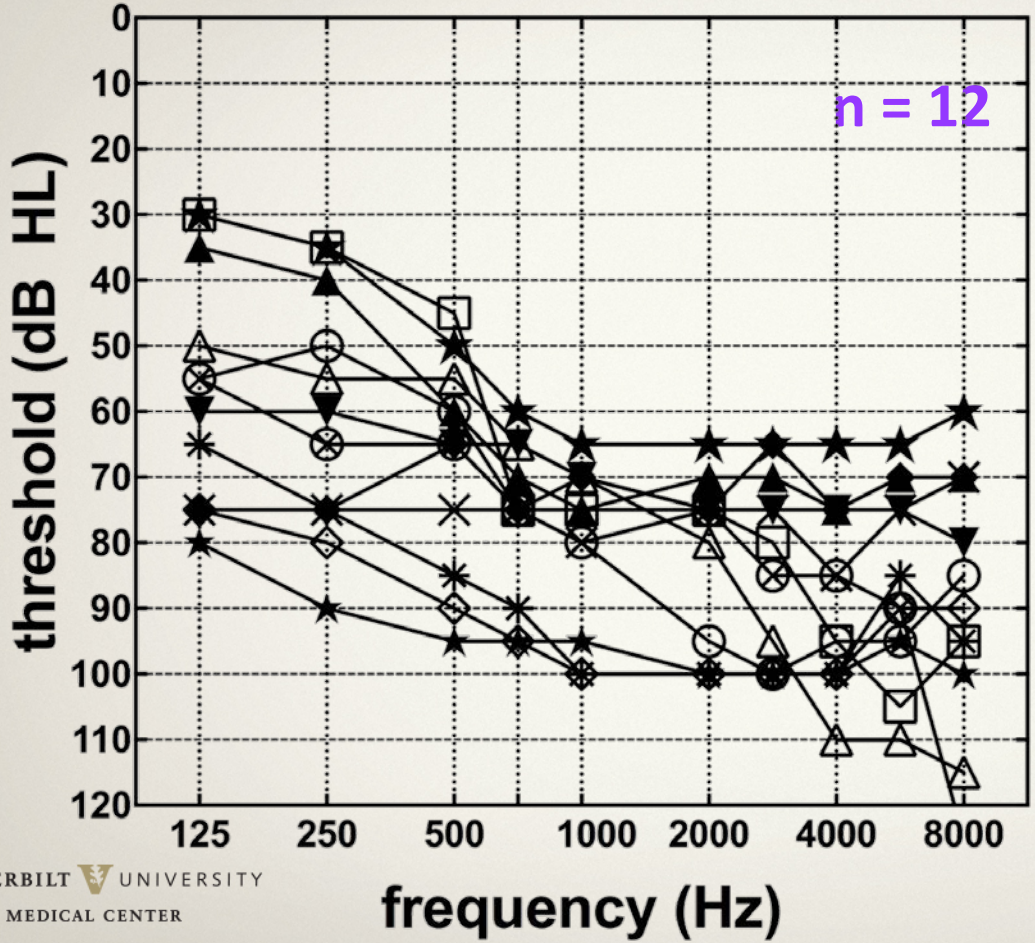
BIMODAL

CI  HA

Gifford et al. (in prep).



- Mean age: 9.5 yrs
  - range: 6.8 to 13.3 yrs
- 3 male, 9 female
- Mean age at CI: 6.5 yrs
  - range 1.3 to 10.7 yrs
- 65 dBA signal + DSL v5 amplification

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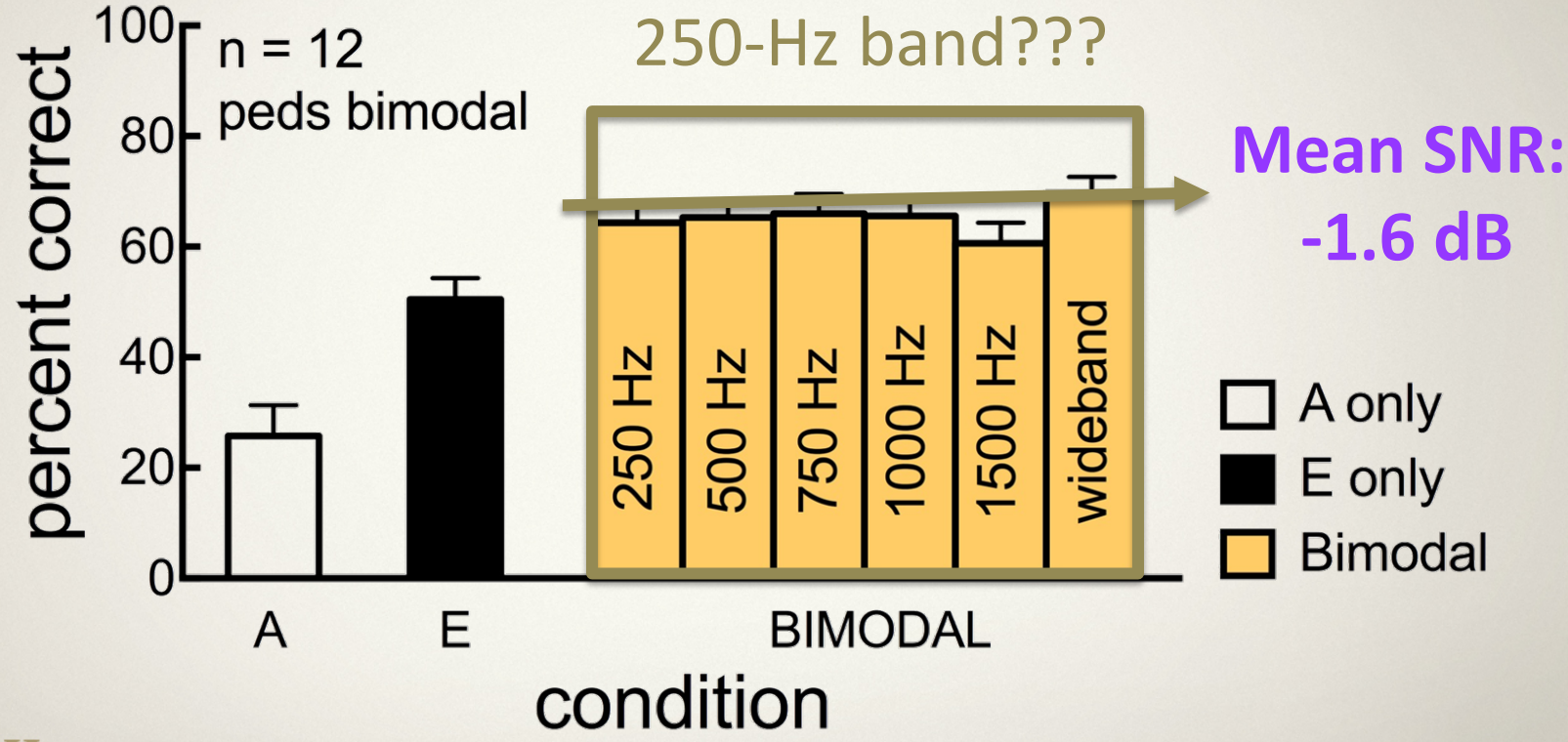
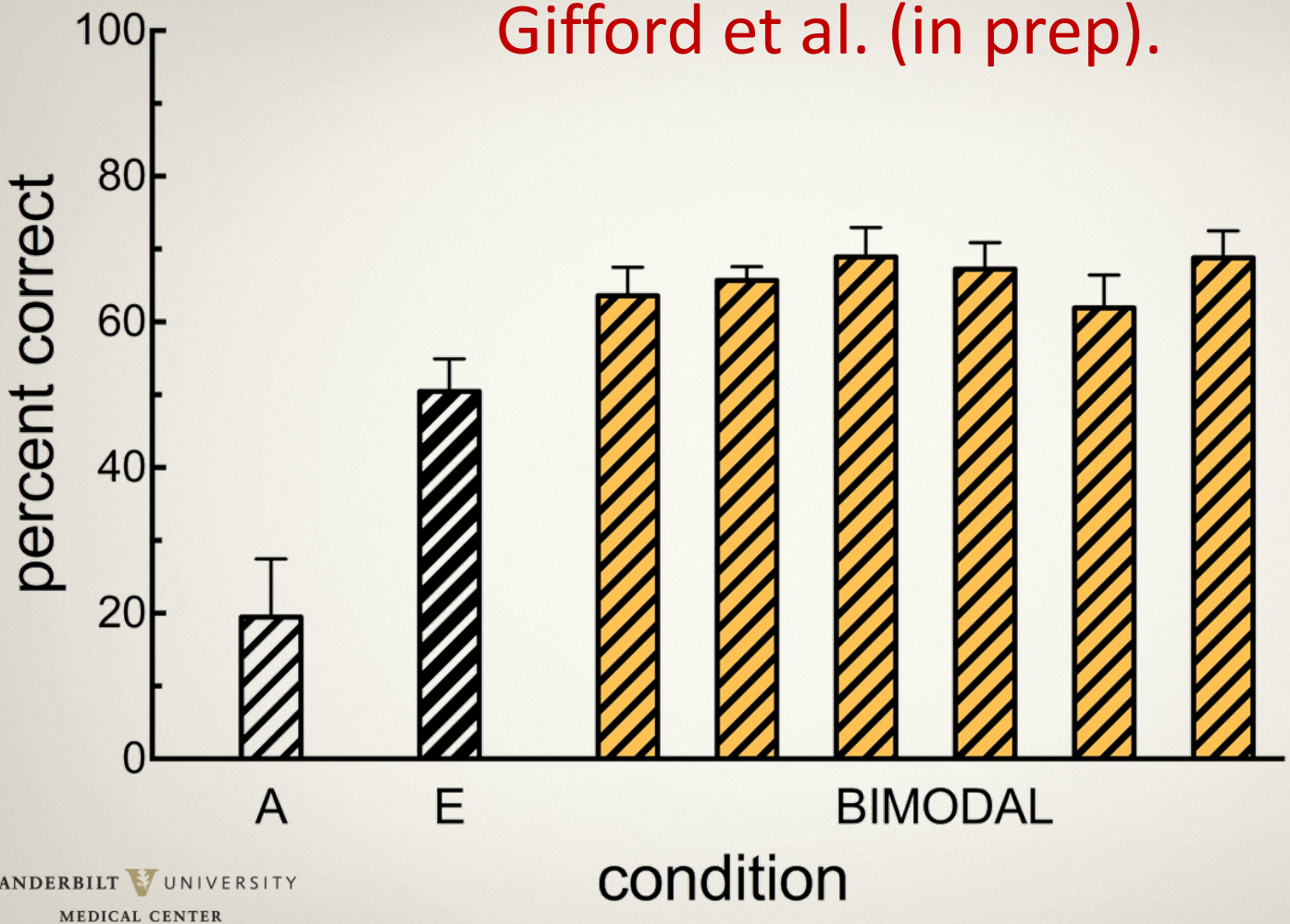
Gifford et al. (in prep).



Gifford et al. (in prep).

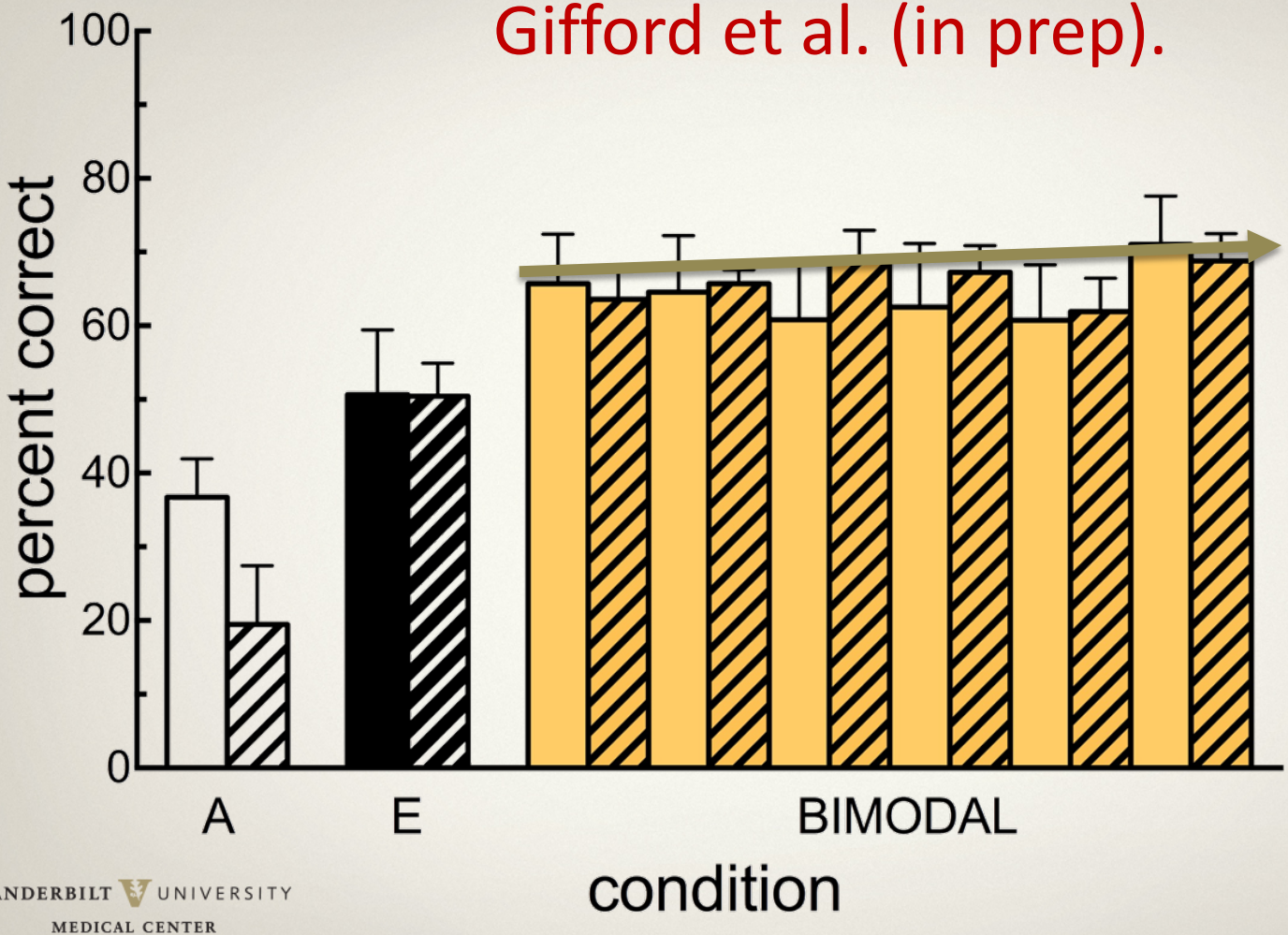


Mean + SNR: +2.5 dB

Mean - SNR: -3.9 dB

negative SNR

Gifford et al. (in prep).



Mean + SNR: +2.5 dB

Mean - SNR: -3.9 dB

postive SNR

negative SNR

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Summary

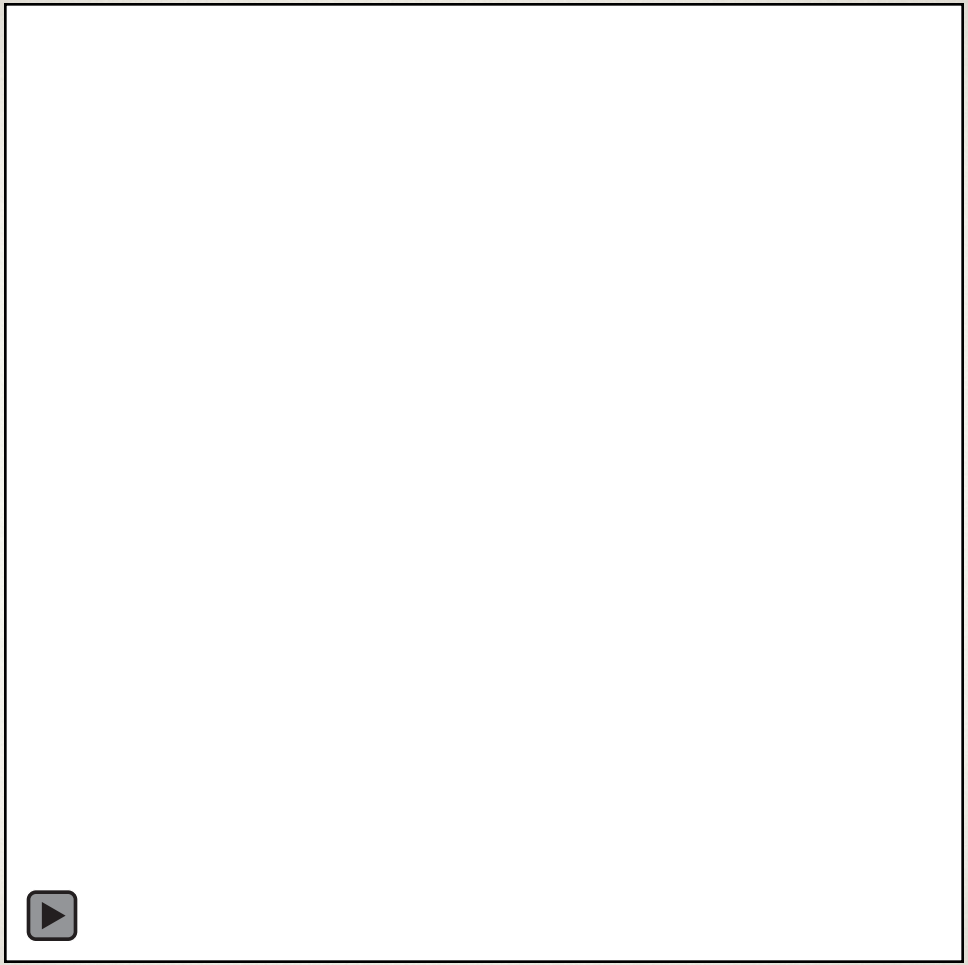
- Significant bimodal benefit observed with acoustic hearing < 250 Hz
- Children may be using *different cues* for bimodal listening (streaming > glimpsing?)
  - But, broader BW did not impair performance
- Clinical Rec: Aid that non-CI ear!

We spend a great deal of time talking about speech understanding.

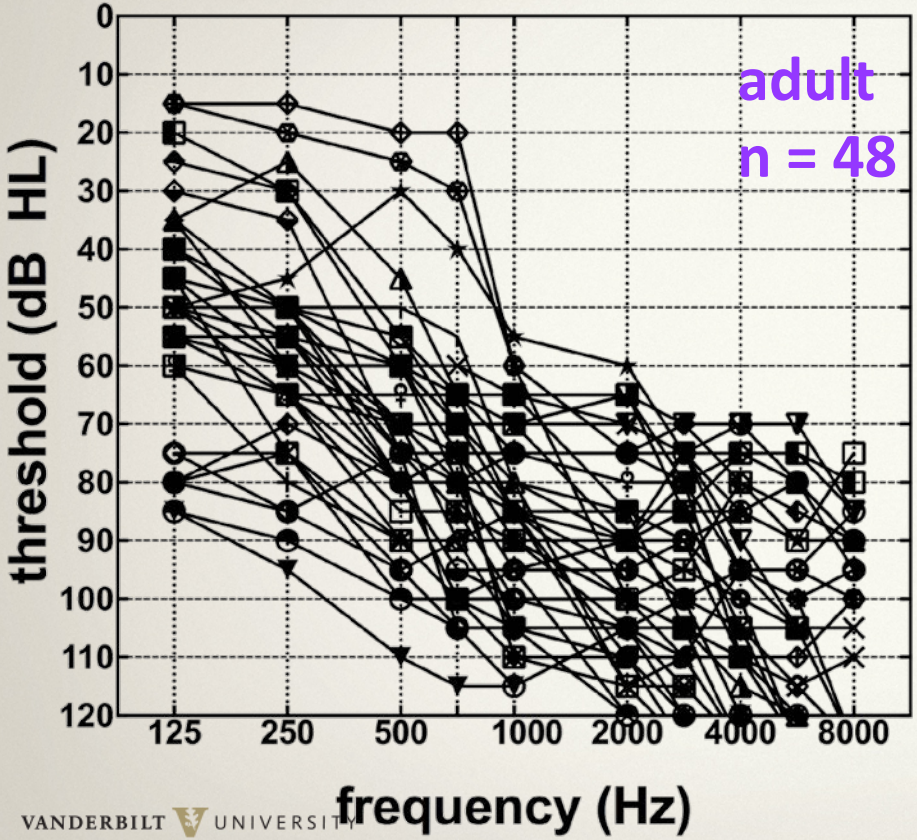
What about music?

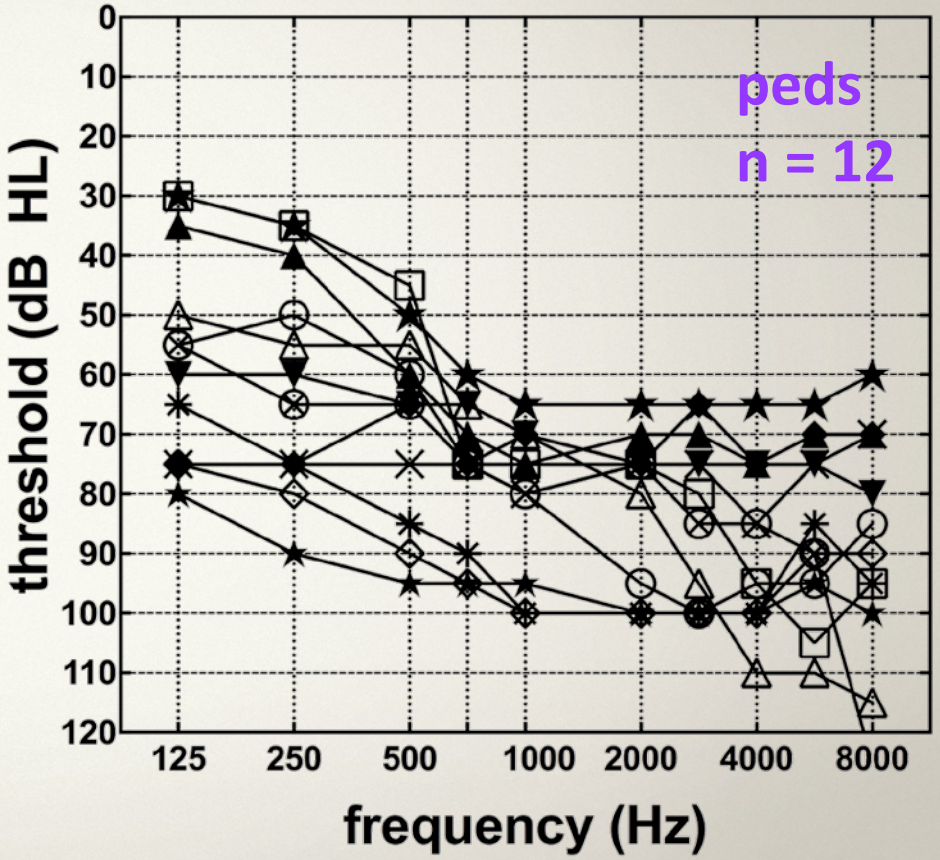
...and might children be different?


Mama
Hearing
at Van

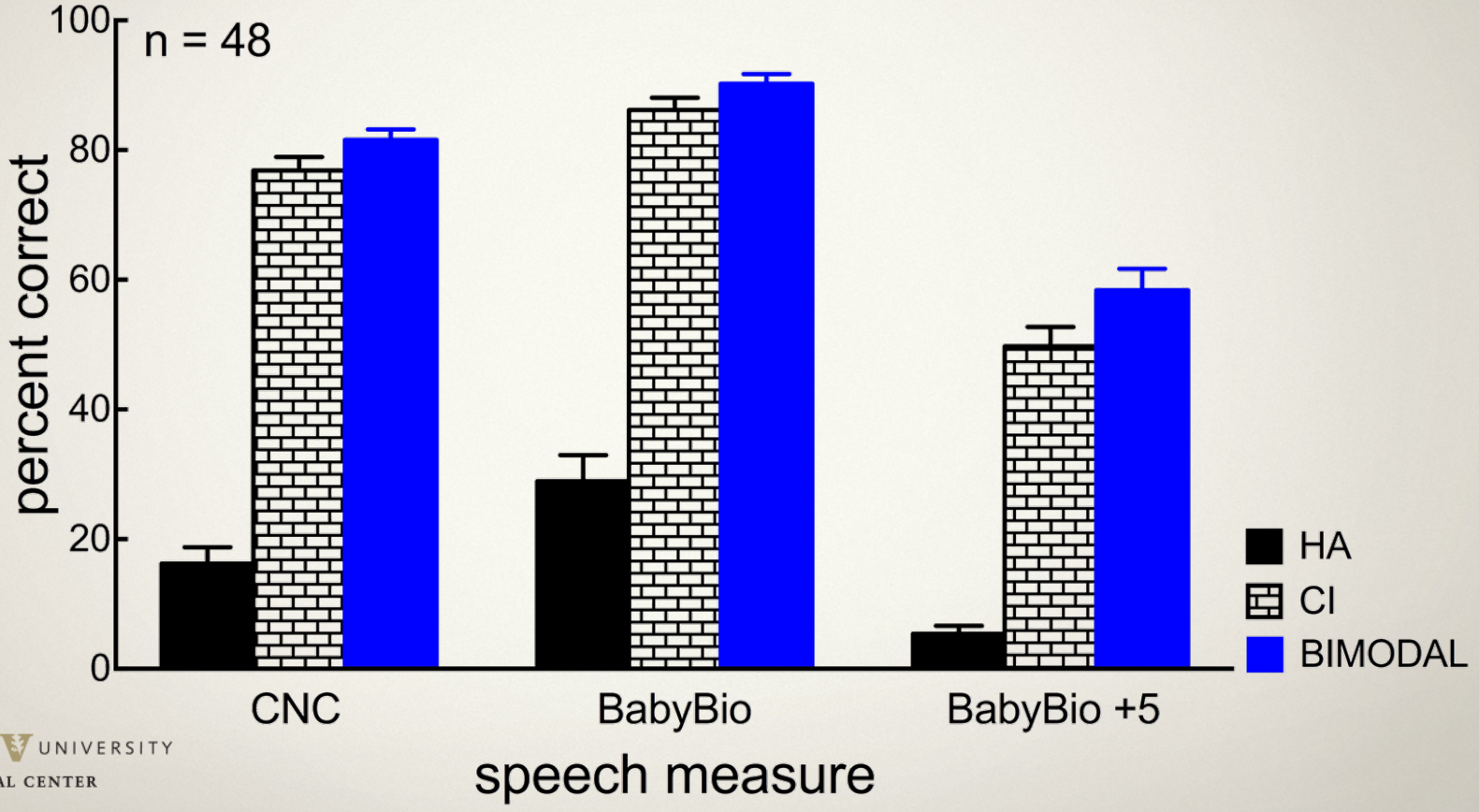


Review: bimodal benefit for speech understanding





Adult bimodal listeners



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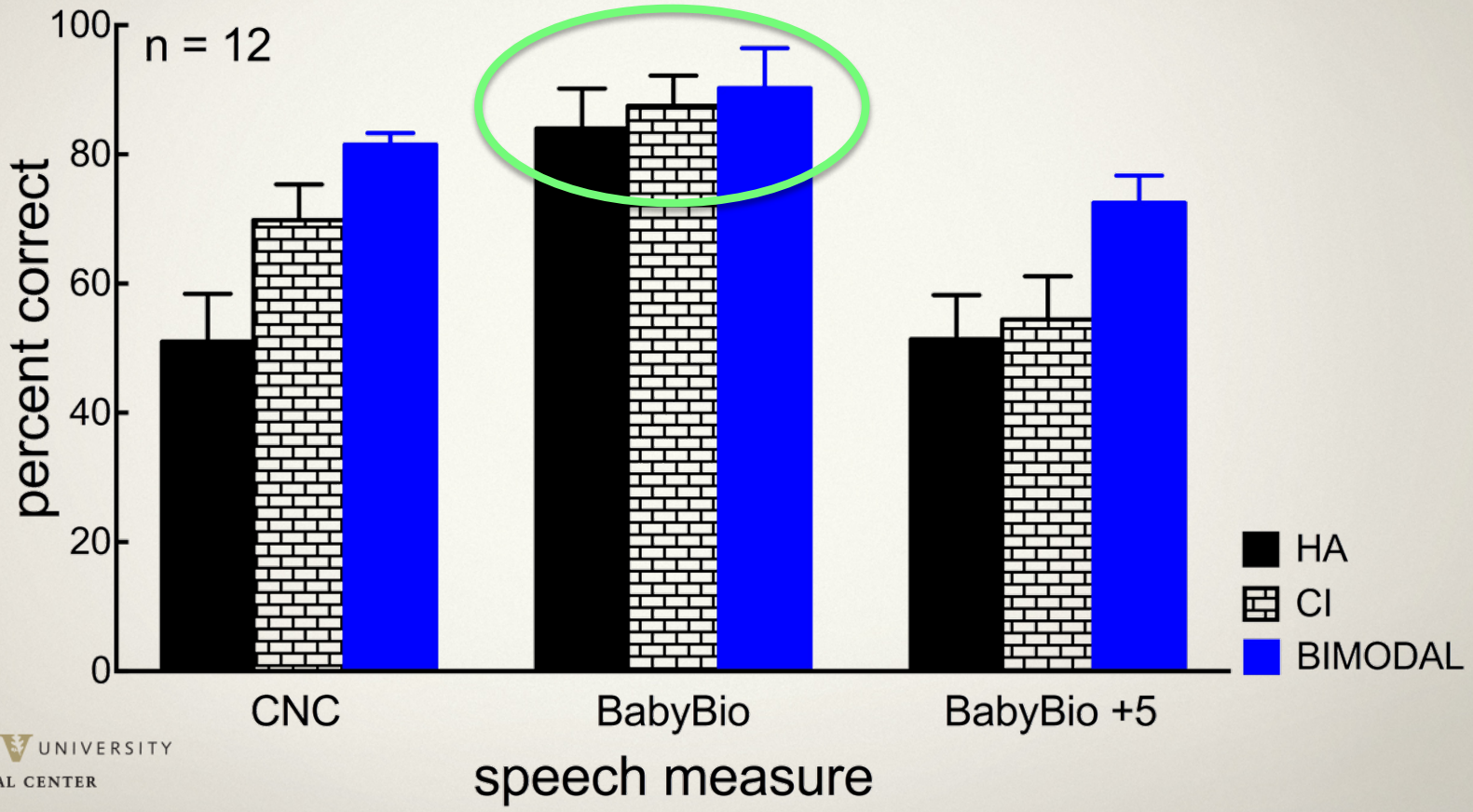
Pediatric bimodal listeners



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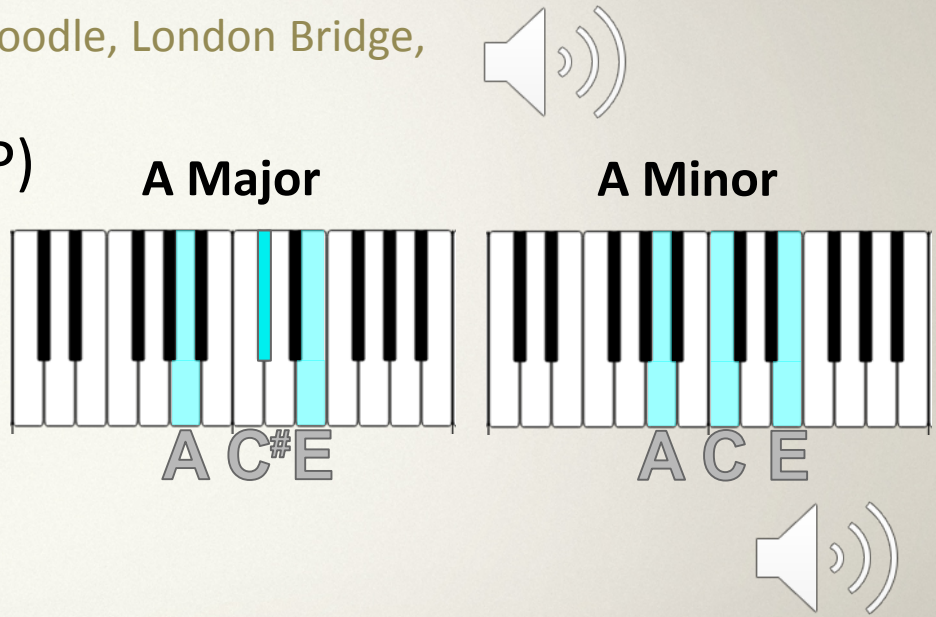
Speech & music perception: bimodal adults and children

Behavioral measures:

- isochronous melody recognition
  - ABC song, Old MacDonald, Yankee Doodle, London Bridge, This Old Man, BINGO, Frere Jacques
- pitch discrimination (UW-CAMP)
- chord discrimination



Subjective qualitative judgments:

- visual analog scale (VAS)
- favorite music

Neuroimaging

- Functional near infrared spectroscopy (fNIRS)

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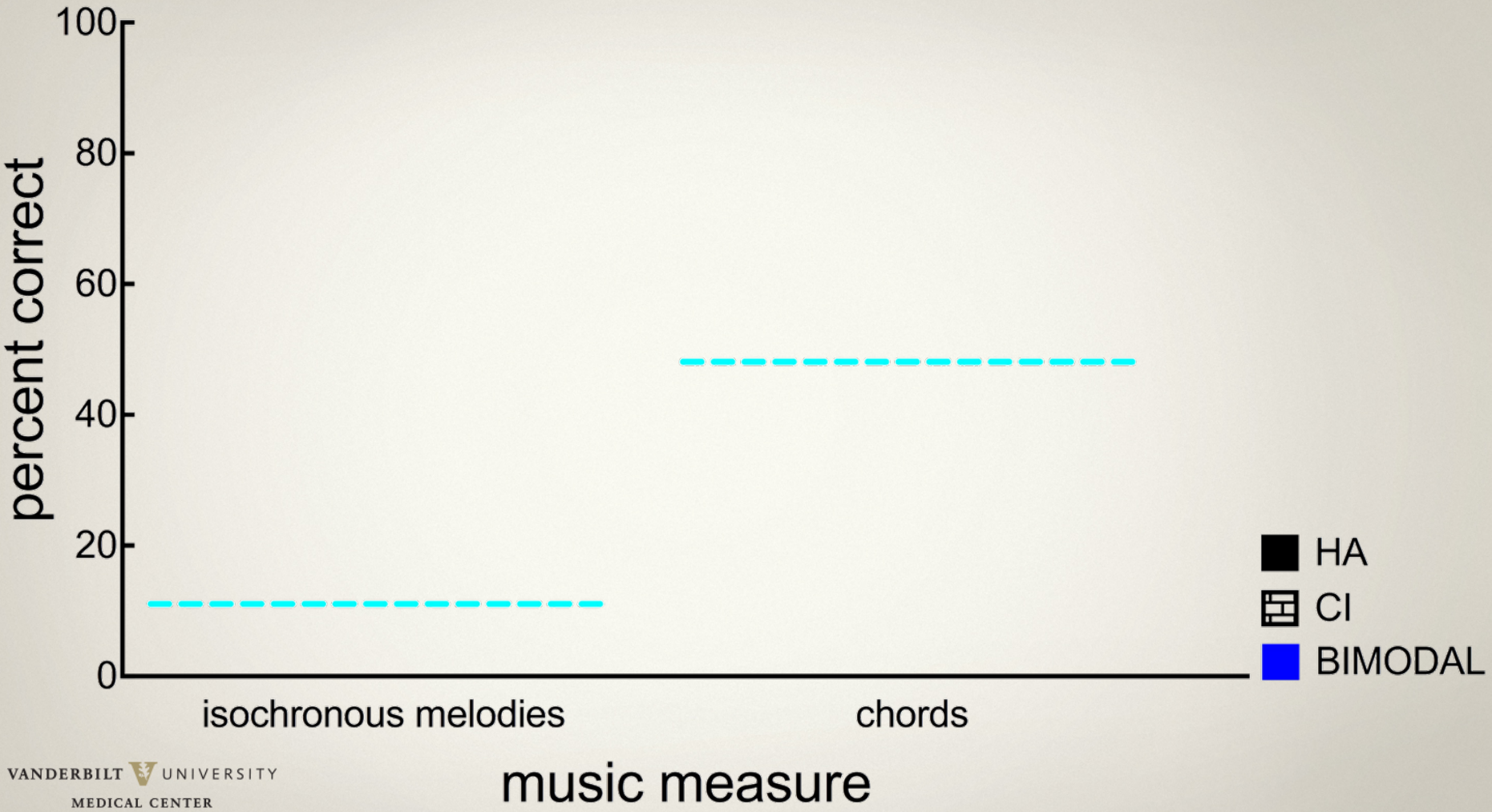
Neuroimaging

- Functional near infrared spectroscopy (fNIRS) → More later!

- HA alone
  - DSL v5
- CI alone
  - 20-25 dB HL
- BIMODAL

- n = 4
- 10, 12, 15, & 17 years



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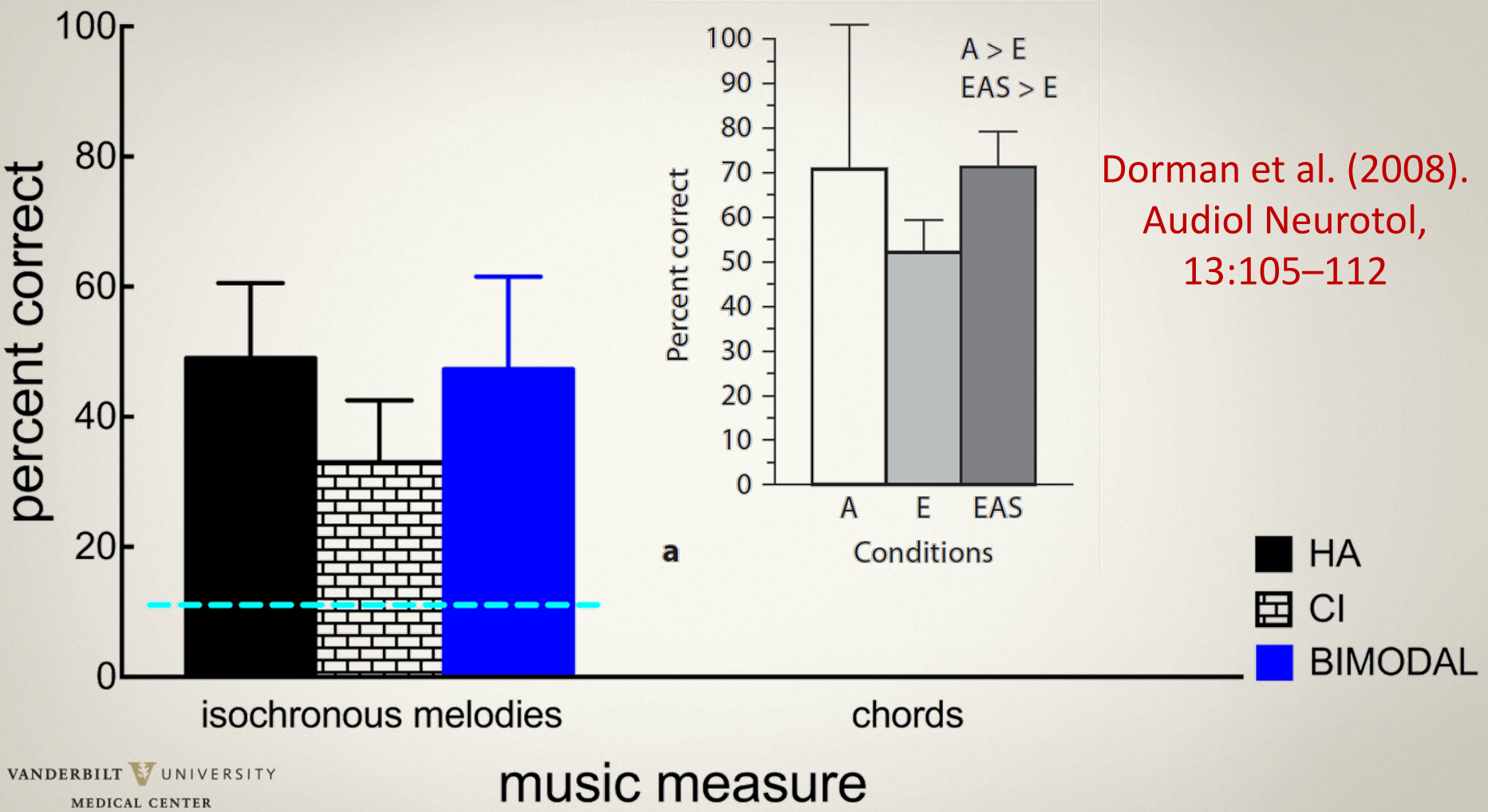

Dorman et al. (2008). Audiol Neurotol, 13:105–112

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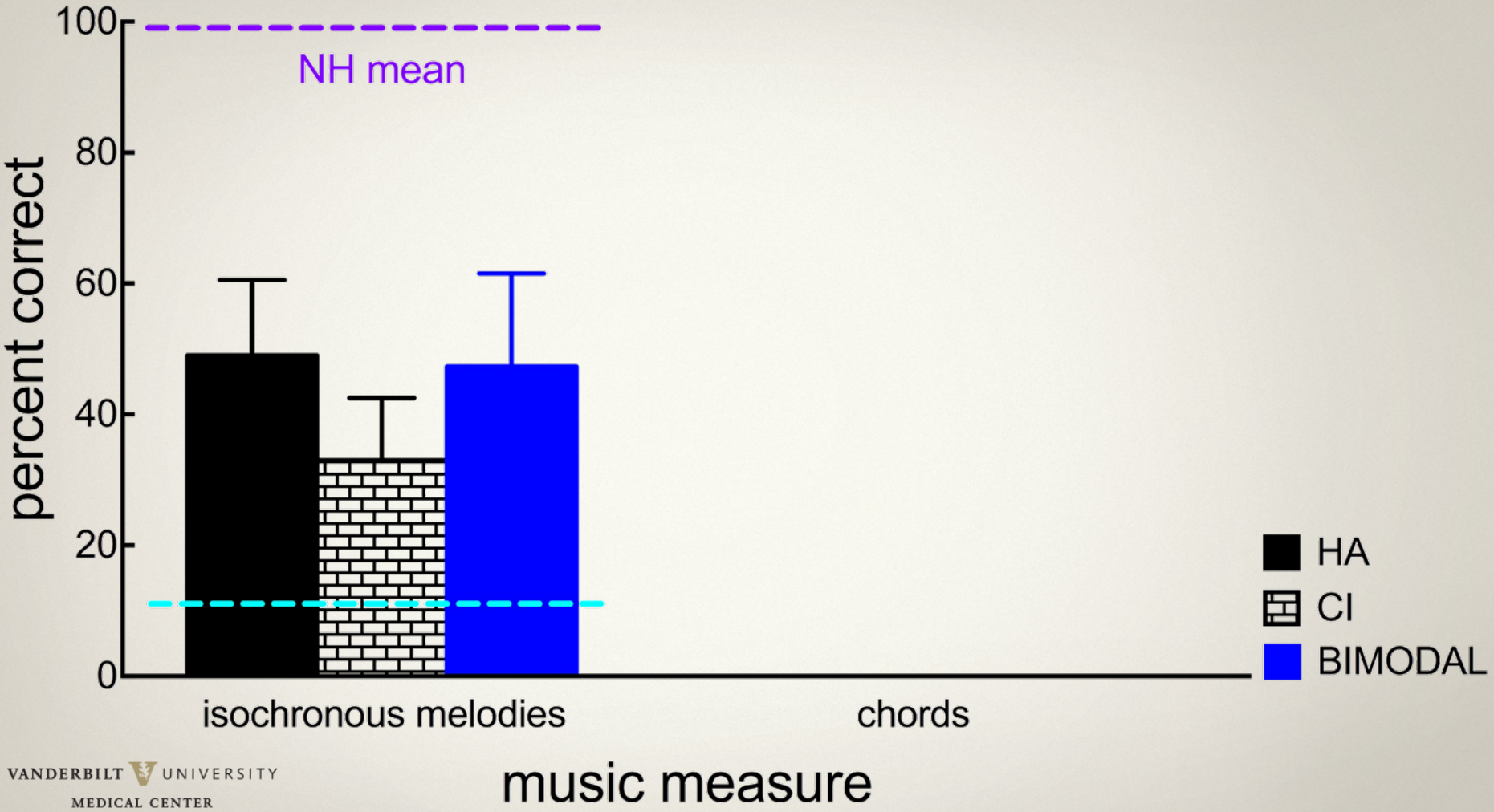

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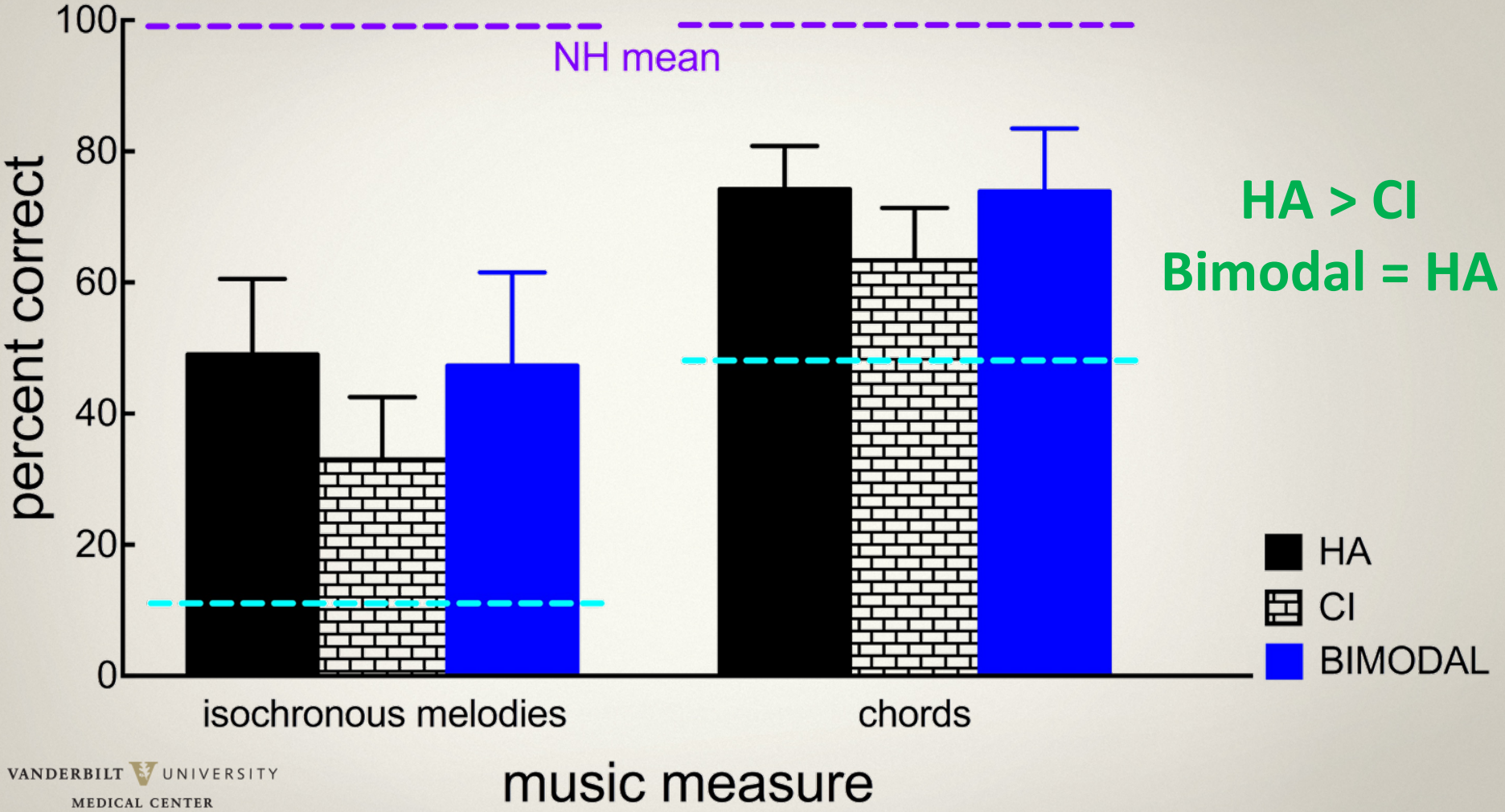

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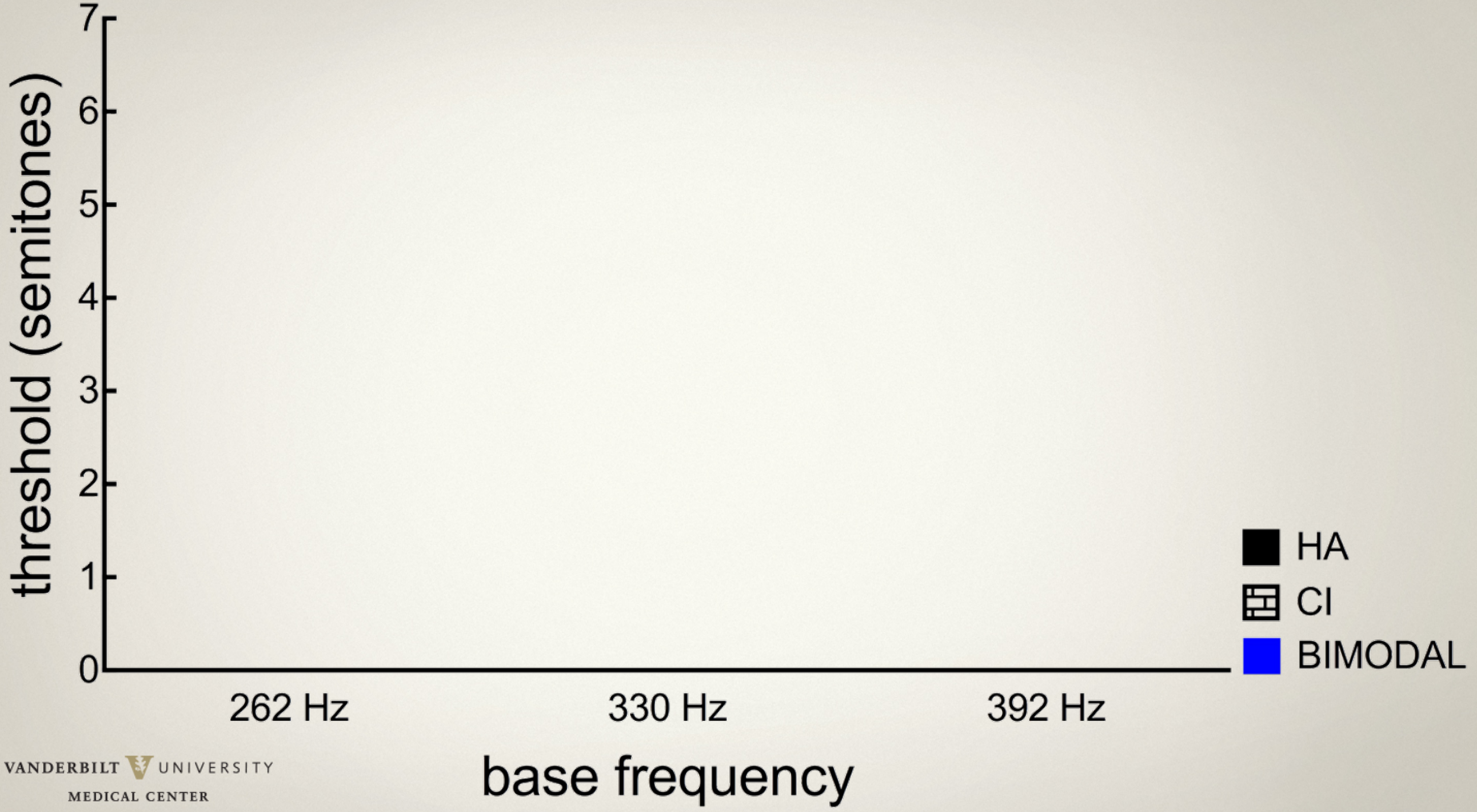

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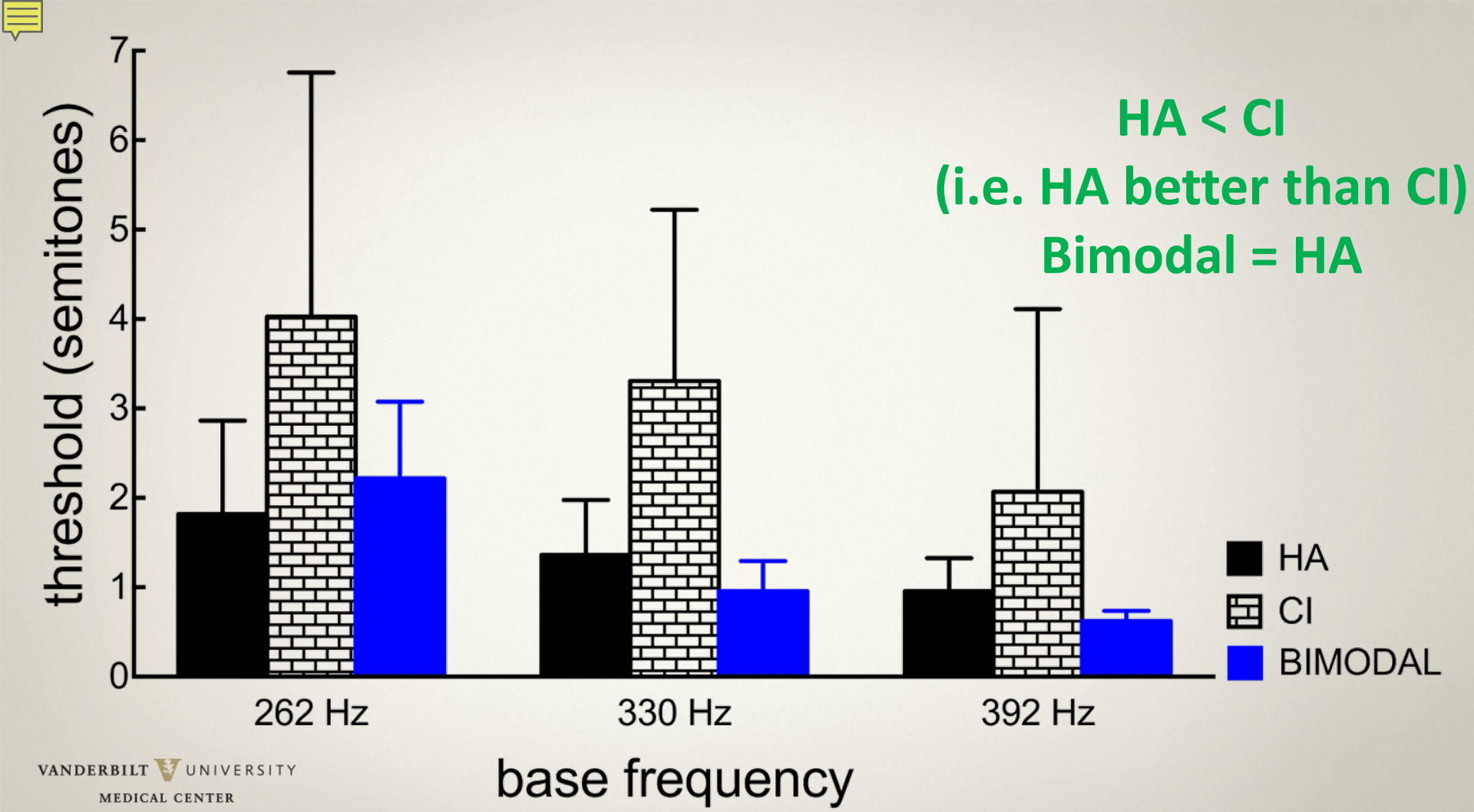

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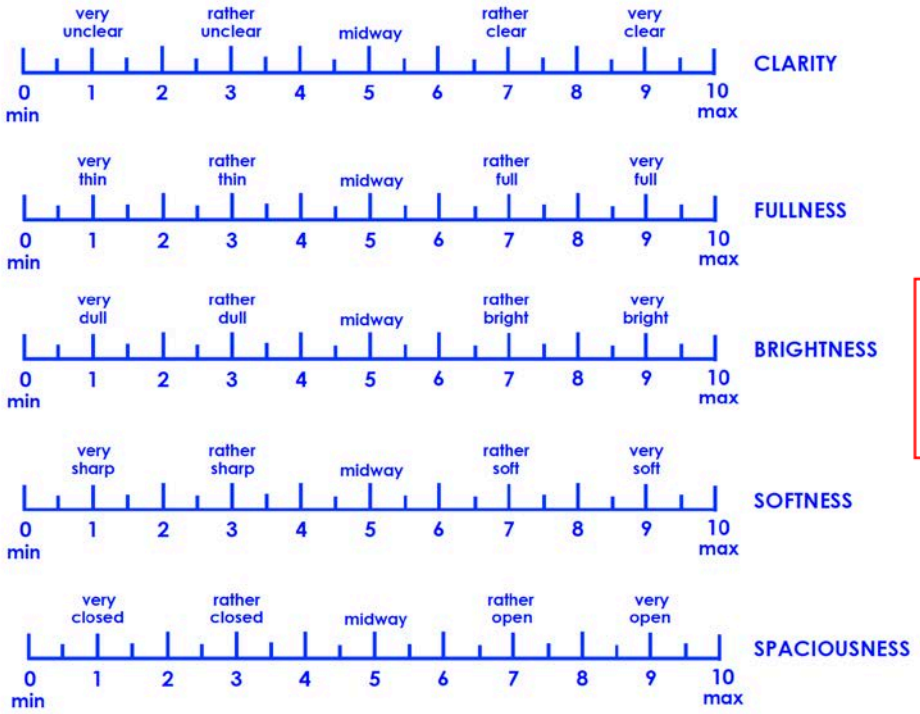
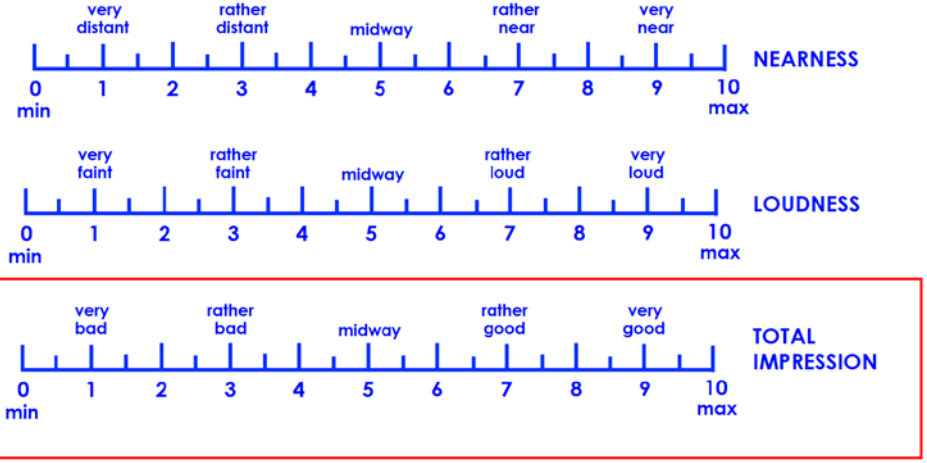
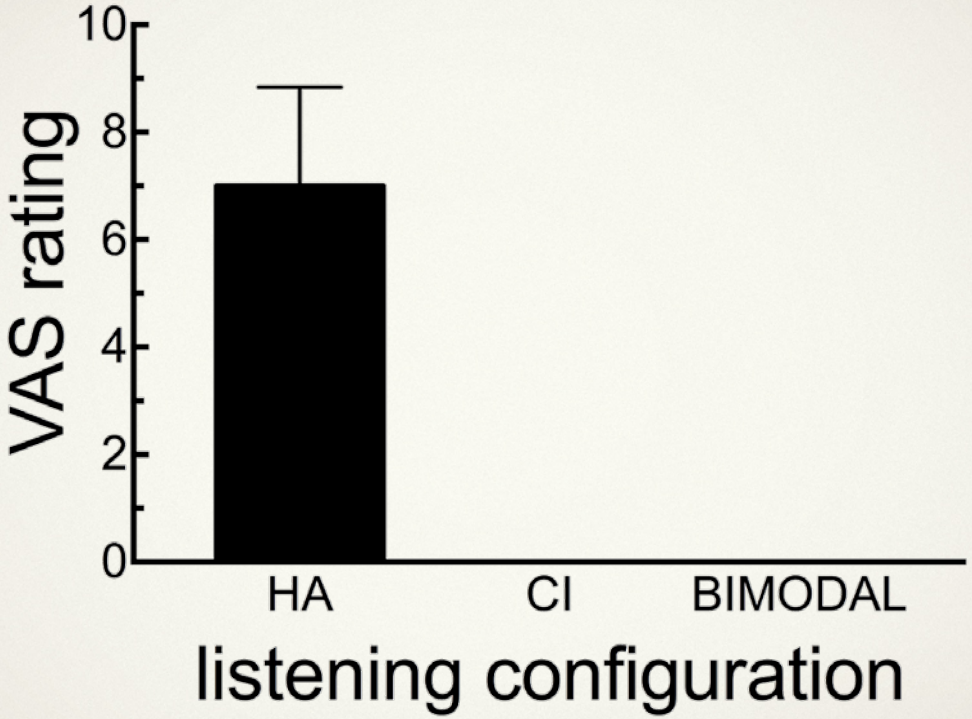
Subjective ratings: Judgment of sound quality

Gabrielsson et al., 1988. JSLHR. 31:166-177.

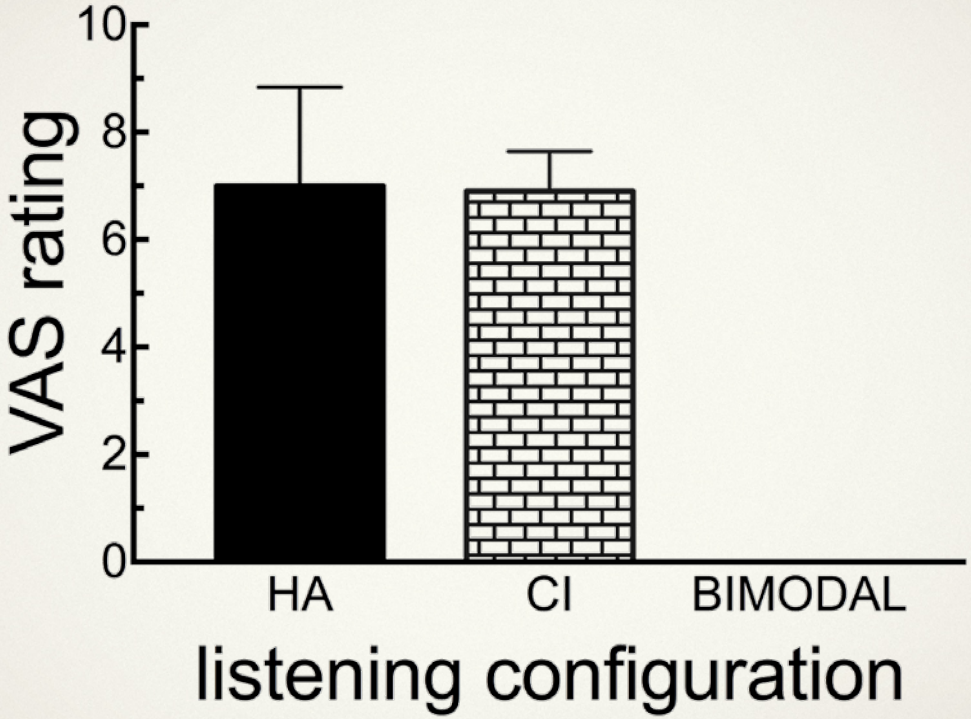




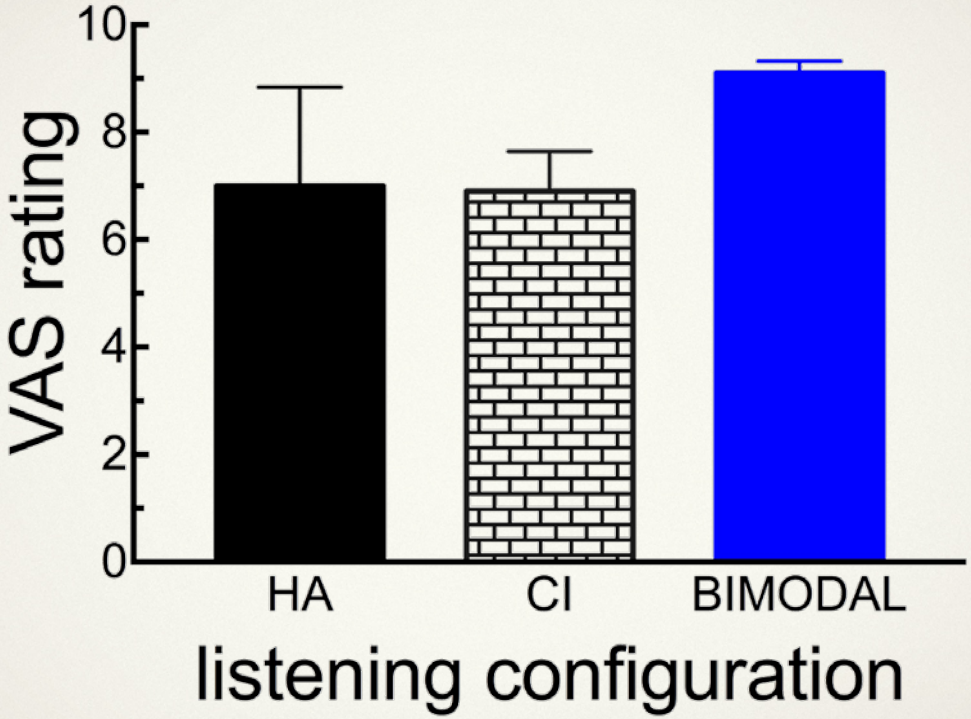
Subjective ratings



Subjective ratings



Subjective ratings



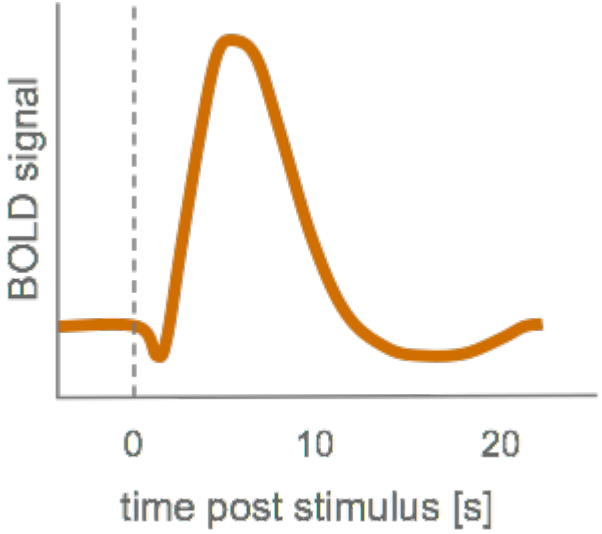
Functional neuroimaging

Functional neuroimaging for speech & music perception

- Could be beneficial to guide clinical decisions and counseling, particularly in young children
  - Candidacy recommendations (re: 2nd CI)
  - Therapy recommendations
  - Counseling for expectations
  - Programming strategies

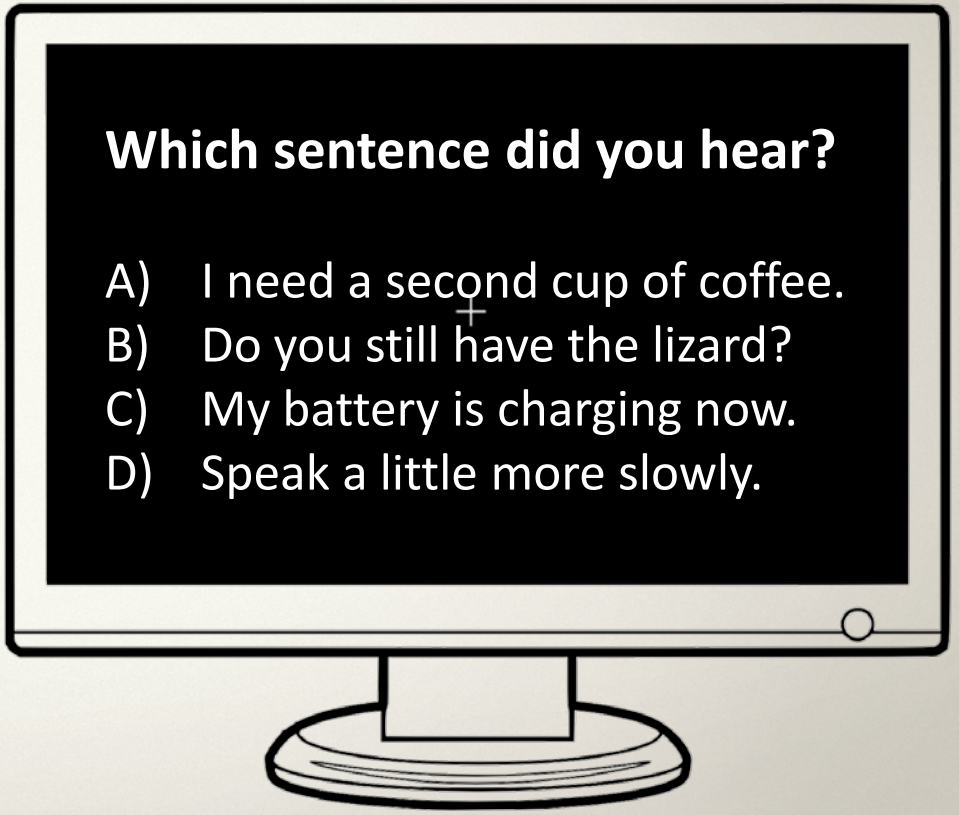
Functional near-infrared spectroscopy (fNIRS)

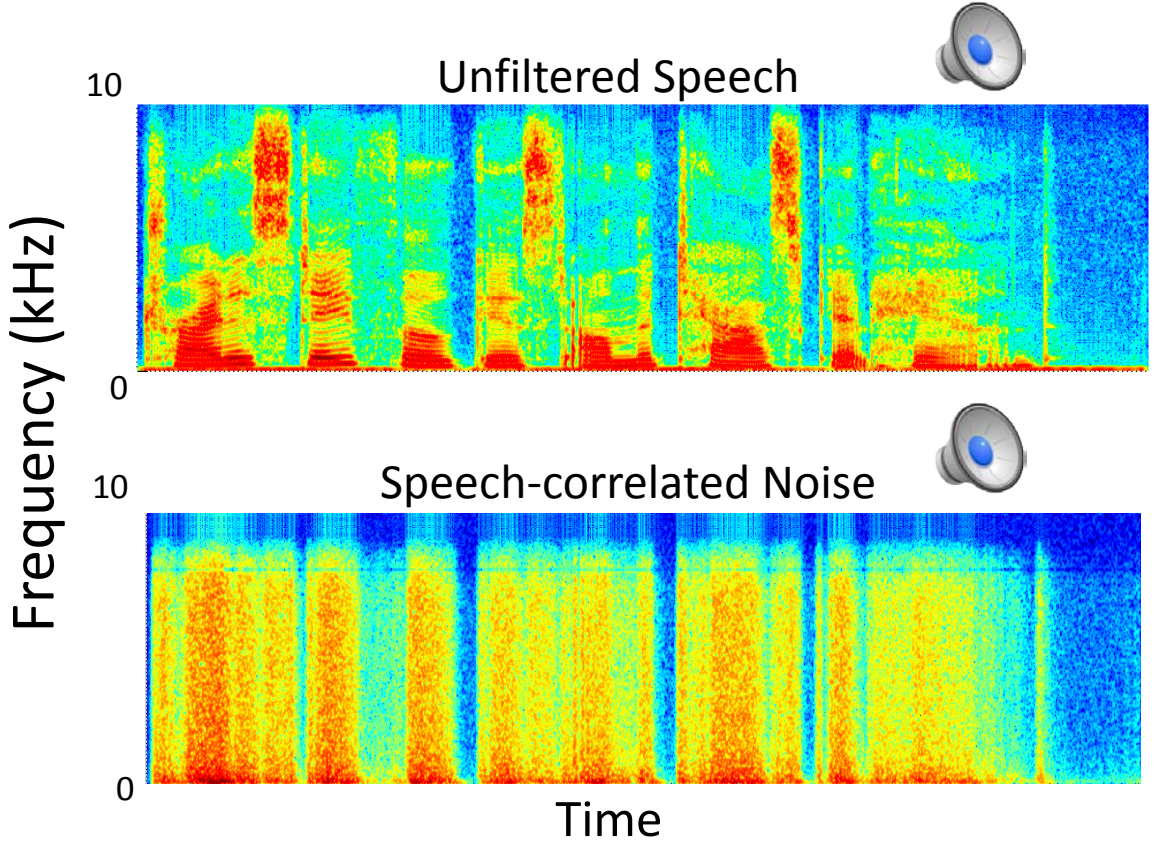
- BOLD signal
- Safe with CIs
- No electrical artifact
- Pediatric friendly

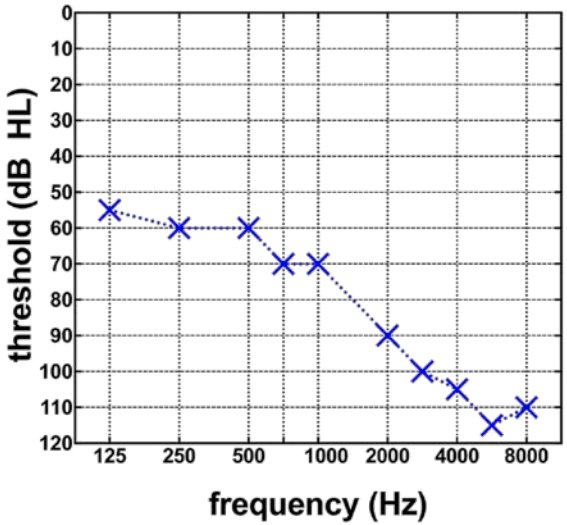


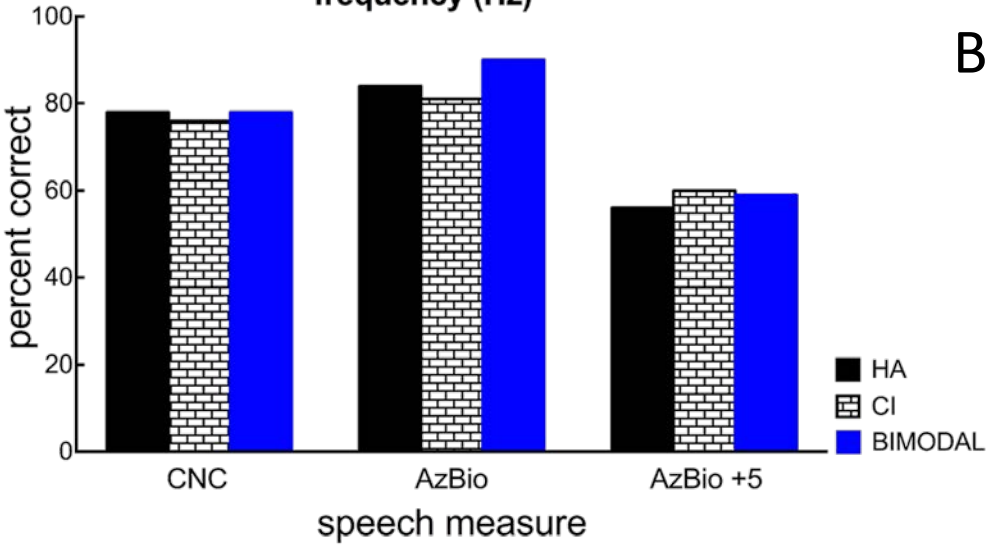
Methods

- Passive listening task
- 9 sentences per 20s block
- Multiple-choice question after each block (to maintain attention)

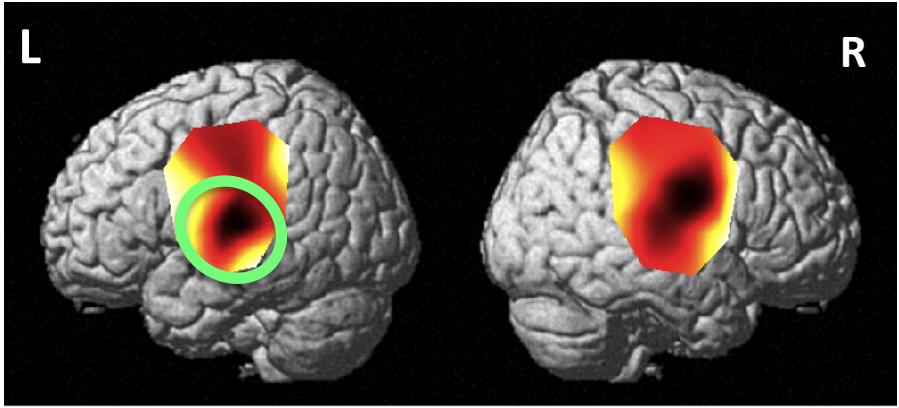



Unfiltered Speech
10
0
Speech-correlated Noise
10
0
Frequency (kHz)
Time

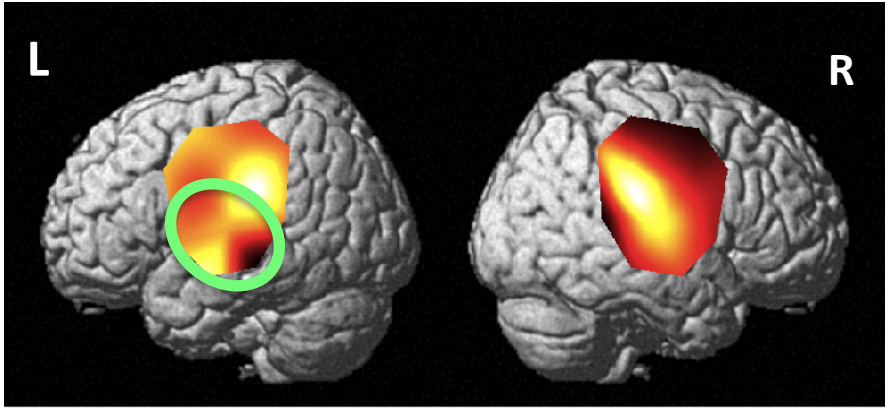


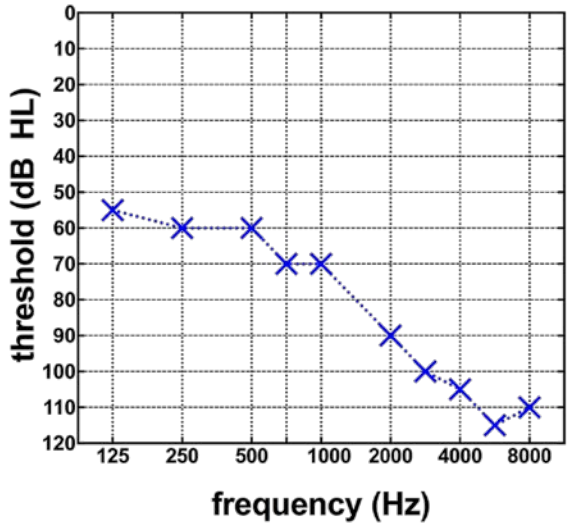


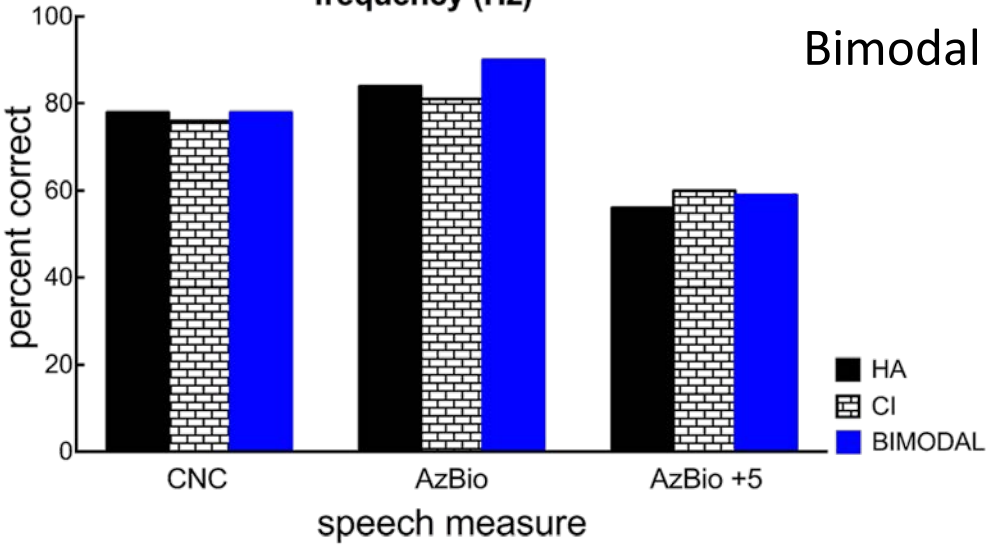
CI only – Speech



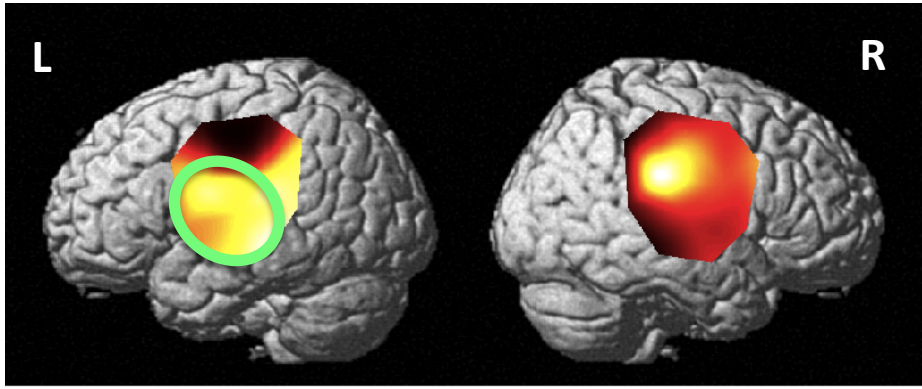
Bimodal – Speech







CI only – Unintelligible Speech-correlated Noise



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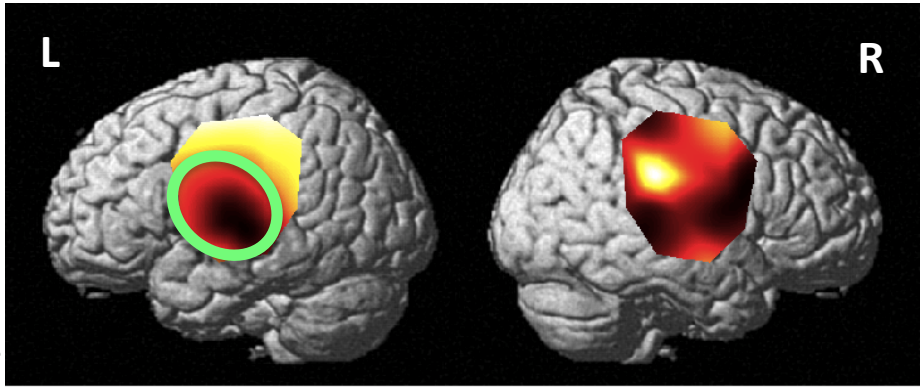
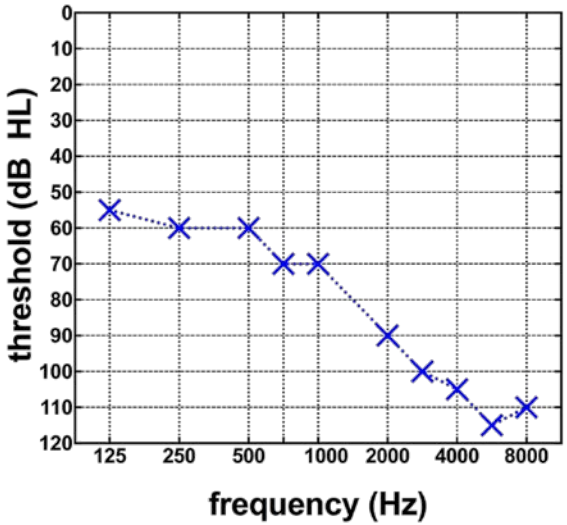
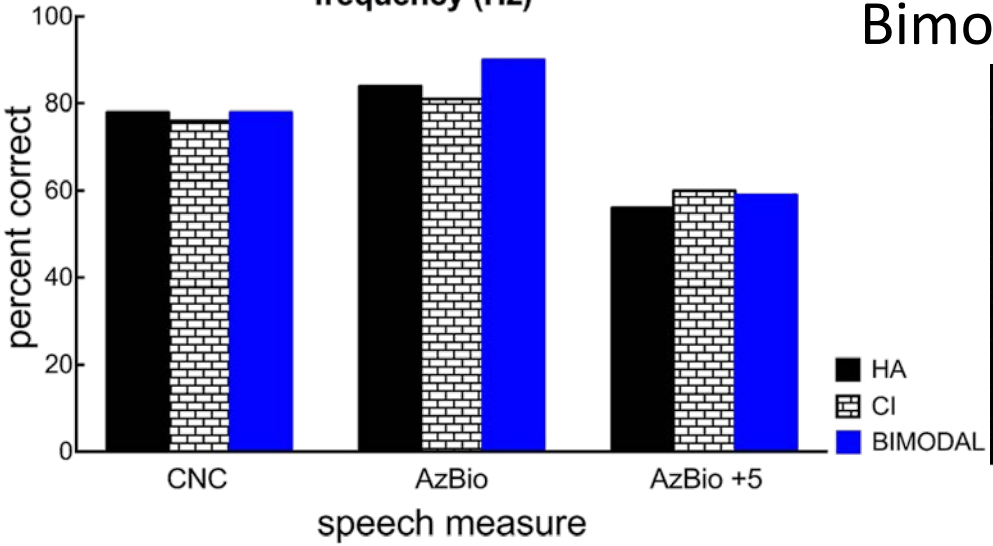
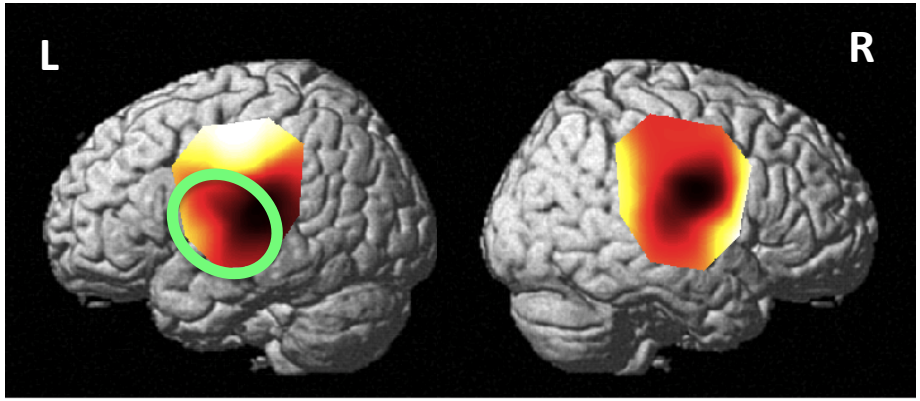


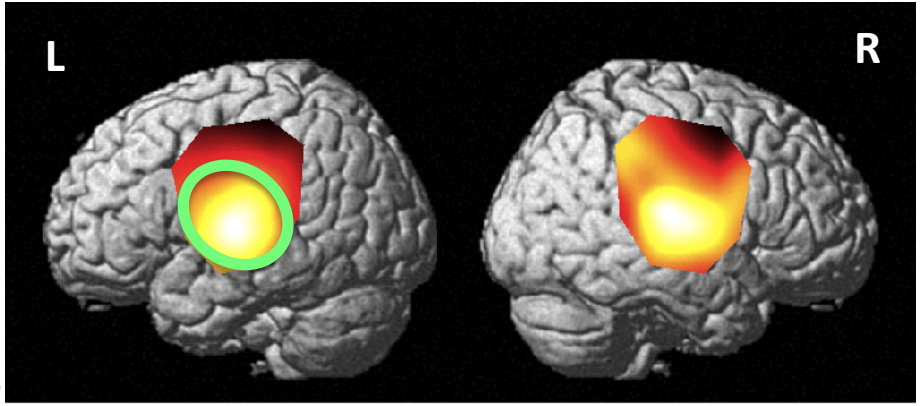




CI only – Speech > Noise



Bimodal – Speech > Noise



Summary

Bimodal hearing → significant benefit over CI alone

- Speech understanding in quiet & noise
- Music perception tasks
- Subjective ratings of music sound quality
- Auditory cortical activation

Significant bimodal benefit can be obtained with *very little acoustic hearing*

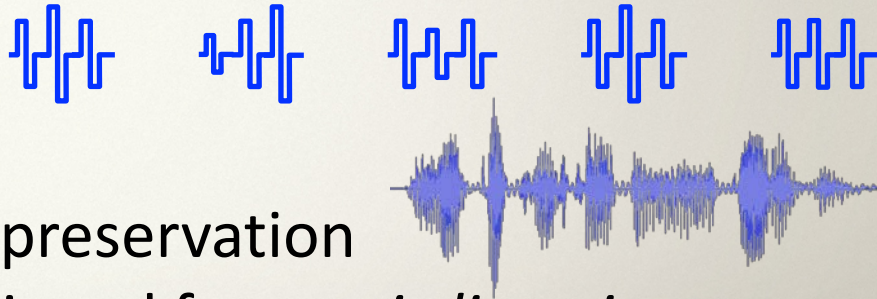
- 250 to 500 Hz
- Increases in acoustic BW → increased performance

Summary

Functional neuroimaging:

- Greater understanding re: neural integration of electric & acoustic stimuli
- Guidance for clinical decision making?
- Outcomes?

What might the future hold?

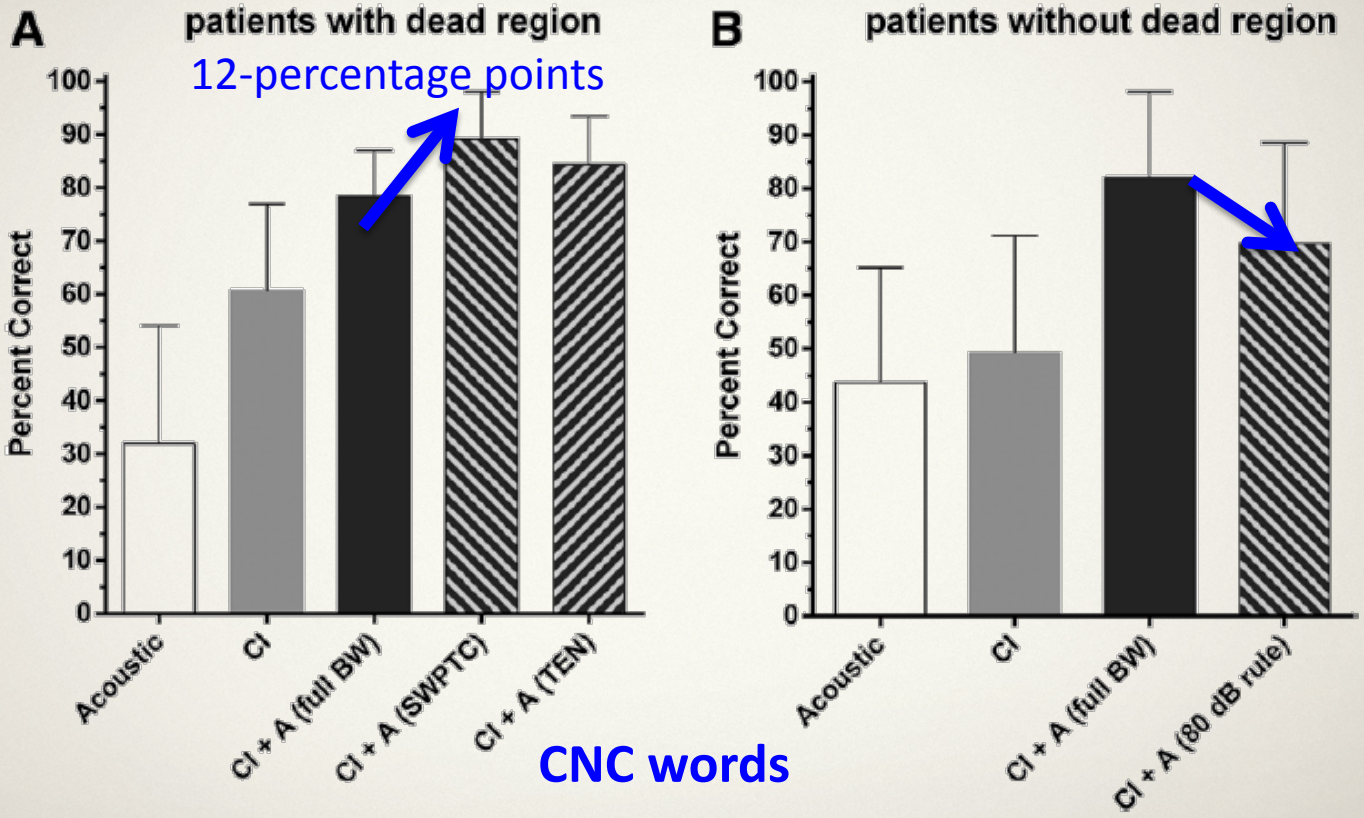


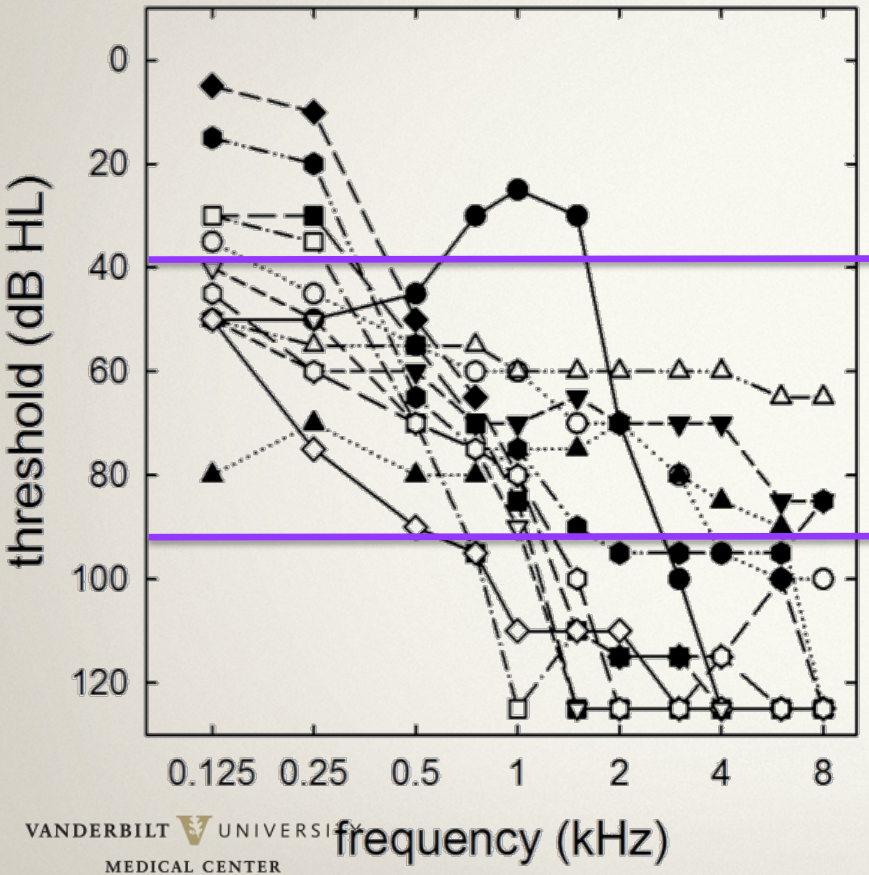
- Music coding strategies for CI
- Bilateral CI + acoustic hearing preservation
- HAs & prescriptive fittings designed for *music listening*

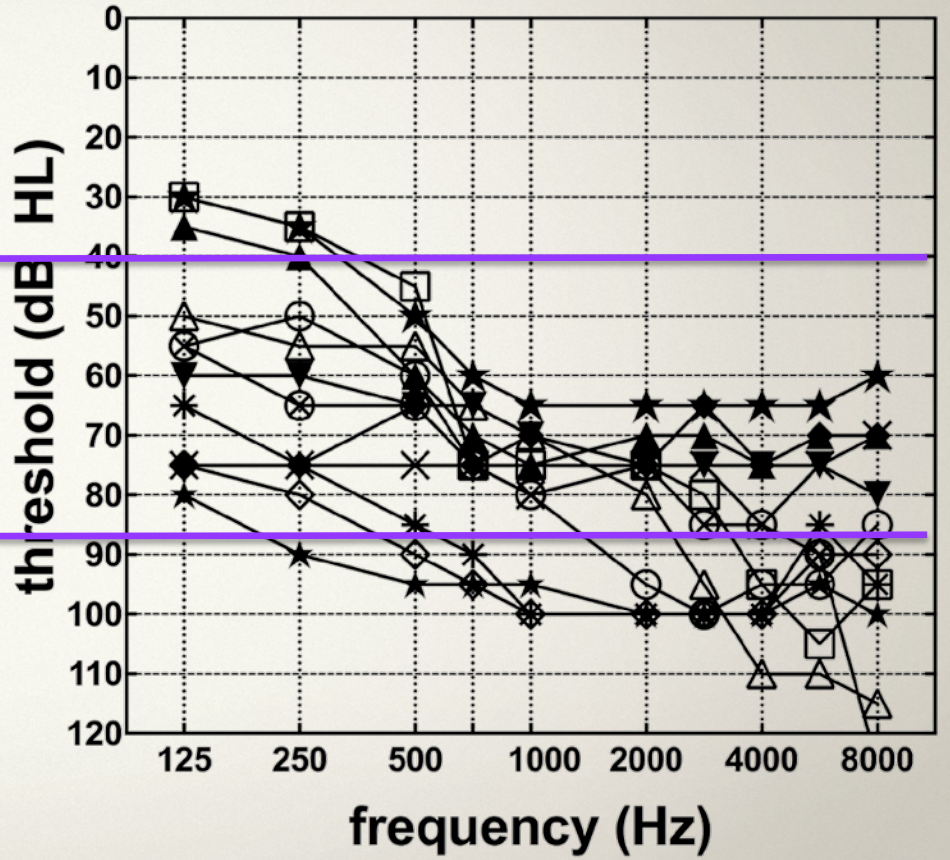
Thank you for your attention.

rene.gifford@Vanderbilt.edu

Zhang et al. (2014). Ear Hear, 35:410–417.







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