

The Benefits of Bimodal Hearing for Adults and Children: Effect of Frequency Region and Acoustic Bandwidth



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DISCLOSURES

Member of Audiology Advisory Board for:

- Advanced Bionics
- Cochlear Americas
- MED-EL

Collaborative Effort

Sterling Sheffield, AuD—PhD student

- Vanderbilt University

Michelle Simha—AuD student

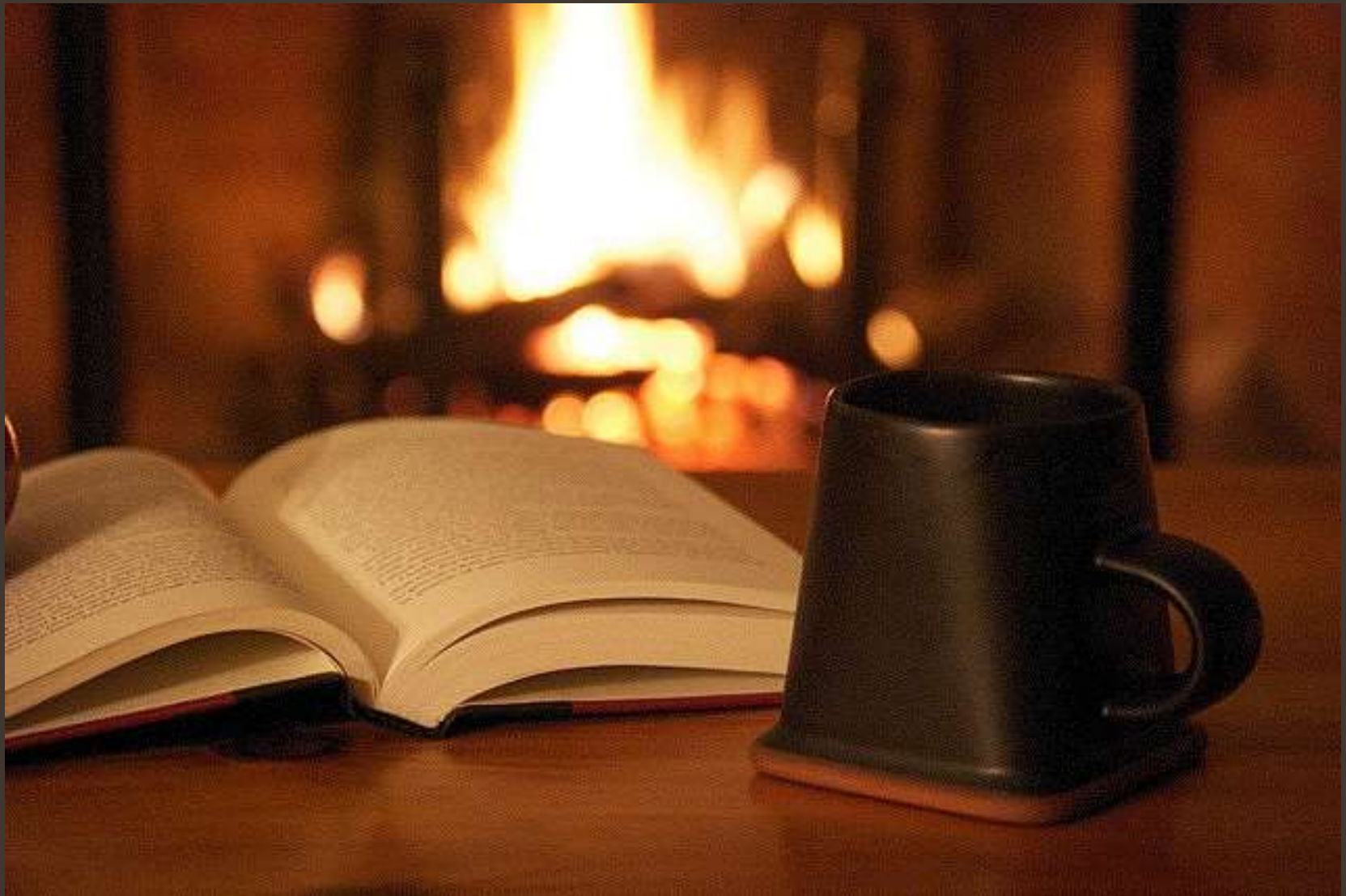
- University of South Florida



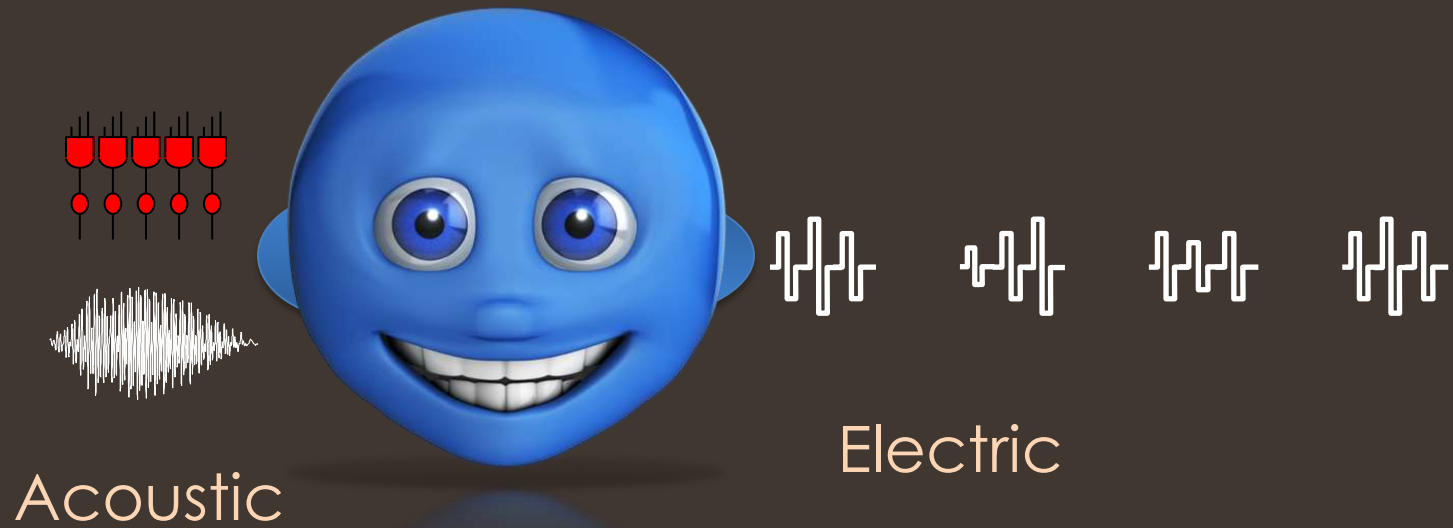












BIMODAL



BILATERAL



BILATERAL



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?

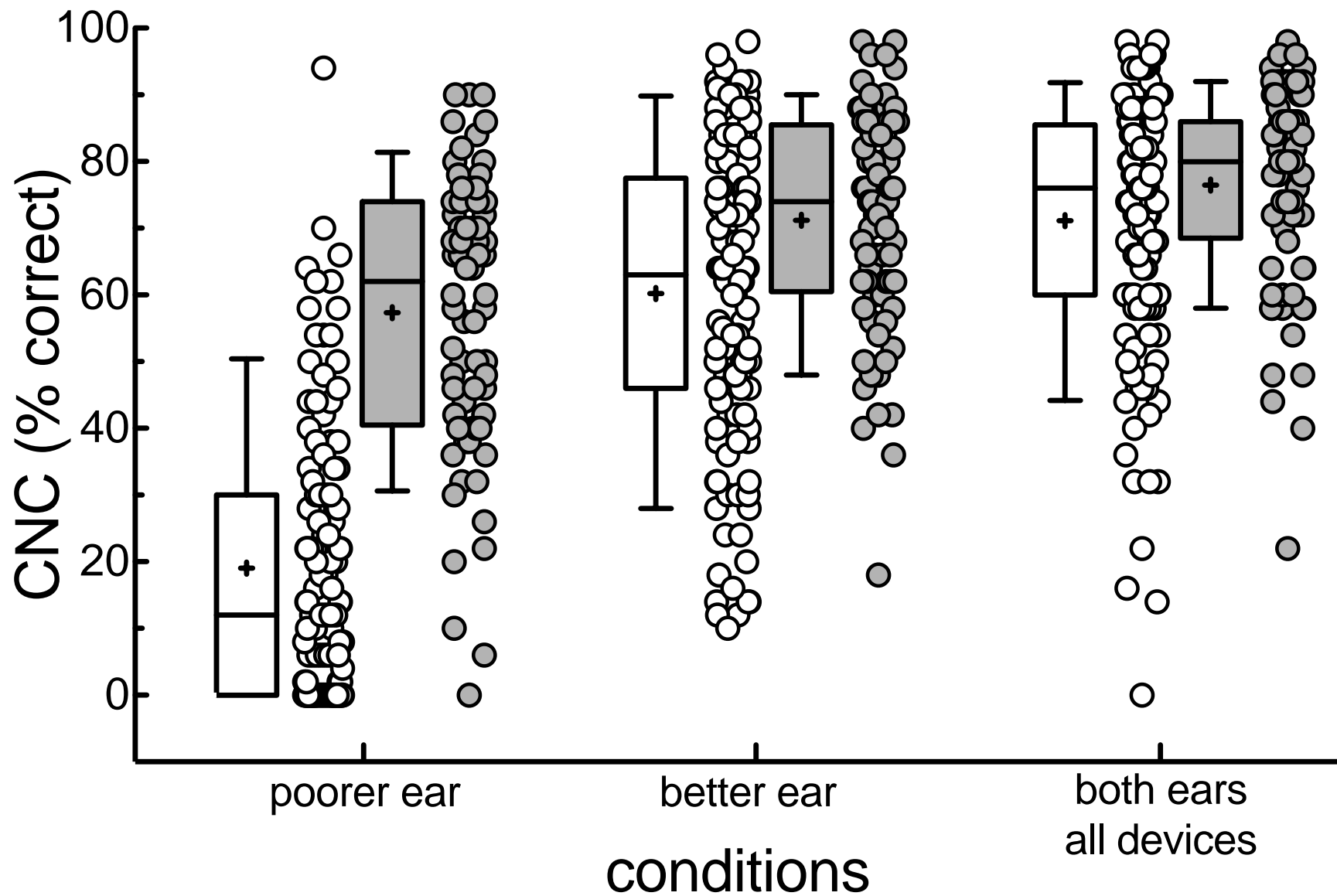


Bimodal vs. Bilateral in adults

Similar levels of performance on measures of speech understanding

- best aided condition

(e.g., Yoon et al., 2012, Otol Neurotol;
Gifford et al., in press, Audiol Neurotol)

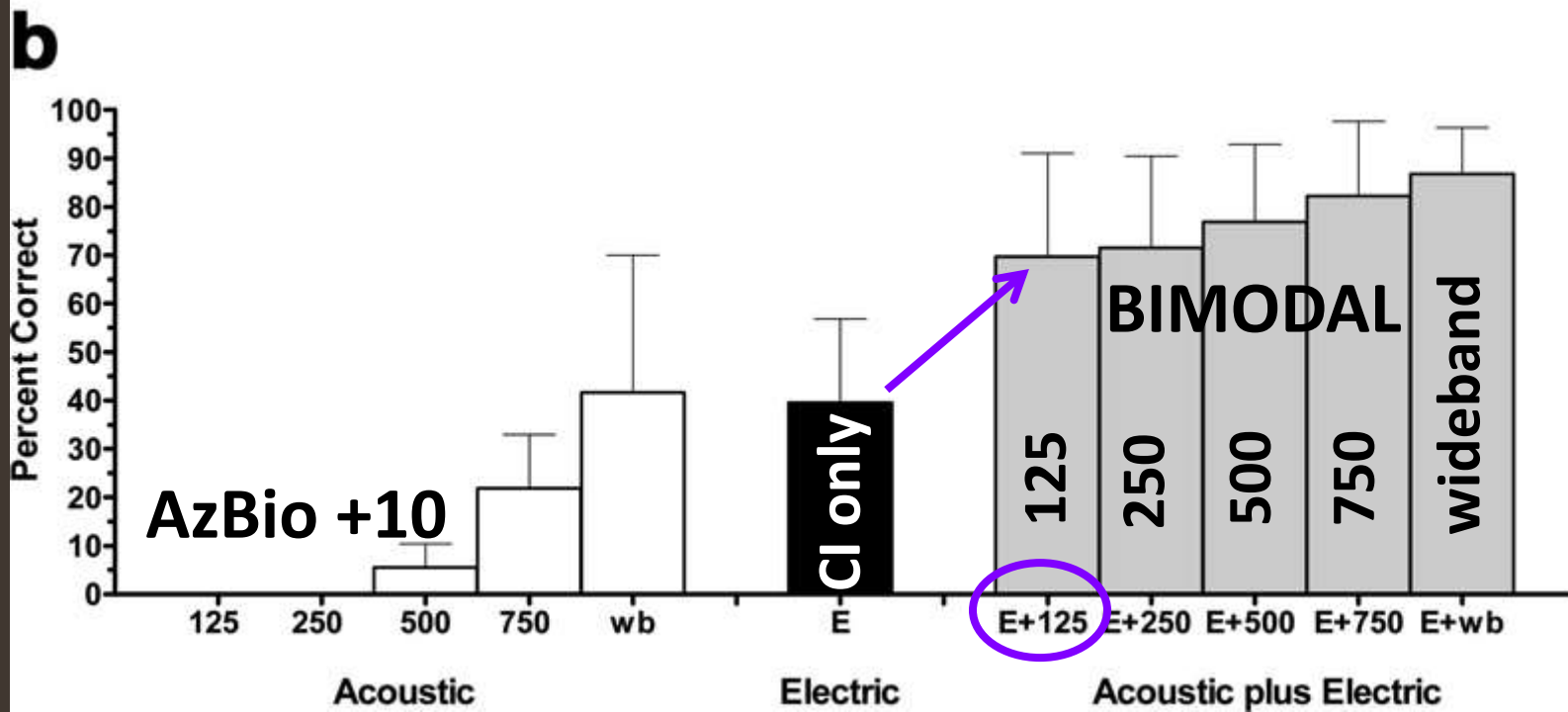
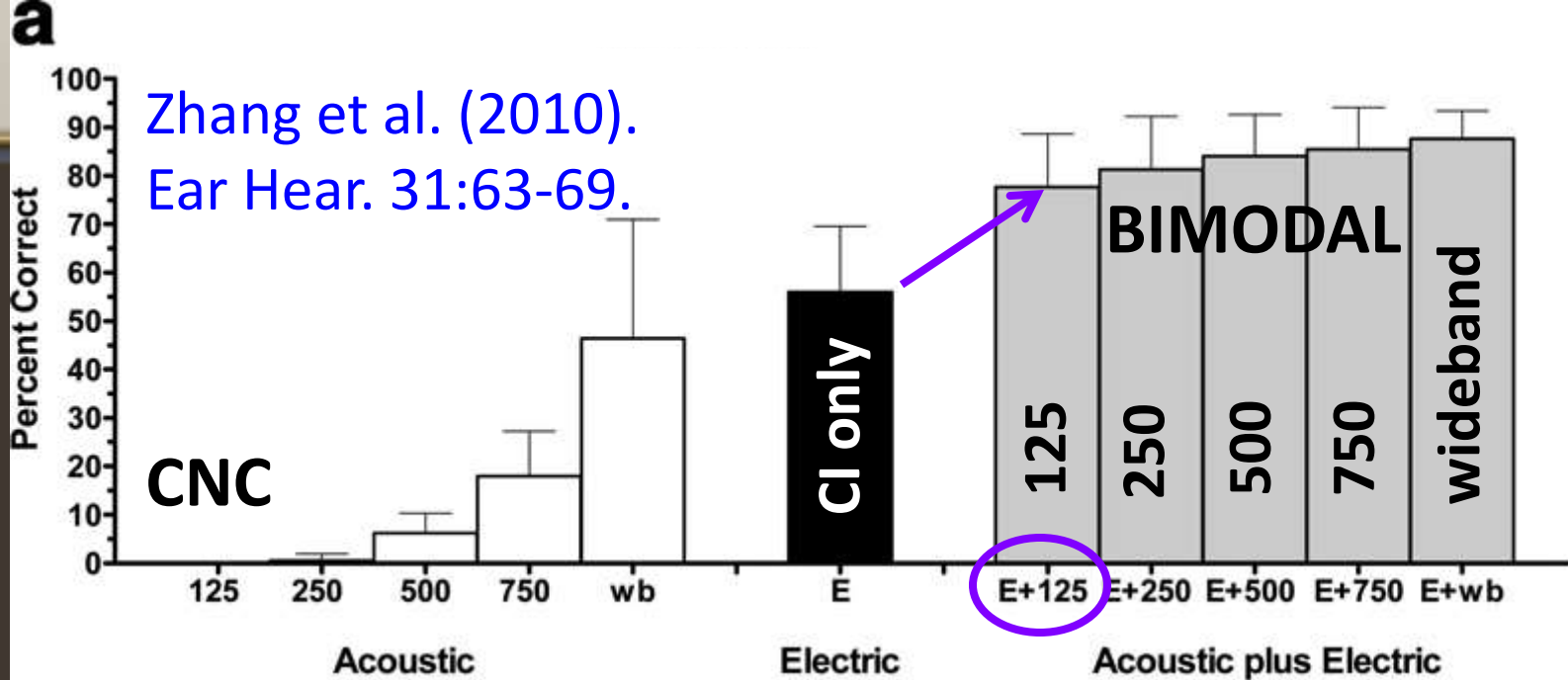


Bimodal: n = 120

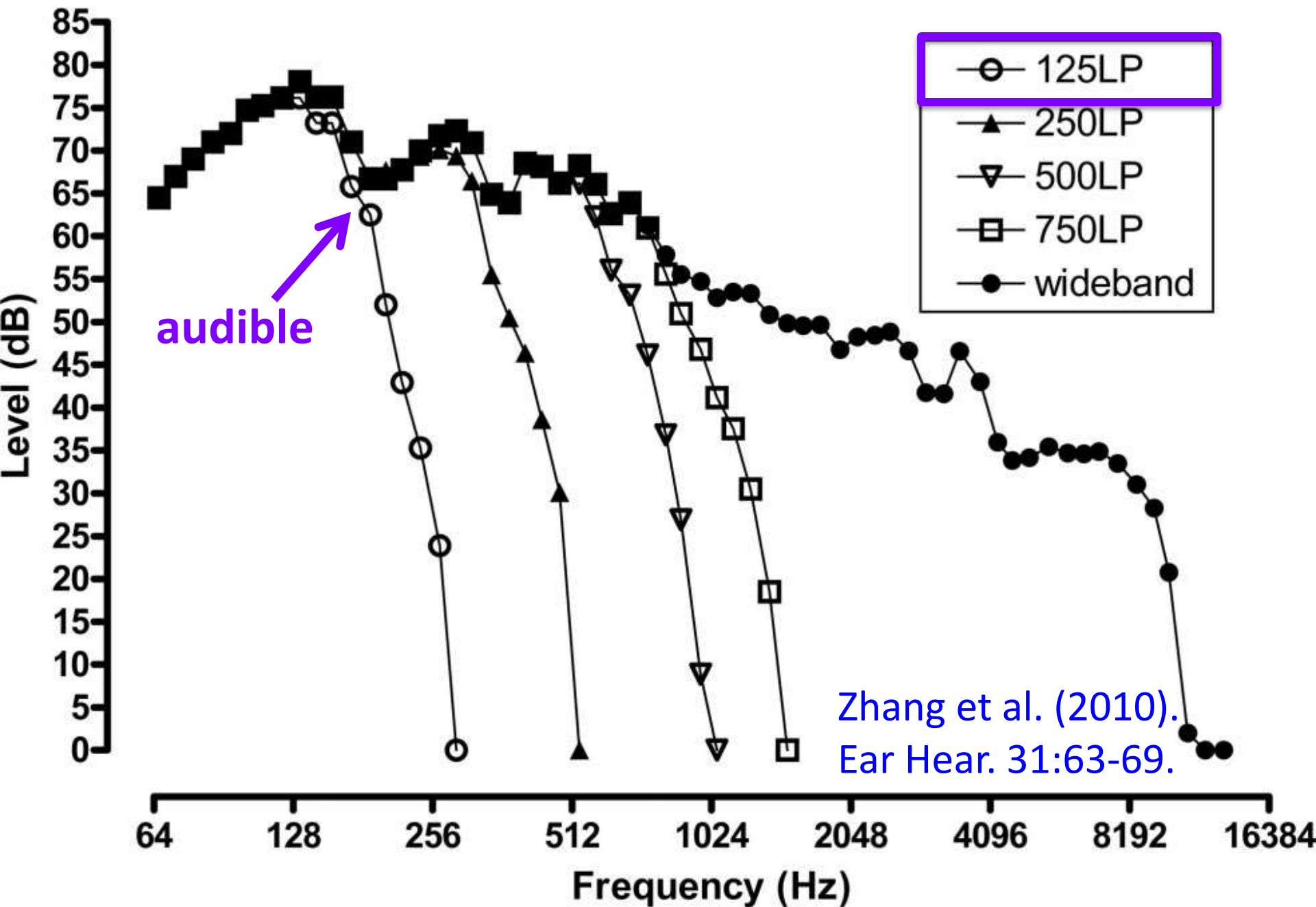
Bilateral: n = 73

□ bimodal
■ bilateral

BIMODAL: It doesn't take much
acoustic hearing in the non-CI
ear to yield benefit...



CNC words



Sheffield & Gifford (in press). Audiol Neurotol.

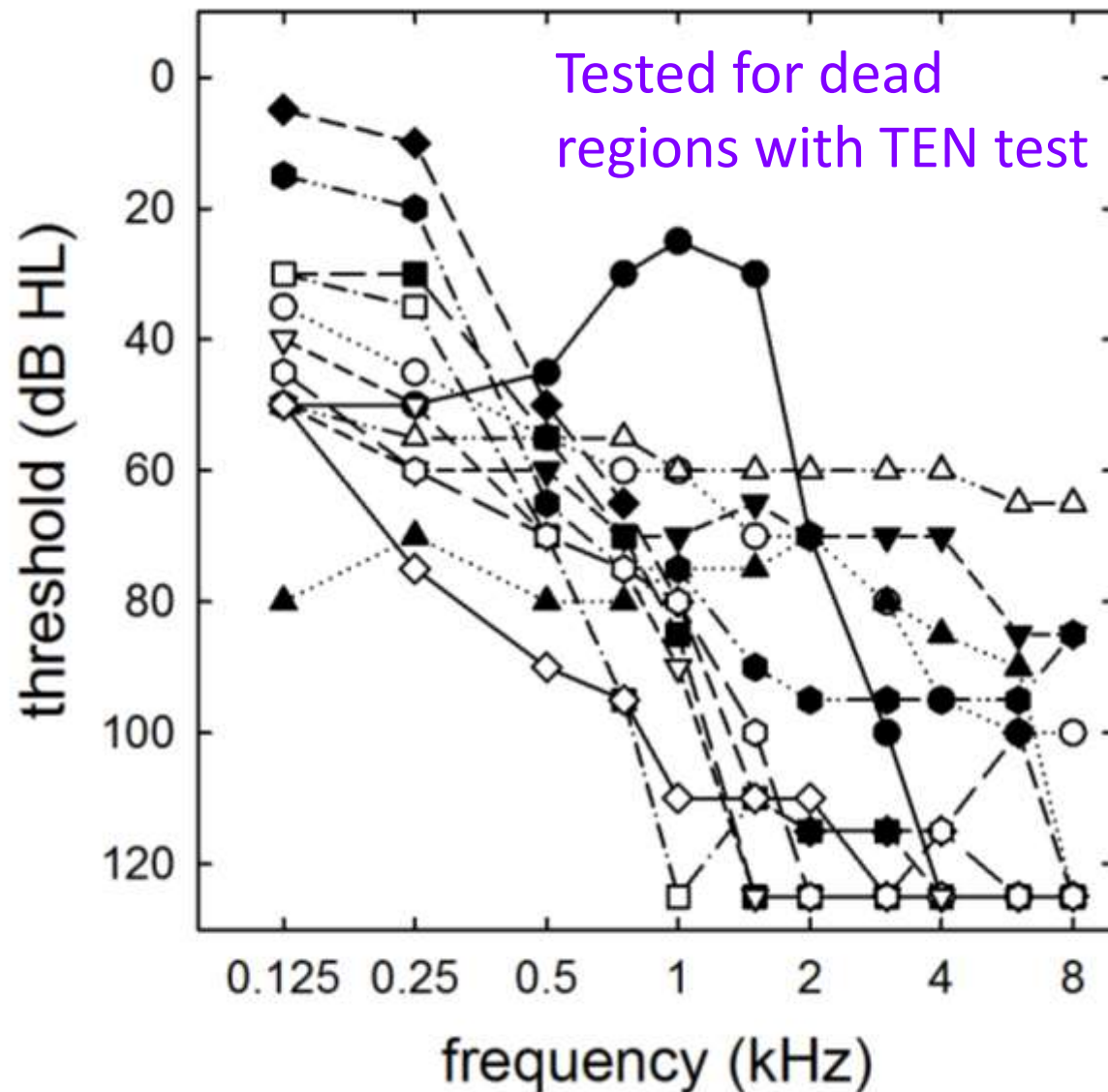
PURPOSES: 1) Replicate Zhang et al. (2010) with steeper filter slopes (90 dB/oct), 2) multiple SNRs, and 3) low- and band-pass filters.

- Bimodal adults ($n = 12$)
- Mean age = 56.3 years
 - Range 42 to 82 years
- Mean CI experience = 54.9 months
 - Range 8 to 138 months

Sheffield & Gifford (in press). Audiol Neurotol.

PURPOSES: 1) Replicate Zhang et al. (2010) with steeper filter slopes (90 dB/oct), 2) multiple SNRs, and 3) low- and band-pass filters.

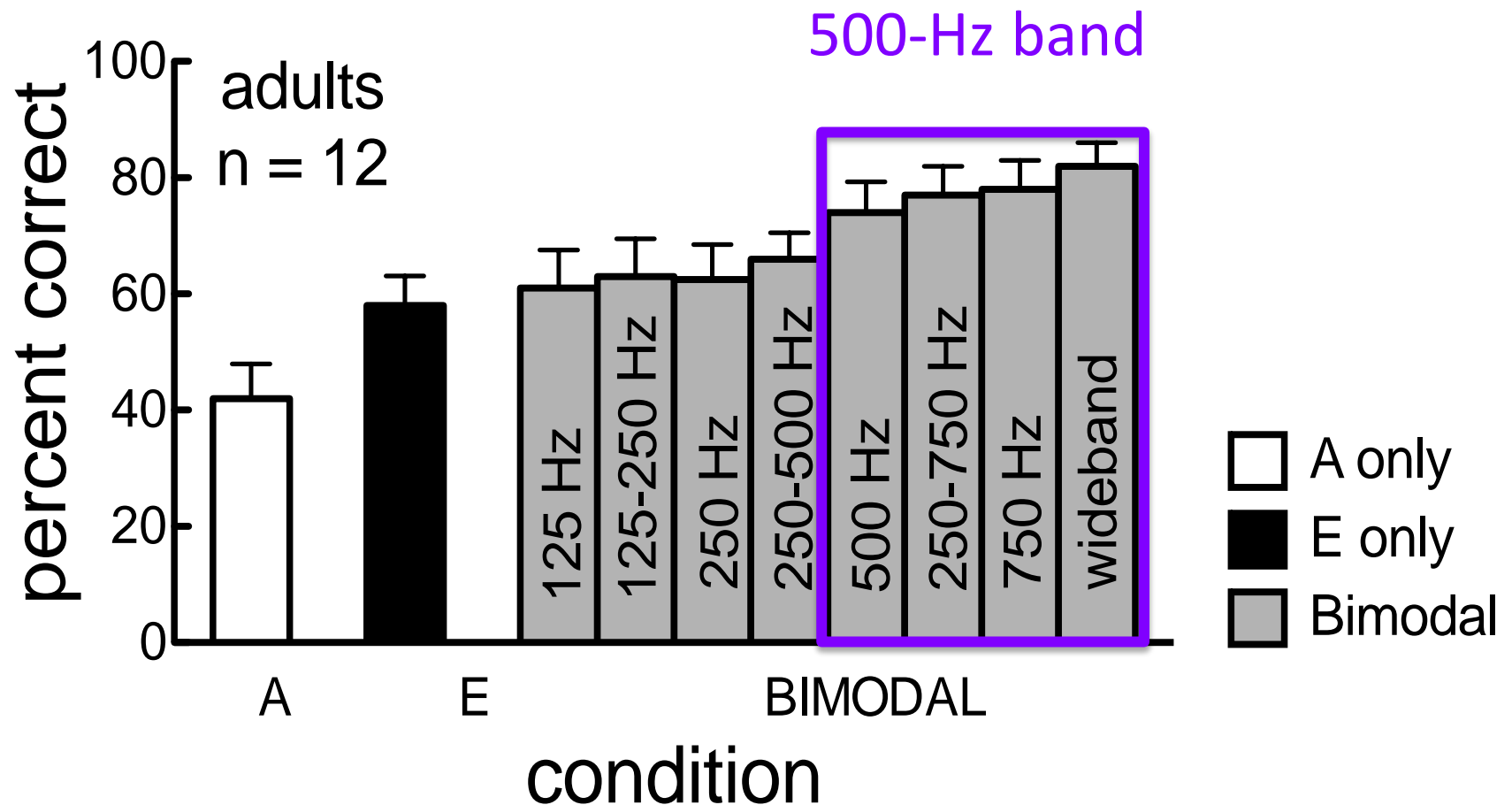
- CNC words
 - 60 dB SPL
- AzBio in noise +10, +5, and 0 dB SNR
 - 65 dB SPL
- LP: <125, <250, < 500, <750 Hz, and wideband
- BP: 125-250, 250-500, and 250-750 Hz



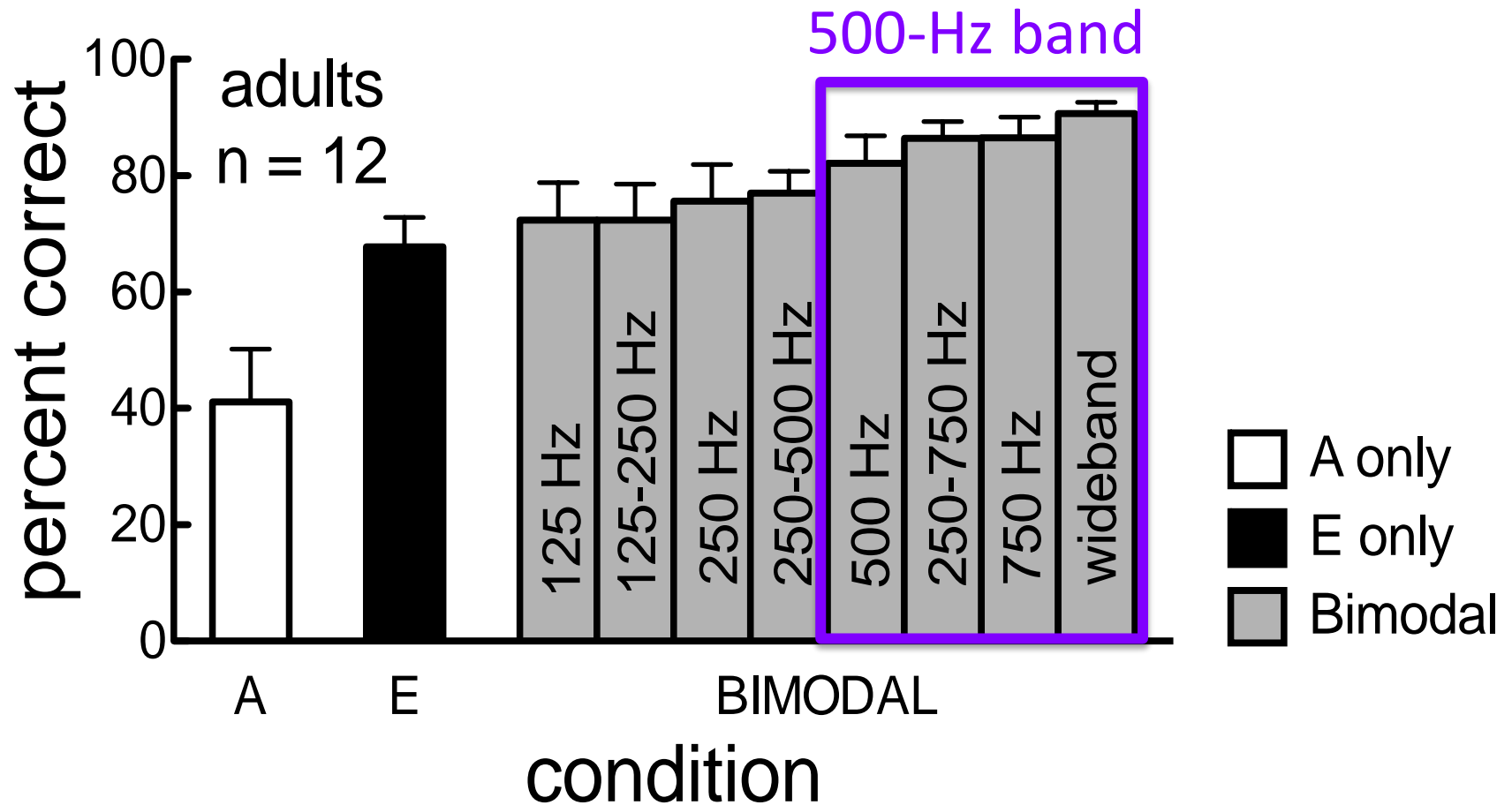
Presentation level
in non-CI ear →

65 dBA signal +
NAL-NL1
amplification

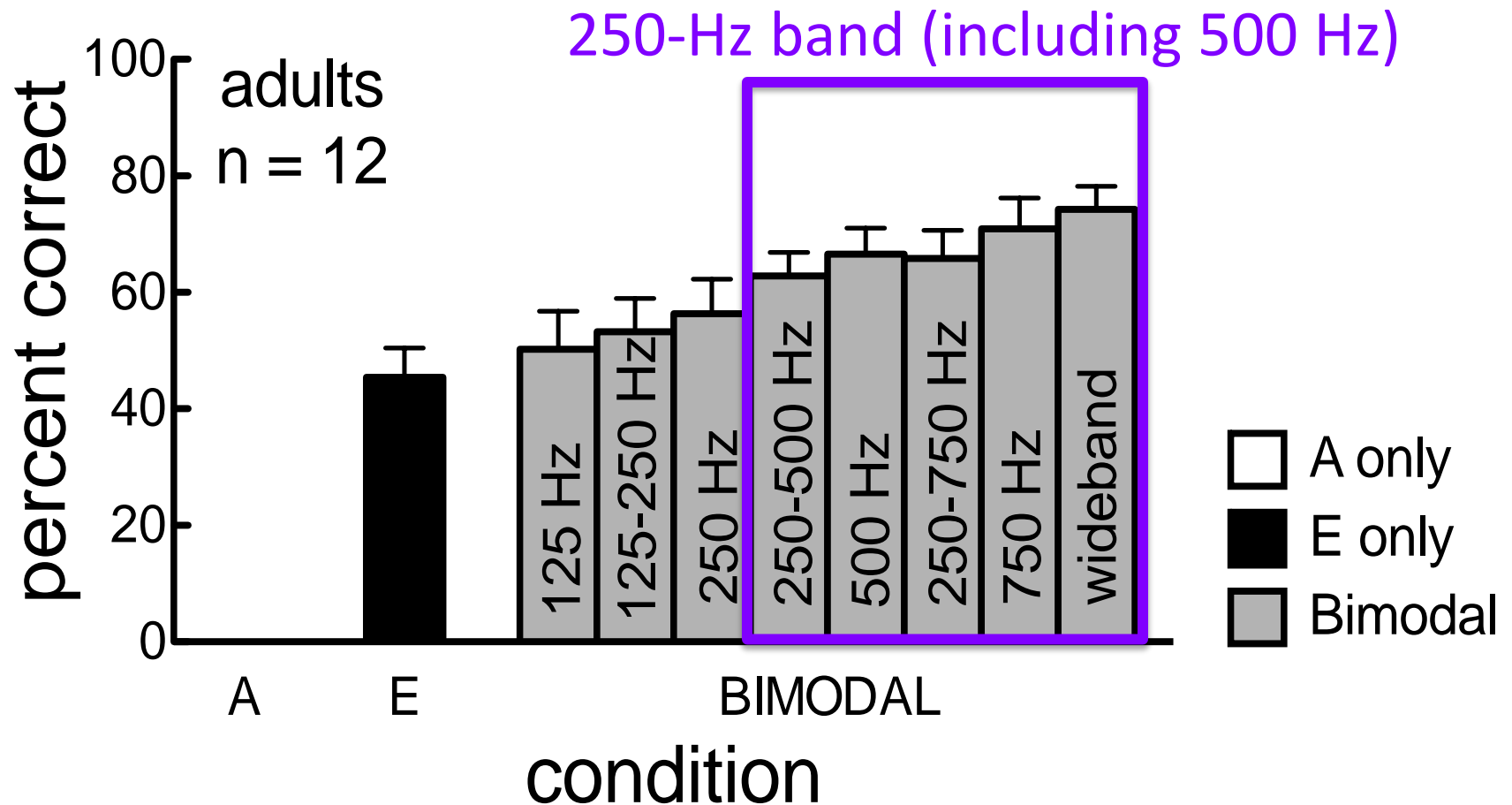
CNC words



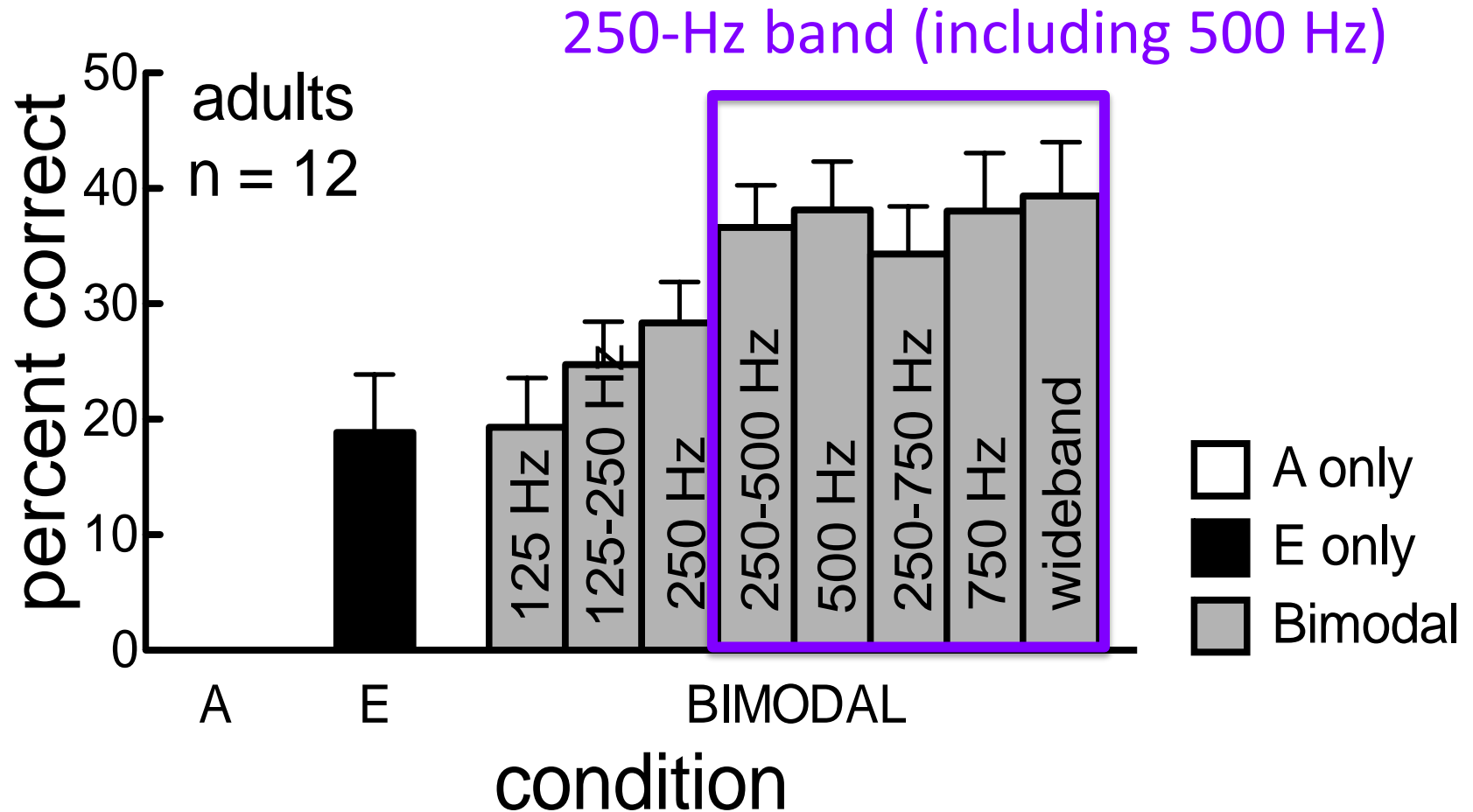
AzBio +10 dB SNR



AzBio +5 dB SNR



AzBio 0 dB SNR (n = 9)



Sheffield & Gifford (in press). Audiol Neurotol.

- Bimodal benefit is possible with limited acoustic bandwidth
 - Even when F0 is not physically present
 - We *might not* have to worry too much about 125 Hz
 - Prescriptive targets, HA output, etc.
 - 250-500 Hz is the magic range

Phonetic Symbol	Example Word	F_1 (Hz)	F_2 (Hz)
/ow/	bought	570	840
/oo/	boot	300	870
/u/	foot	440	1020
/a/	hot	730	1090
/uh/	but	520	1190
/er/	bird	490	1350
/ae/	bat	660	1720
/e/	bet	530	1840
/i/	bit	390	1990
/iy/	beet	270	2290

F_1 mean = 490 Hz

BIMODAL: It doesn't take much
acoustic hearing in the non-CI
ear to yield benefit...

for adults with postlingual SNHL.

Why might children be different?

Why might children be different?



Why might children be different?
Children are not little adults.



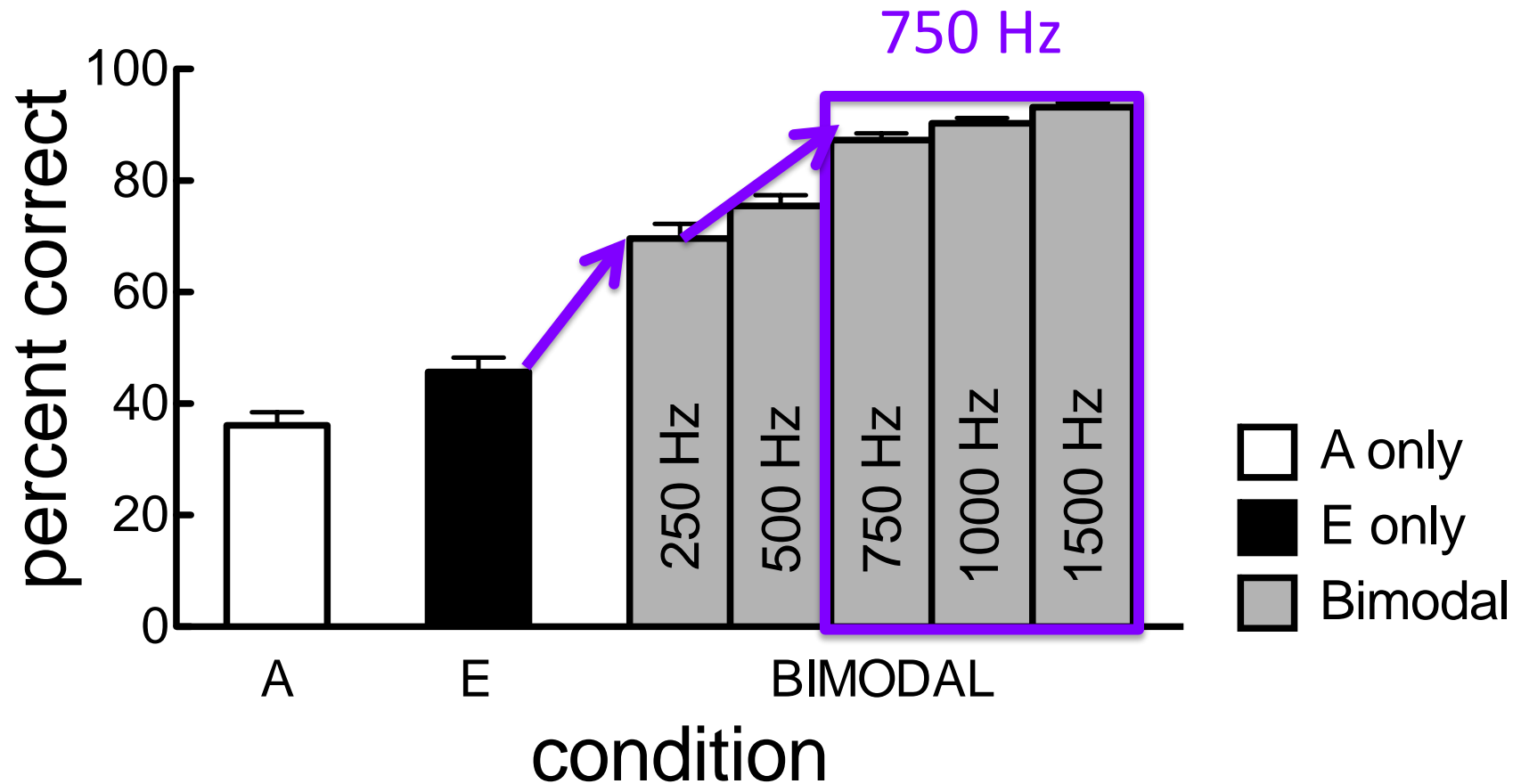
Hypotheses

- 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.

Simha, Sheffield & Gifford (in prep).

- Children with normal hearing ($n = 20$)
- Mean age = 9.2 years
 - Range 6 to 12 years
- CI simulations (vocoder as in Litvak et al., 2007)
- Bimodal simulations: 90 dB/oct
 - <250, <500, <750, <1000, and <1500 Hz
- BabyBio sentences at variable SNR
 - SNR \rightarrow ~50% for “CI-only” condition
 - Mean = 6.6 dB

BabyBio sentences



$$\chi^2 = 90.2, p < 0.0001$$

Simha, Sheffield & Gifford (in prep).

PRIMARY CONCLUSION

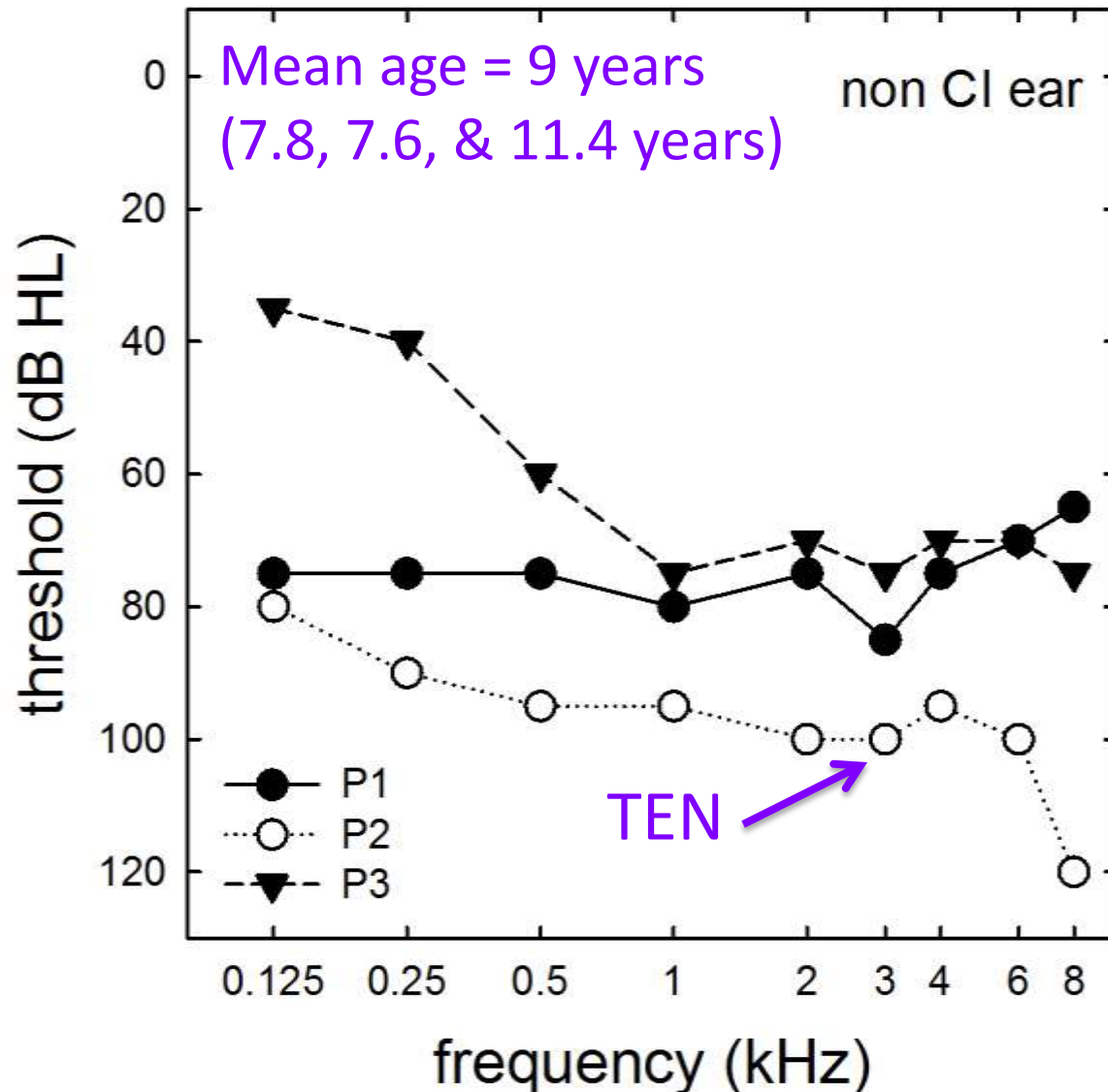
Children require a wider acoustic BW to achieve maximum bimodal benefit than adults.

BUT...they demonstrated significant bimodal benefit with narrower BWs.

What about bimodal children (CI and HA)?

PRELIMINARY DATA





SNR

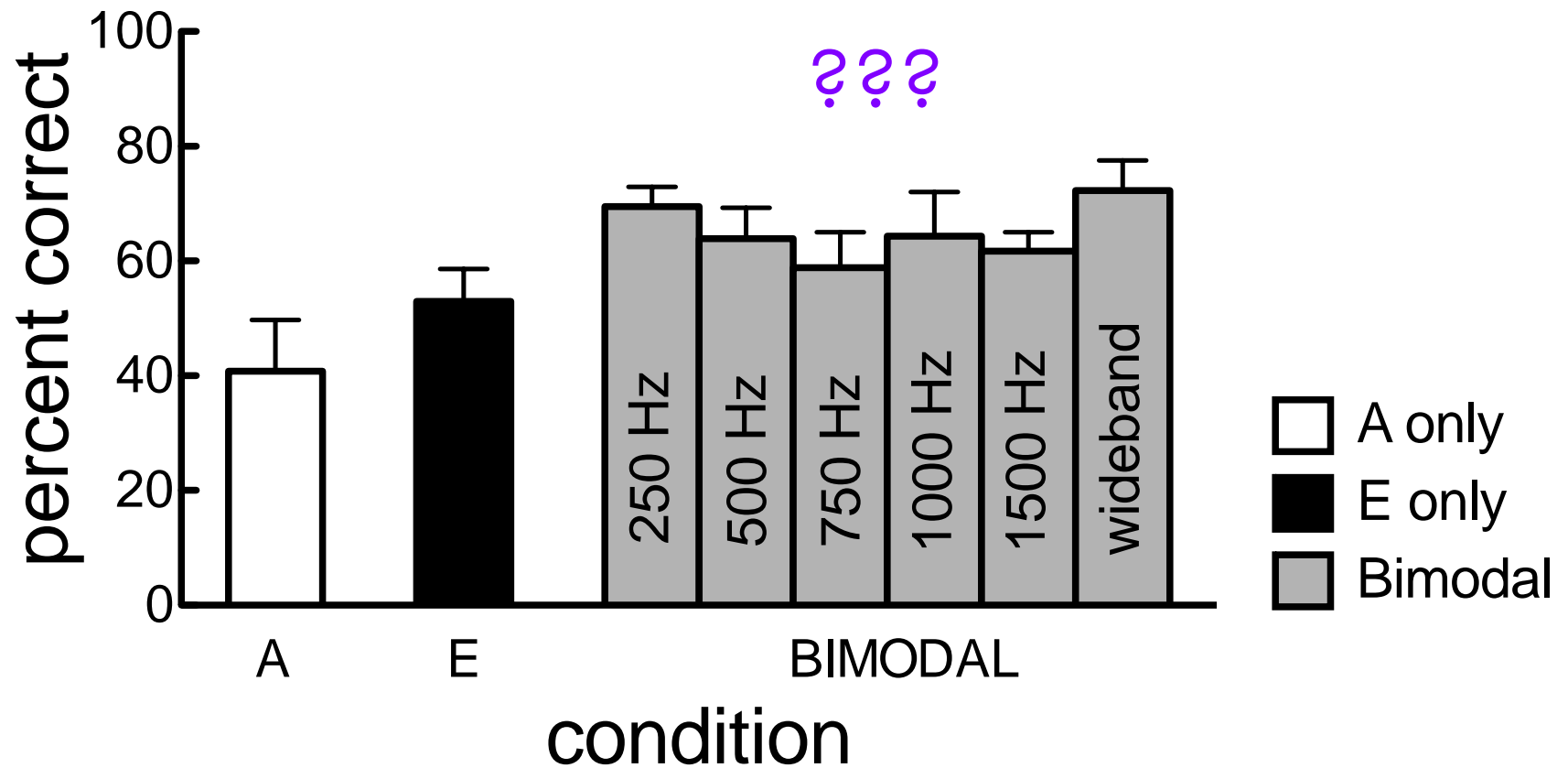
→ 50% CI only

→ 0 to 1 dB SNR!

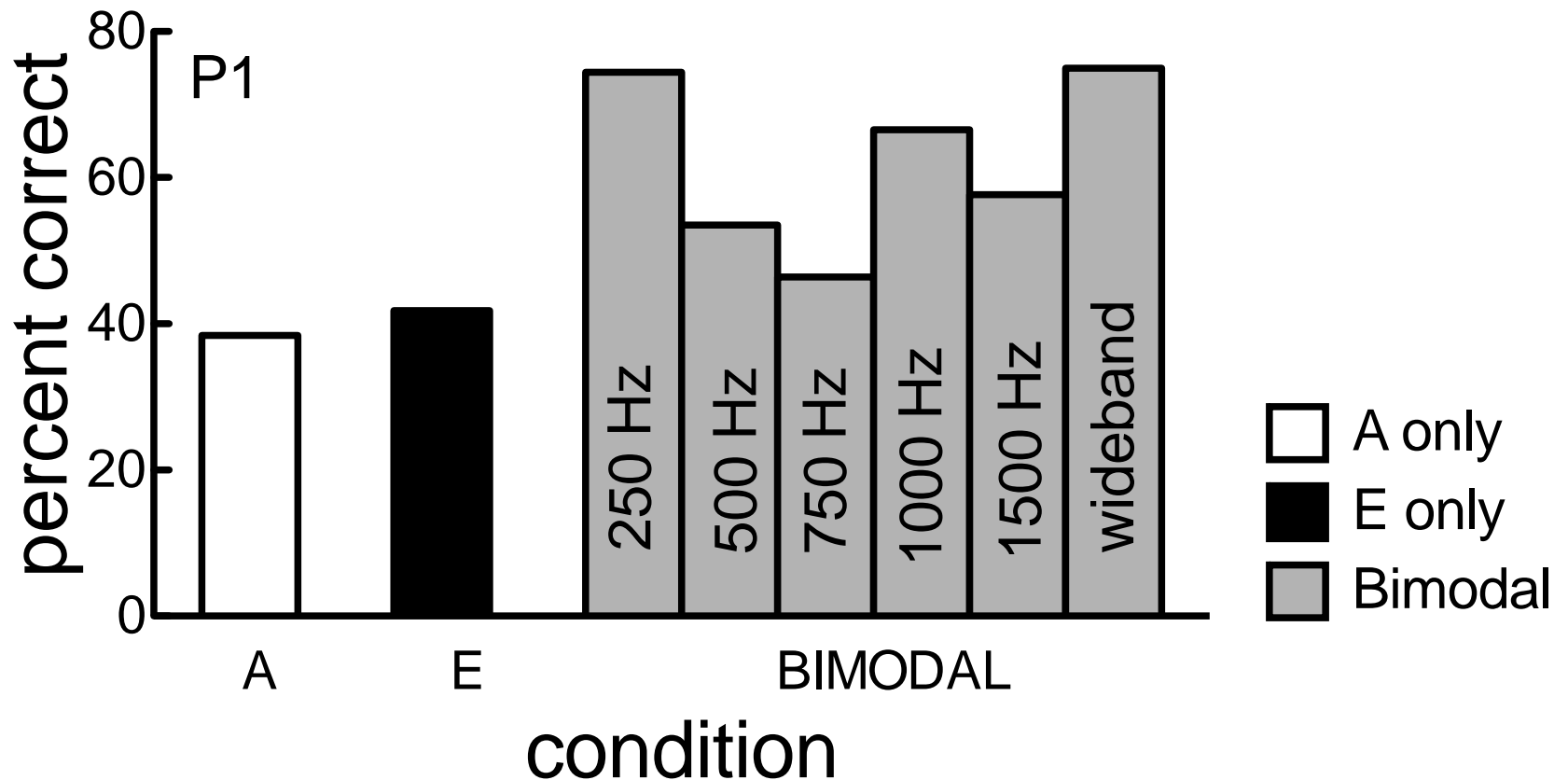
Presentation level
in non-CI ear →

65 dBA signal +
DSL amplification

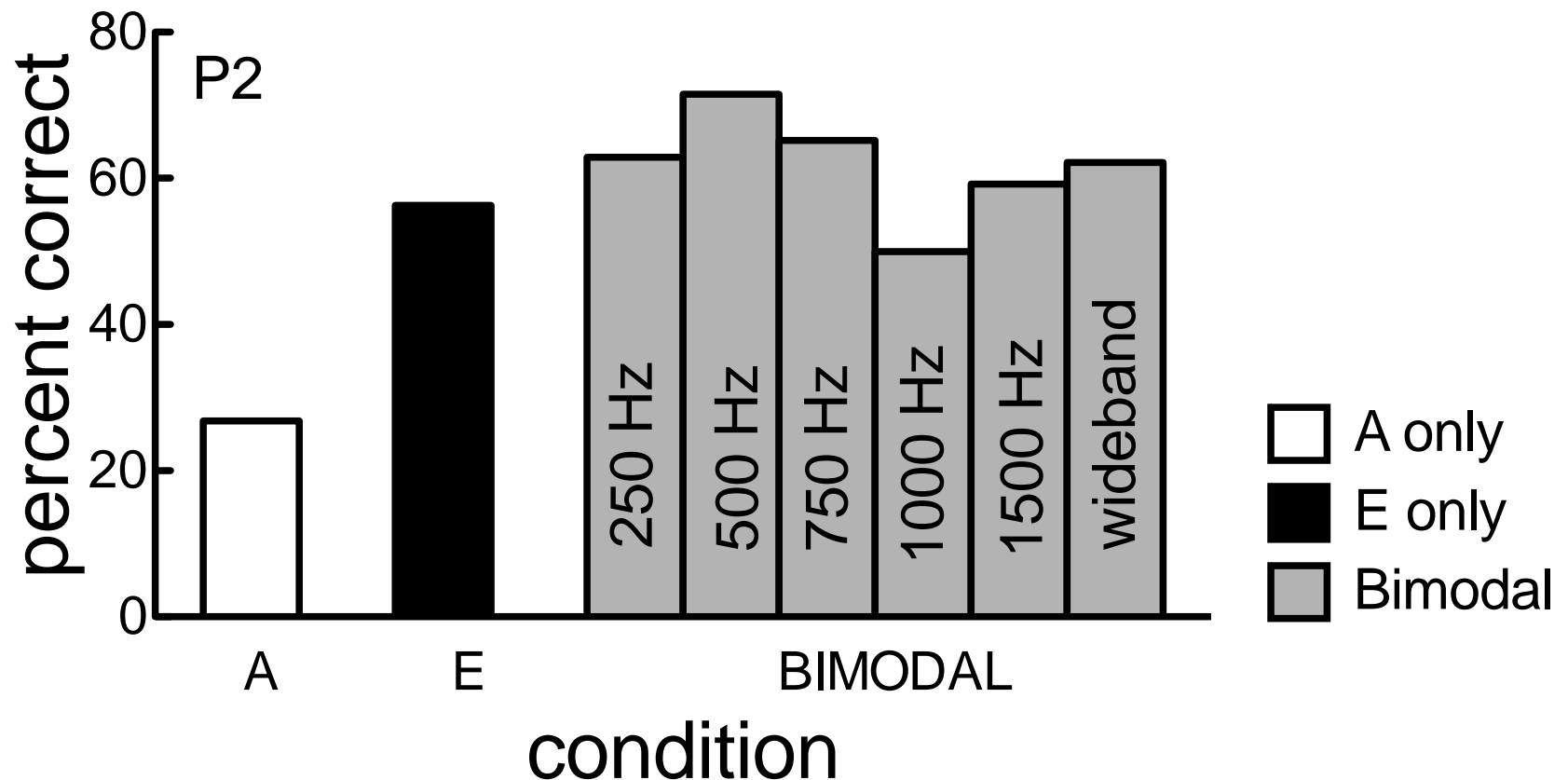
BabyBio sentences



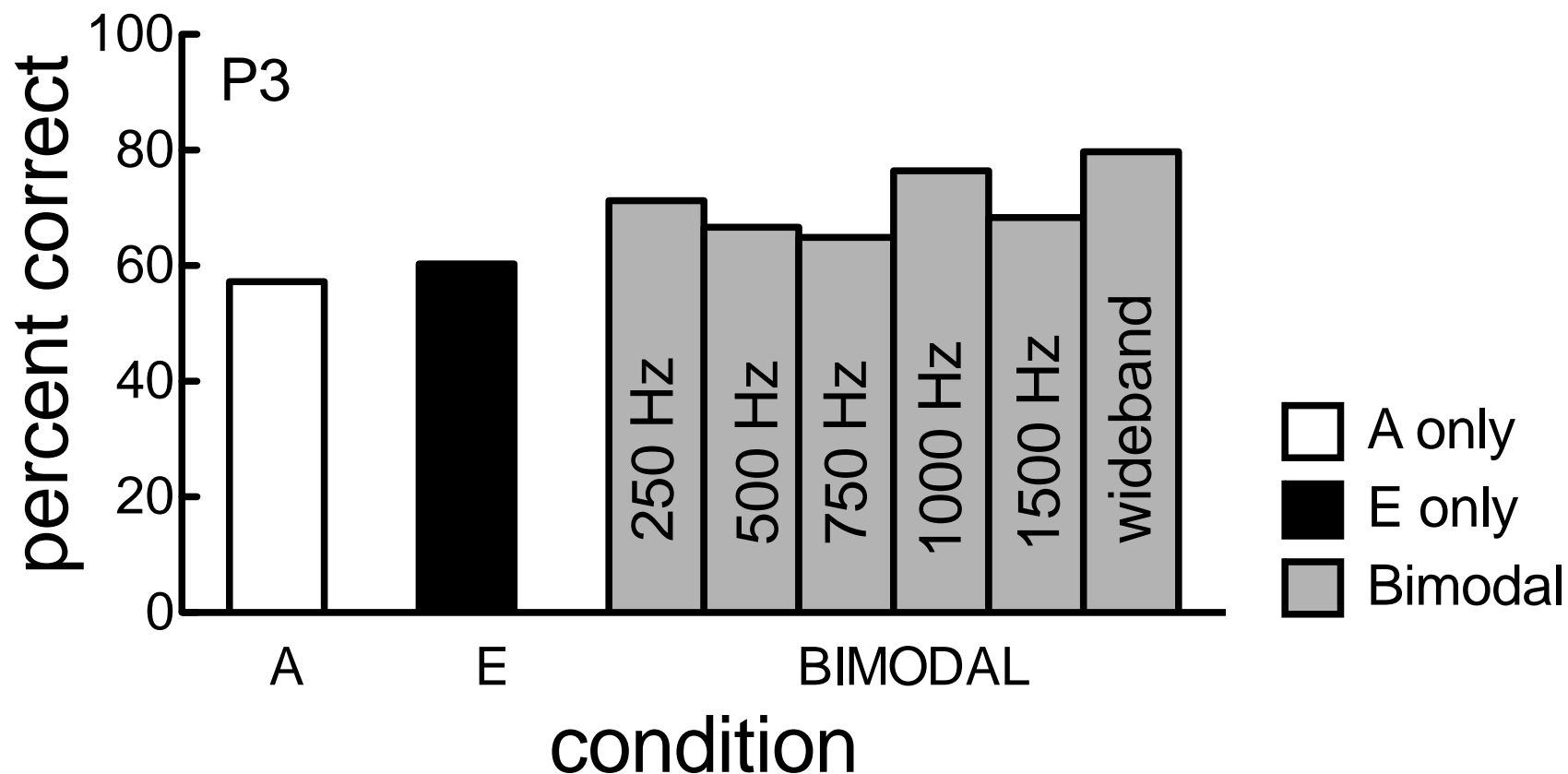
Individual variability?



Flat loss at 70 dB HL




Flat loss 80-100 dB HL



Sloping loss 30 to 70 dB HL

SUMMARY

- Bimodal hearing → great benefit
- Little acoustic hearing is needed for significant benefit and for *max benefit*
- Much work is needed in this area!
- Spectral bandwidth? NLFC? Syncing the CI and HA? Age of child? Severity of HL in non-CI ear? Co-morbidities?



Cochlear Implant Research Laboratory

**Thank you for
your attention!**



Questions/comments



