Effect of Aging on Forward-Masking Estimates of Medial Olivocochlear Gain Reduction: Computational Simulations and Behavioral Data

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Introduction

- Aging is associated with cochlear synaptopathy (CS), a loss of synapses between inner hair cells and auditory-nerve (AN) fibers [1].
- The medial olivocochlear (MOC) system is a feedback network receiving inputs from the AN, cochlear nucleus, and inferior colliculus (IC), and reduces basilar-membrane gain [2].
- Beyond affecting afferent auditory pathway, CS may also alter efferent control of cochlear gain by reducing AN input to the MOC system.
- Forward masking refers to the elevation in probe detection threshold caused by a precursor sound
- Given its relatively slow onset (≈25 ms) and because MOC activation by moderate-level sounds reduces cochlear responses to low-level probes (**Fig 1**), forward masking under specific conditions (low probe levels, long precursors, and precursor–probe gaps around 20 ms) has been proposed as an estimate of MOC-mediated cochlear gain reduction [3].

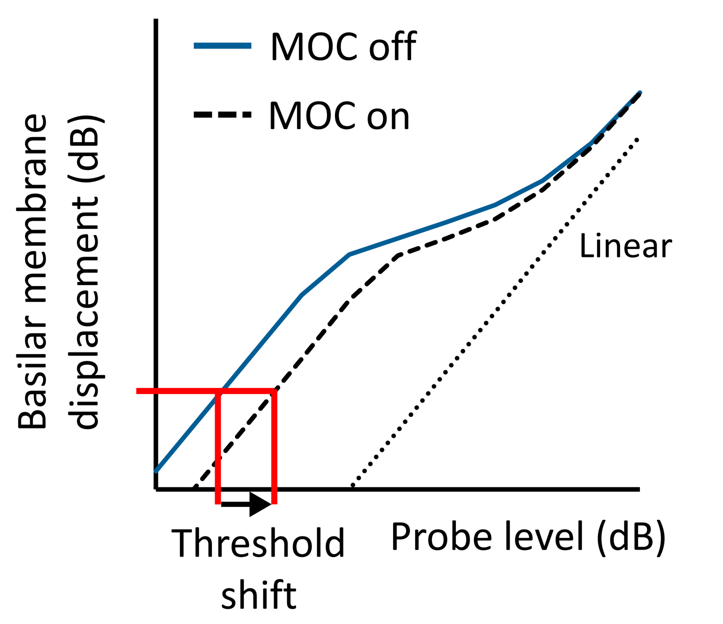


Figure 1. MOC activation is expected to change BM input/output curves and increase tone detection thresholds [2]

Knowledge gap

- The impact of age-related CS on forward-masking estimates of cochlear gain reduction remains unexplored.

Aim

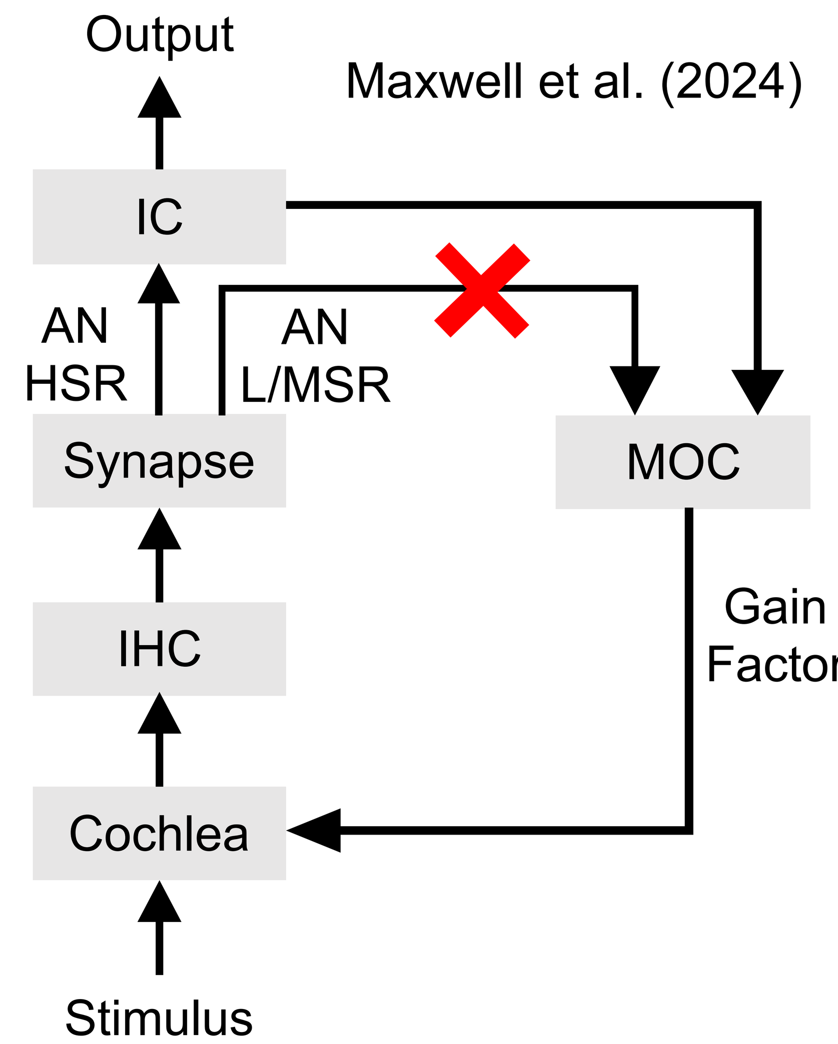
- We use computational modelling and psychophysics to investigate the effects of age-related CS on forward masking.

Hypotheses:

- Older normal-hearing listeners will show smaller precursor-induced threshold shifts due to reduced AN input to the MOC system.
- Temporally modulated precursors will produce larger threshold shifts because the MOC receives modulation-sensitive input from the IC [4].
- This modulation effect will be stronger in older listeners, whose MOC activation may depend more heavily on IC input.

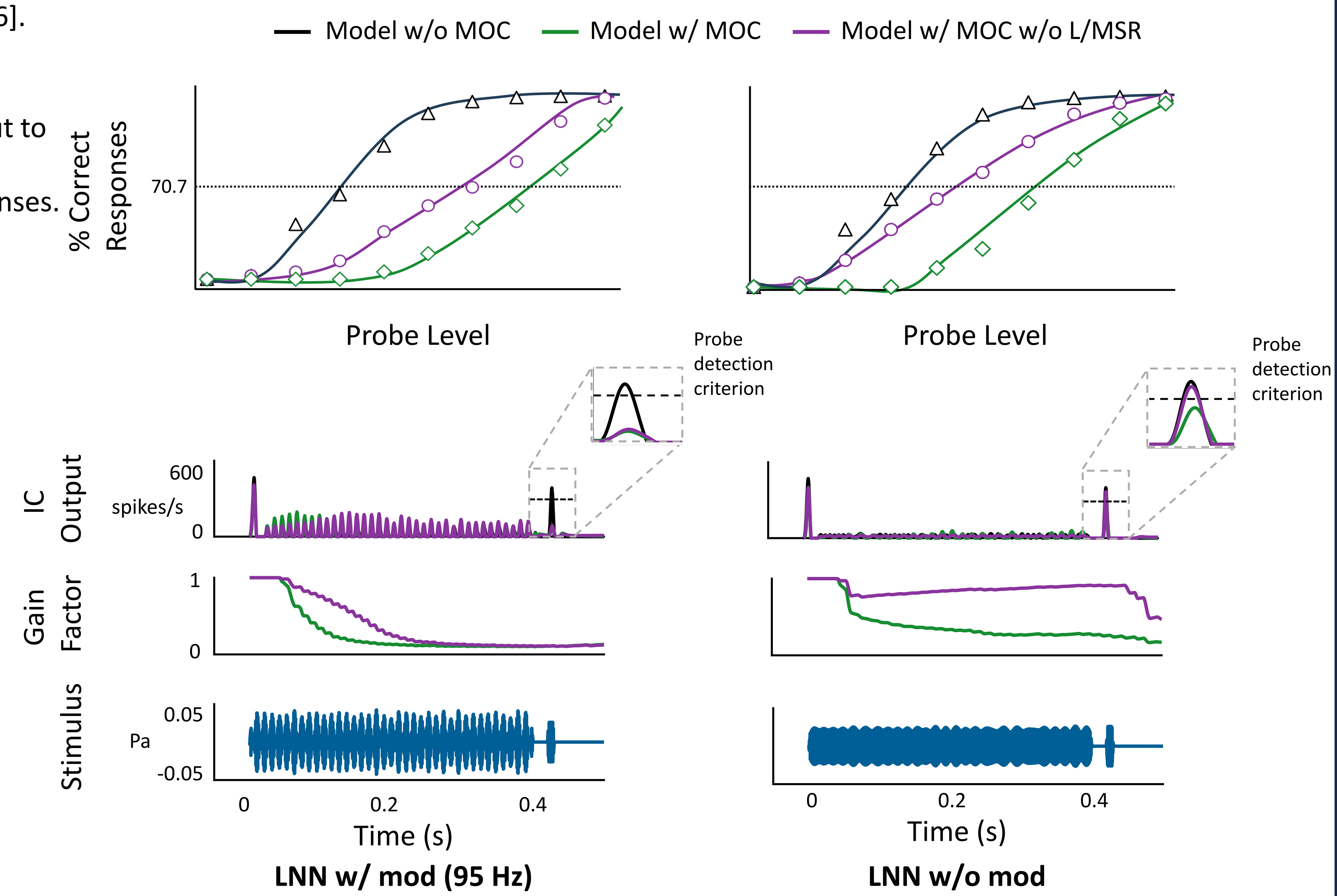
Methods: Simulations

- Human-based, single channel AN model (CF = 2 kHz) + IC model tuned to 64-Hz modulations [6].
- MOC feedback driven by L/MSR (AN) and IC inputs.
- CS was simulated by removing the L/MSR input to the MOC.
- Detection thresholds computed from IC responses.



Model threshold estimation

Method of constant stimuli: 50 presentations per probe level + psychometric-function fit



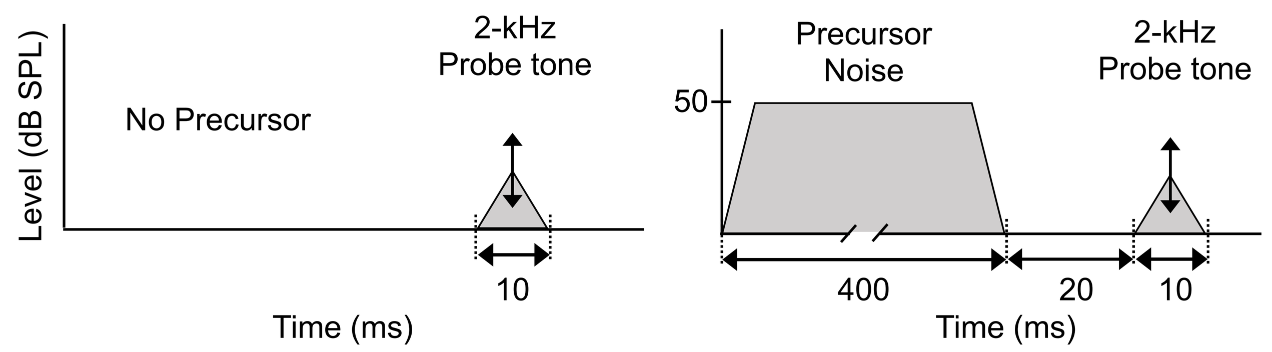
Methods: Forward Masking Task

Probe

- 2-kHz, 10-ms tone
- Probe detection thresholds levels were measured using 3AFC adaptive procedure.

Precursor

- 50-dB SPL, 400-ms noise
  - Narrowband (1/3 ERB) low-noise noise (LNN) w/and w/o 95-Hz amplitude modulation [5].
  - Broadband pink noise (0.25–8.5 kHz).
  - Pulse-spreading harmonic complexes (PSHC) (0.25–8.5 kHz) w/and w/o 95-Hz amplitude modulation [5].



Threshold Shift (dB) = Threshold $_{Precursor}$ – Threshold $_{No\ precursor}$

Participants

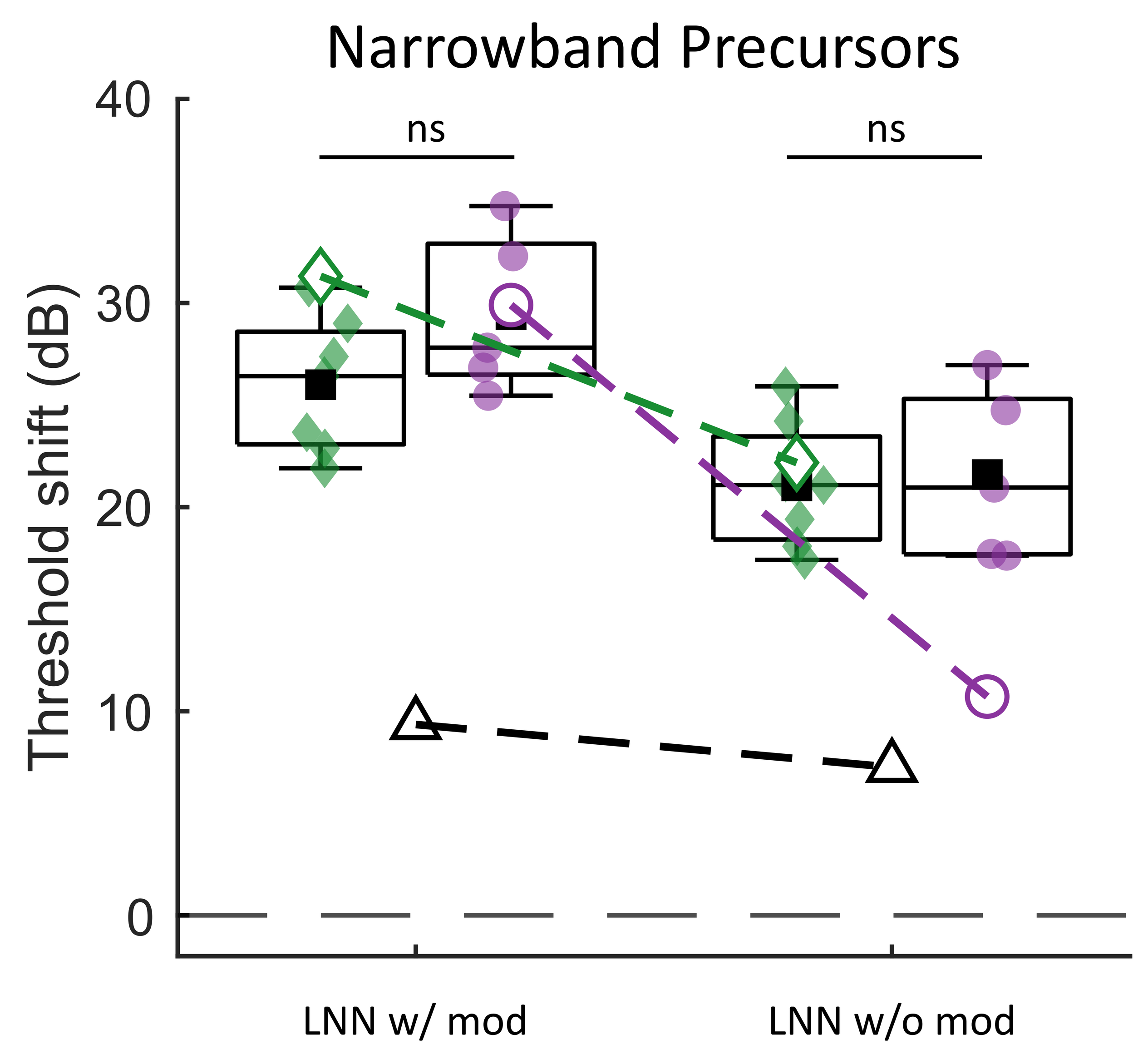
- Young normal-hearing (yNH): n = 8 22.5 ± 1.1 y.o.
- Older normal-hearing (oNH): n = 7 47.6. ± 2.5 y.o.

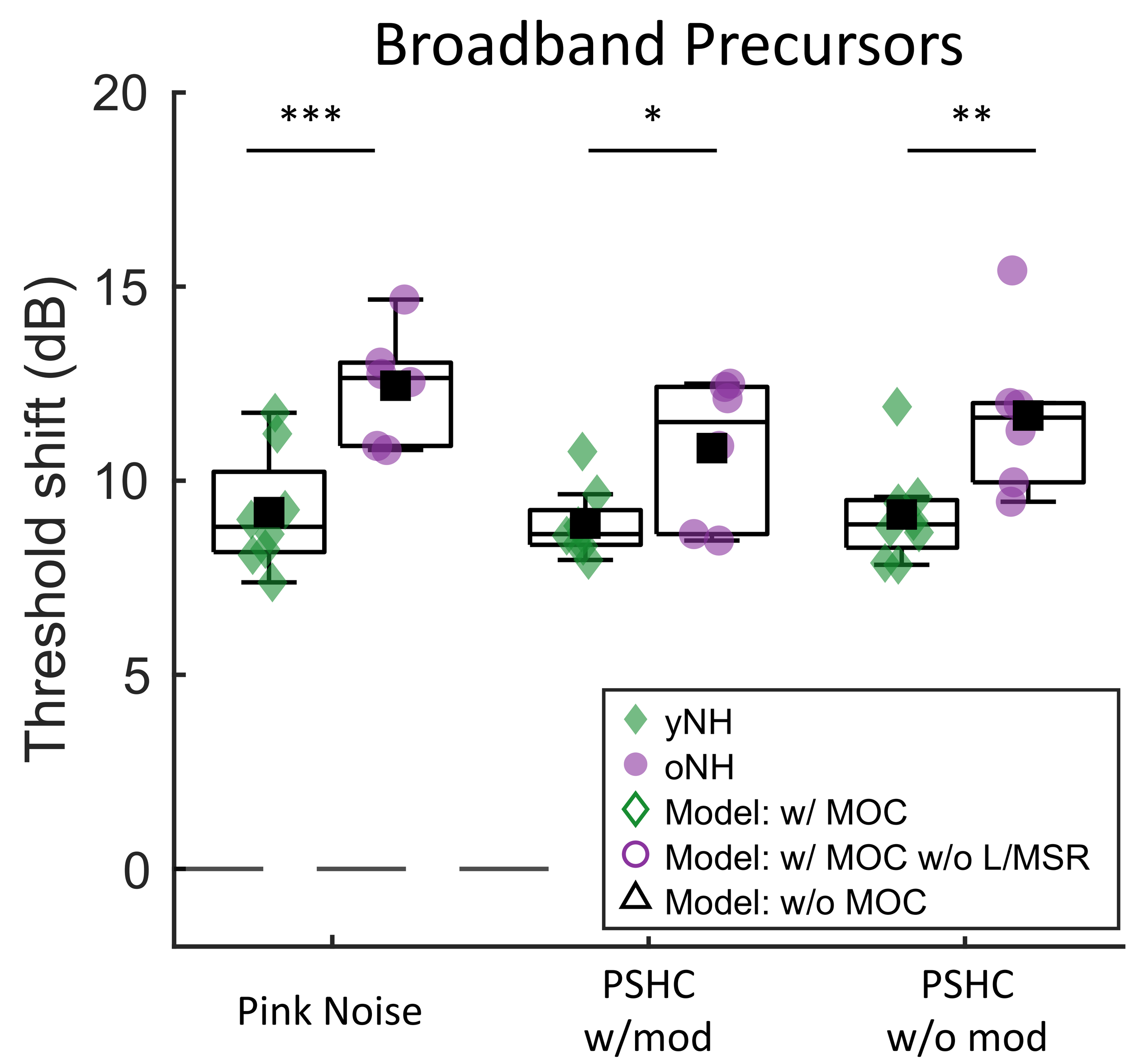
Audiological assessment

- Audiometric thresholds < 25 dB HL between 0.25-8 kHz
- Acoustic reflex thresholds:
  - above 60 dB HL for broadband elicitors
  - above 50 dB HL for narrowband elicitors

Results

1. Model simulations predicted reduced forward-masking threshold shifts when auditory-nerve input to the MOC system was reduced. The predicted reduction was strongest for narrowband precursors with weak temporal-envelope fluctuations.
2. In contrast to model predictions, behavioral data showed no group differences in probe threshold shift for narrowband precursors.
3. For broadband precursors, oNH listeners showed larger threshold shifts than the yNH listeners.
4. Only narrowband precursors produced larger probe threshold shifts when temporally modulated, but the magnitude of this effect did not differ between yNH and oNH listeners.





Discussion

- These results suggest that forward-masking estimates of cochlear gain reduction reflect more than MOC-mediated gain reduction alone. Age-related changes in neural adaptation and/or temporal integration can play a role.
- Future work should use objective measures of MOC function (OAEs) to better isolate age-related changes in MOC control of cochlear gain.

Conclusions

Behavioral and modelling results show that forward-masking estimates of cochlear gain reduction cannot be explained solely by MOC-mediated feedback in aging listeners.

References

1. Wu et al. (2019) Neurosci J.
2. Lopez-Poveda (2018) Front. neurol.
3. Salloum et al. (2025). JASA
4. Brennan et al. (2024) JASA
5. Hilkhuysen and Macherey (2014) JASA
6. Maxwell et al. (2024) eNeuro

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