



MACQUARIE
University

Hidden Hearing Loss

Dr. Joaquin Valderrama (joaquin.valderrama@nal.gov.au)

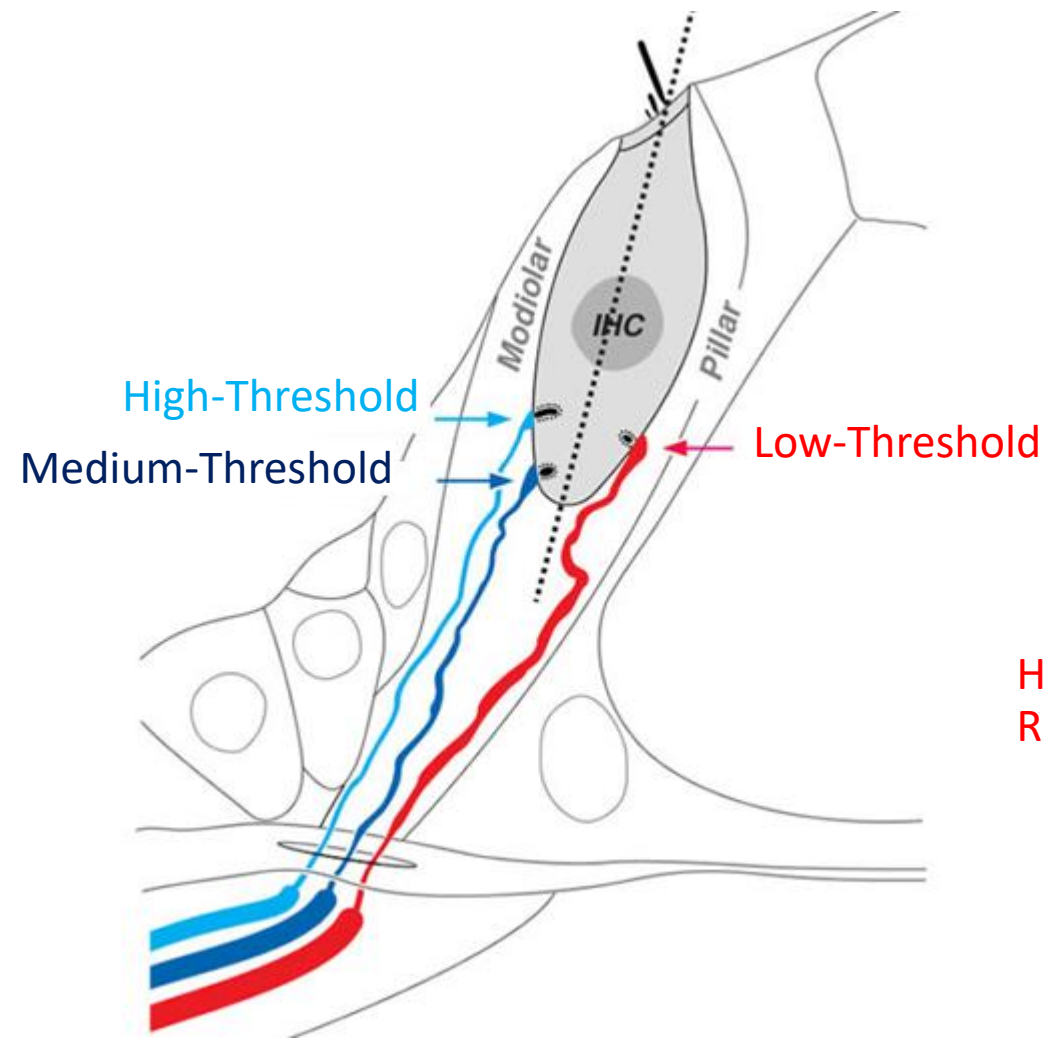
National Acoustic Laboratories

Dpt of Linguistics, Macquarie University

Sydney, 13th July, 2021

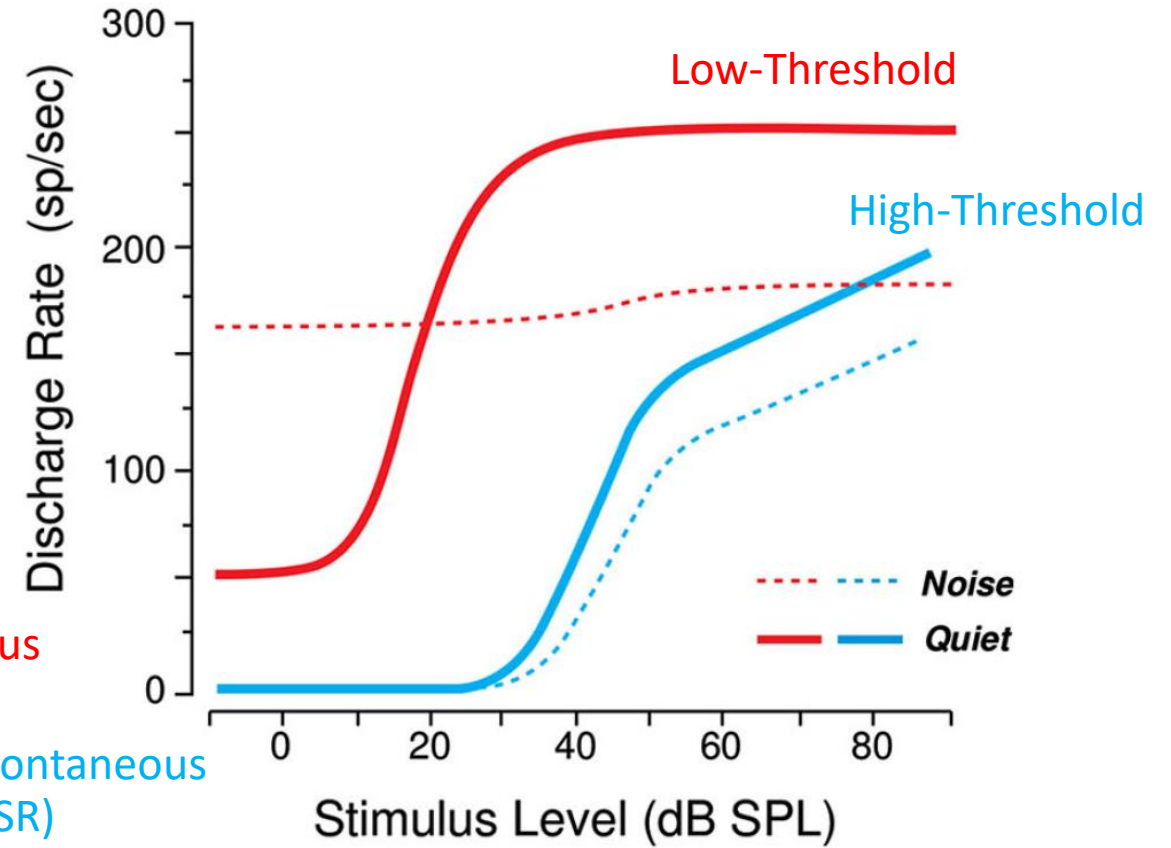


■ 120 dB $\rightarrow I_{\max} = 1,000,000,000,000 \cdot I_{\min}$



High Spontaneous Rate (HSR)

Low Spontaneous Rate (LSR)

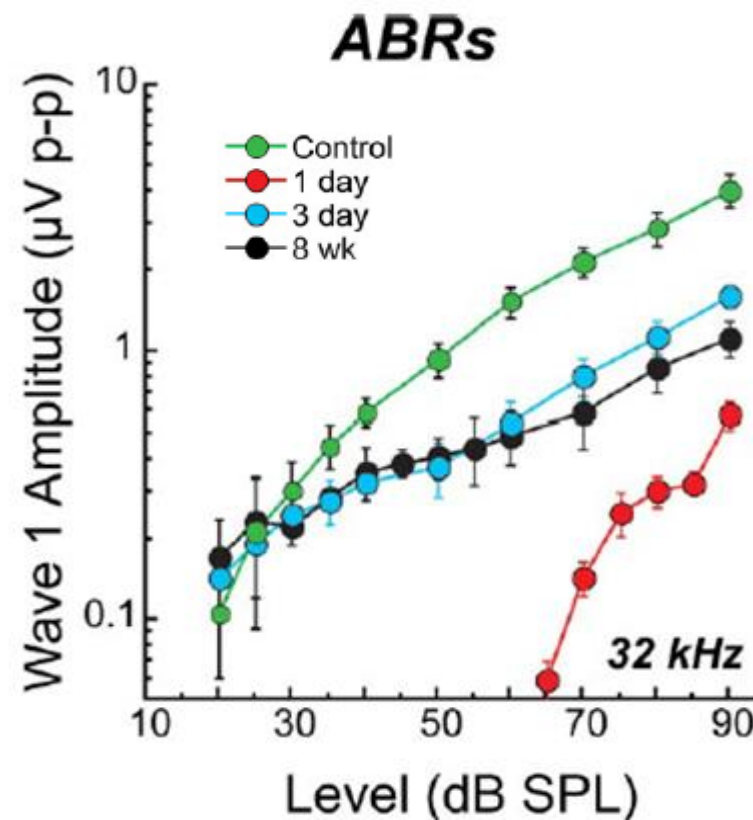
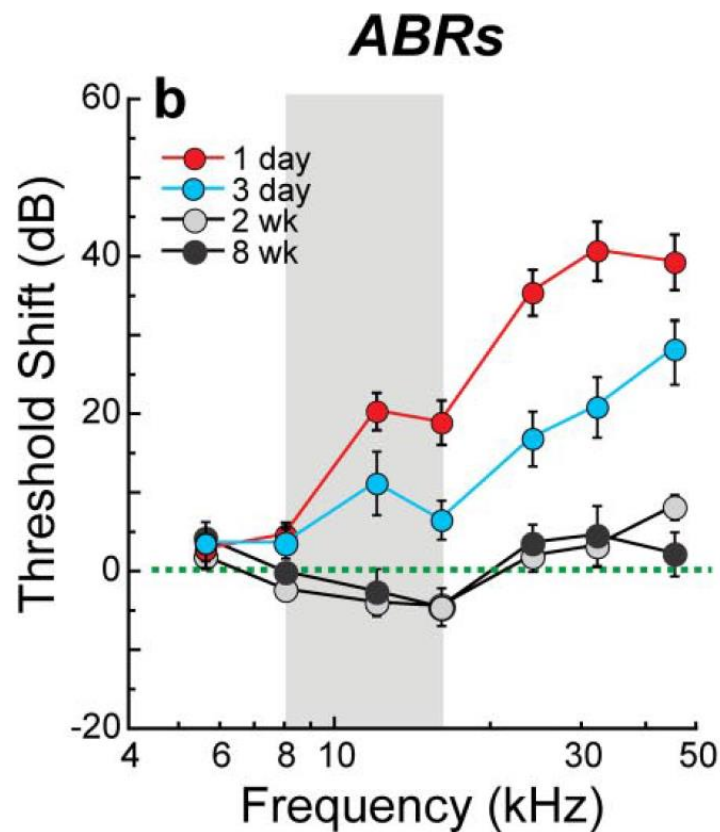


HT fibres (LSRs) play an important role in speech perception in noise

- Anaesthetized mice
- 8-16 kHz noise
- 2 h, 100 dB SPL

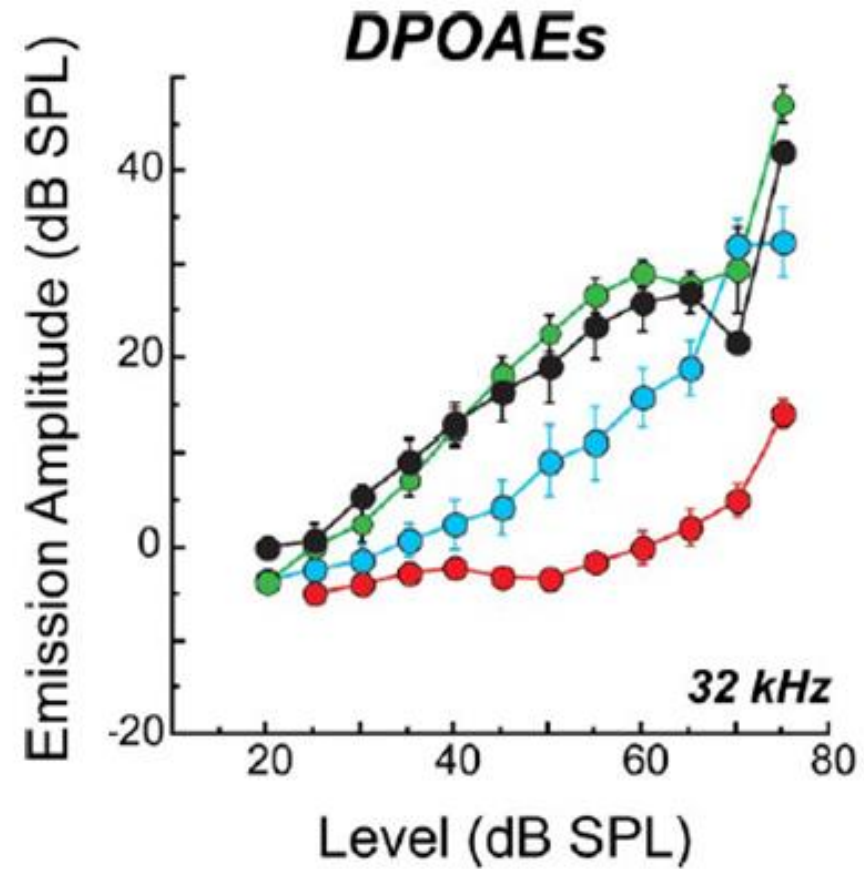
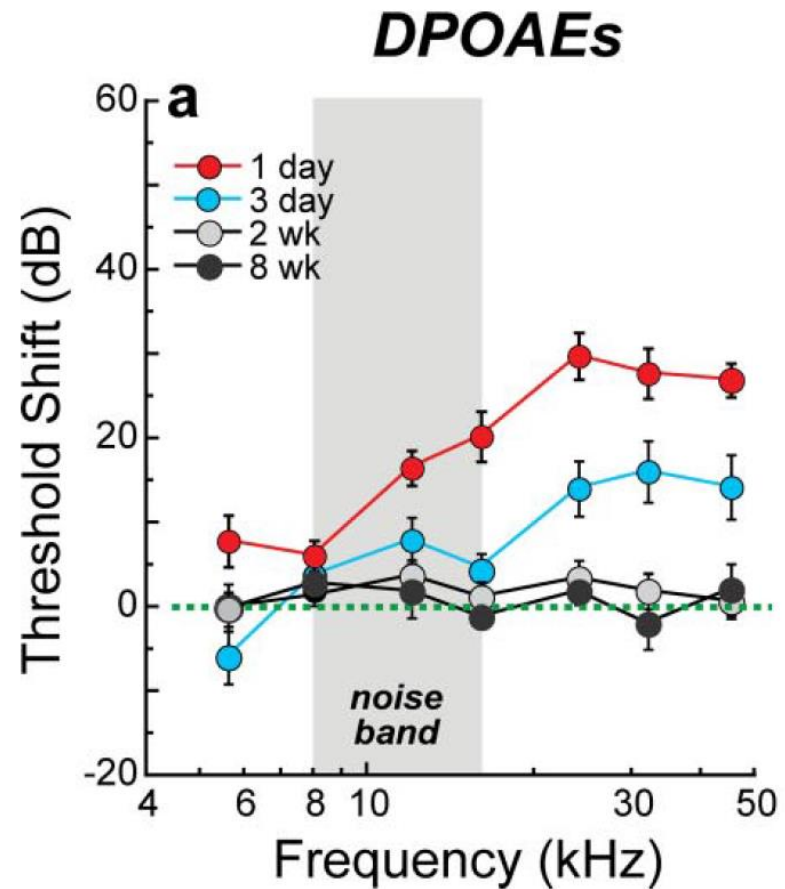
Adding Insult to Injury: Cochlear Nerve Degeneration after “Temporary” Noise-Induced Hearing Loss

Sharon G. Kujawa^{1,2,3,4} and M. Charles Liberman^{1,2,4}

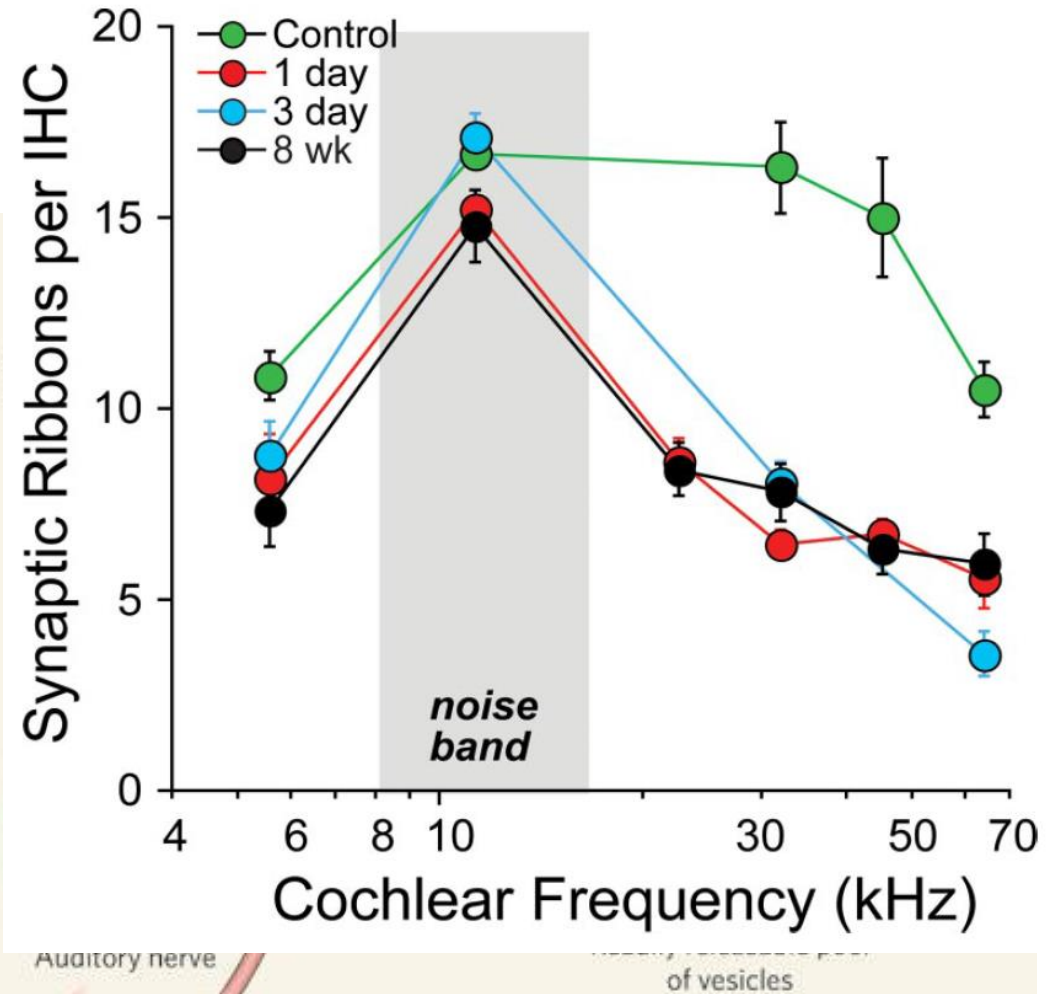
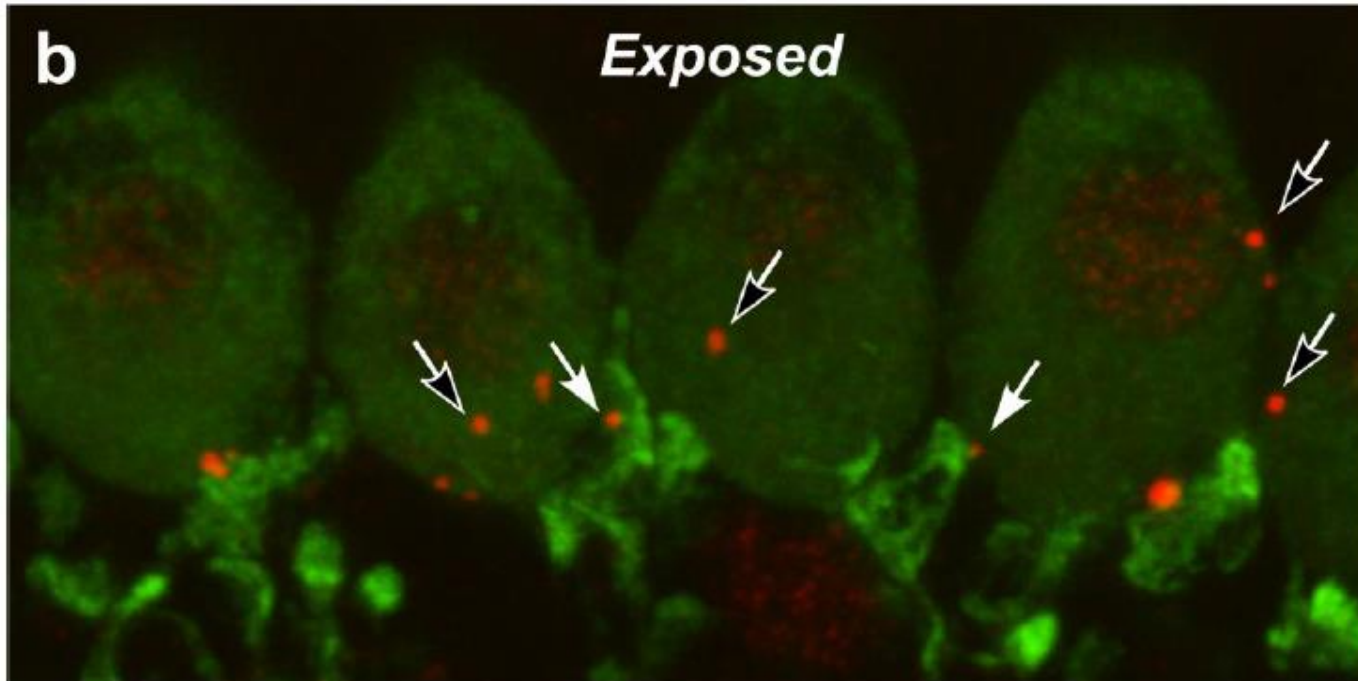
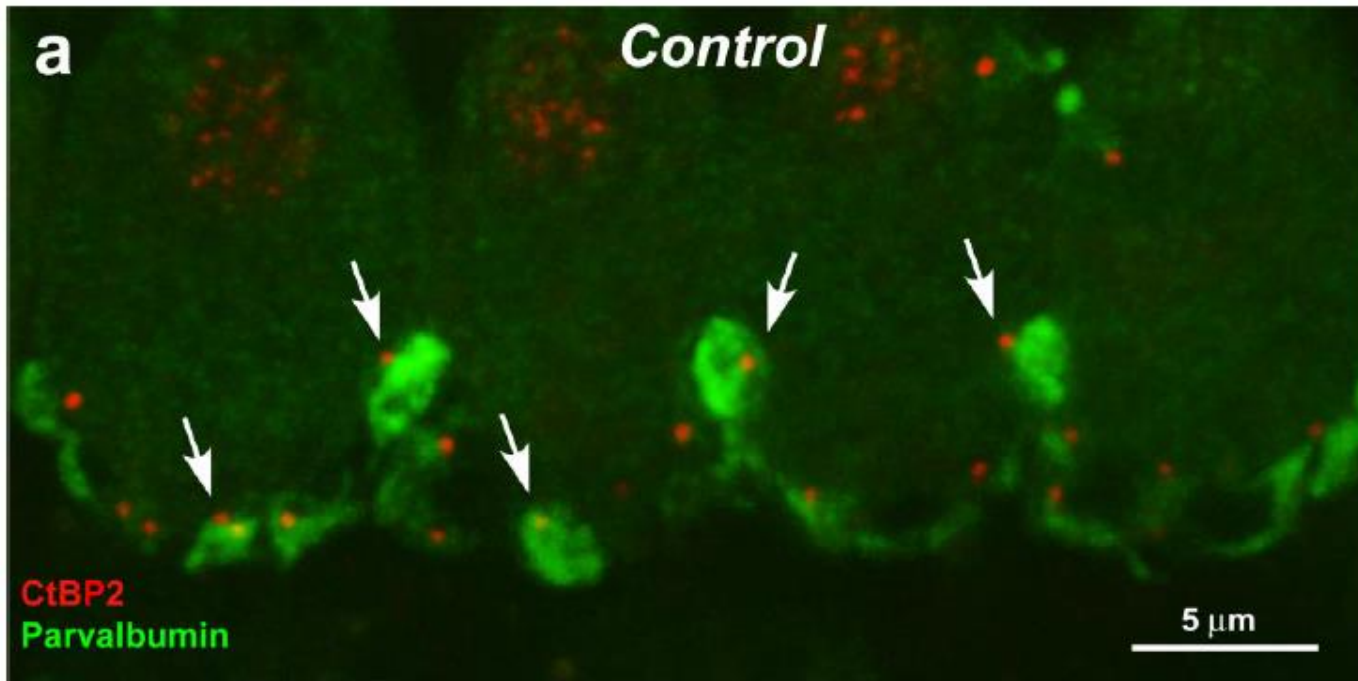


Noise damaged HT fibers

And how were hair cells affected?



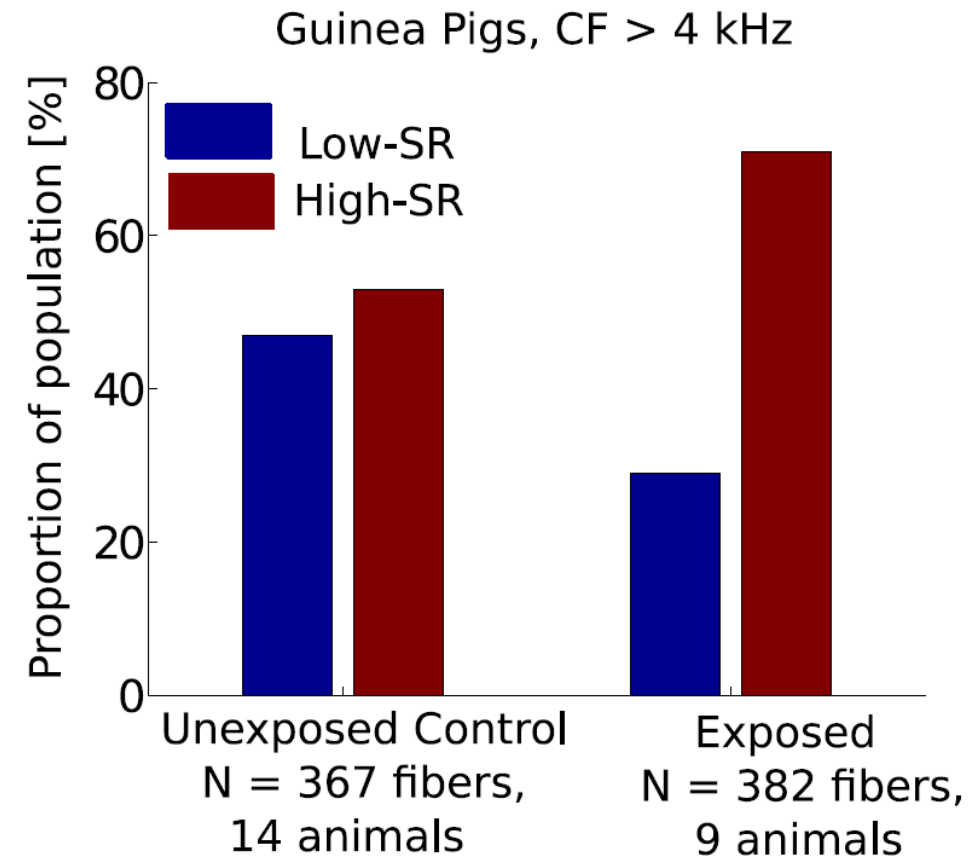
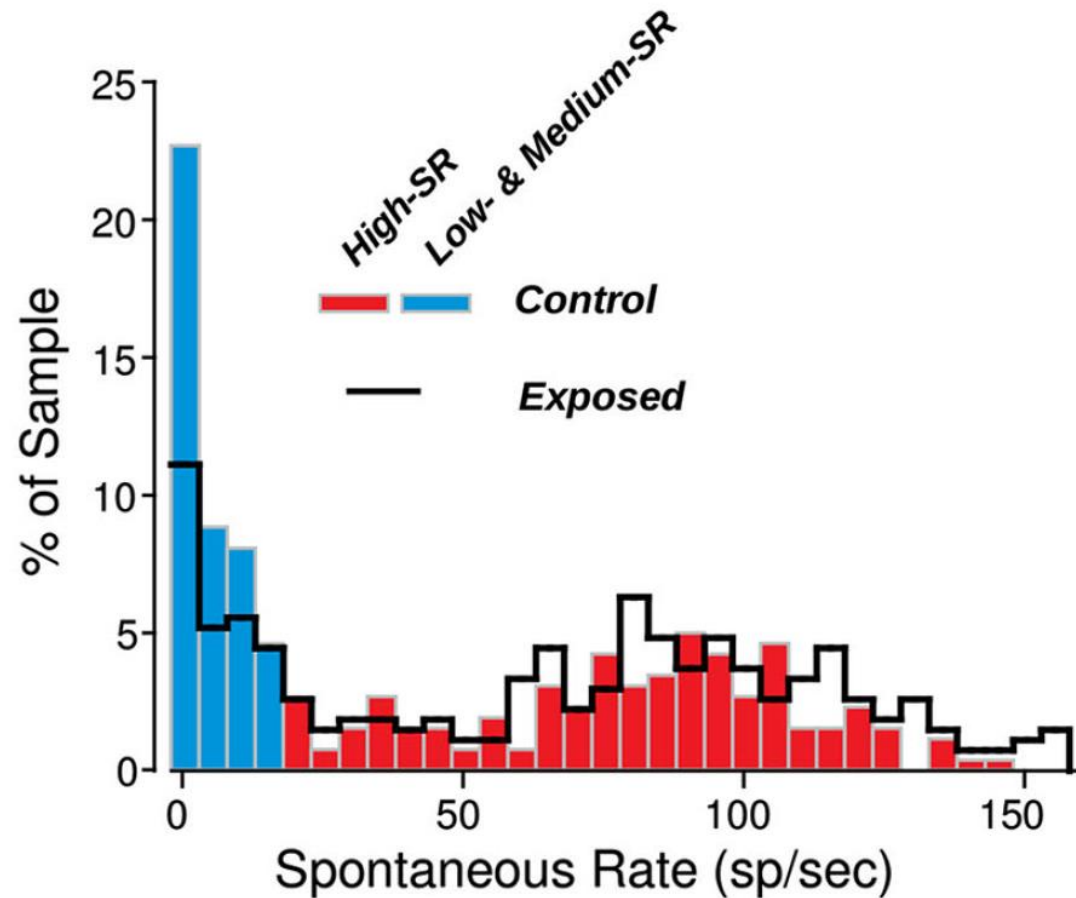
Noise did not damage outer hair cells

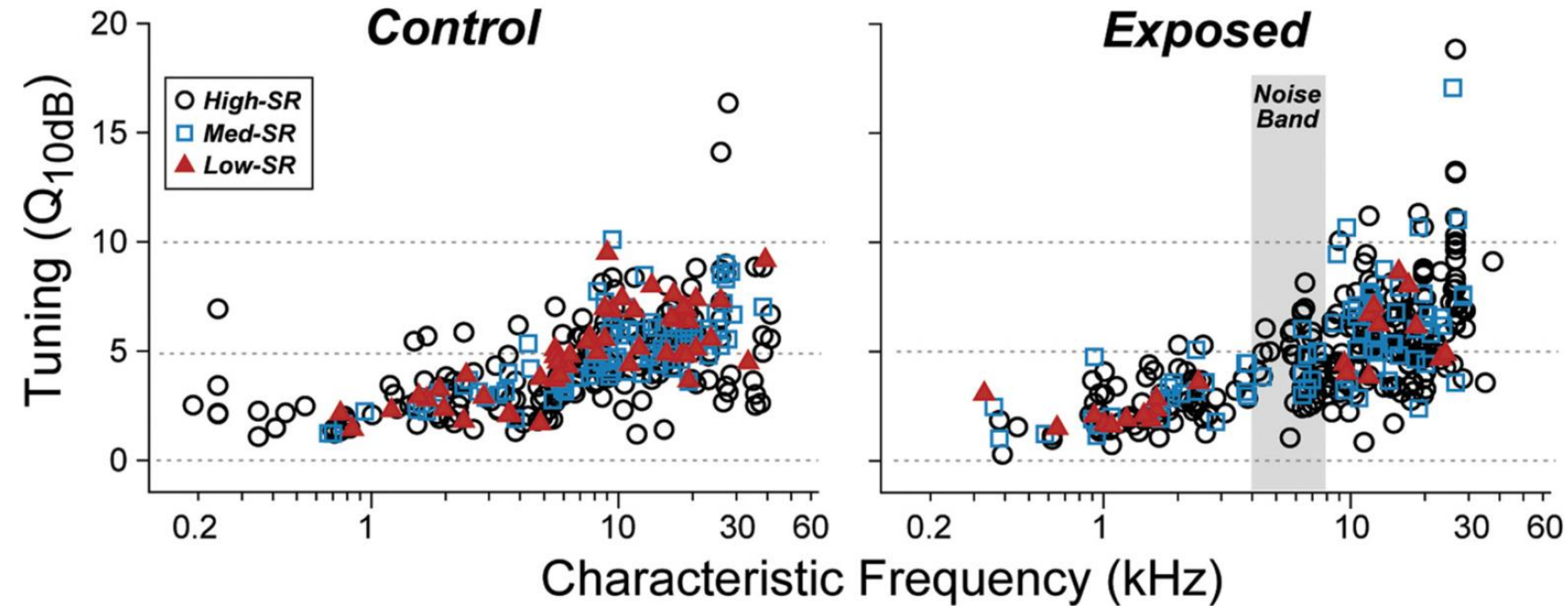


Noise-exposure “disconnects” hair cell synaptic ribbons from cochlear nerve terminals

Noise-induced cochlear neuropathy is selective for fibers with low spontaneous rates

Adam C. Furman,^{2,4} Sharon G. Kujawa,^{1,3,4} and M. Charles Liberman^{1,2,4}

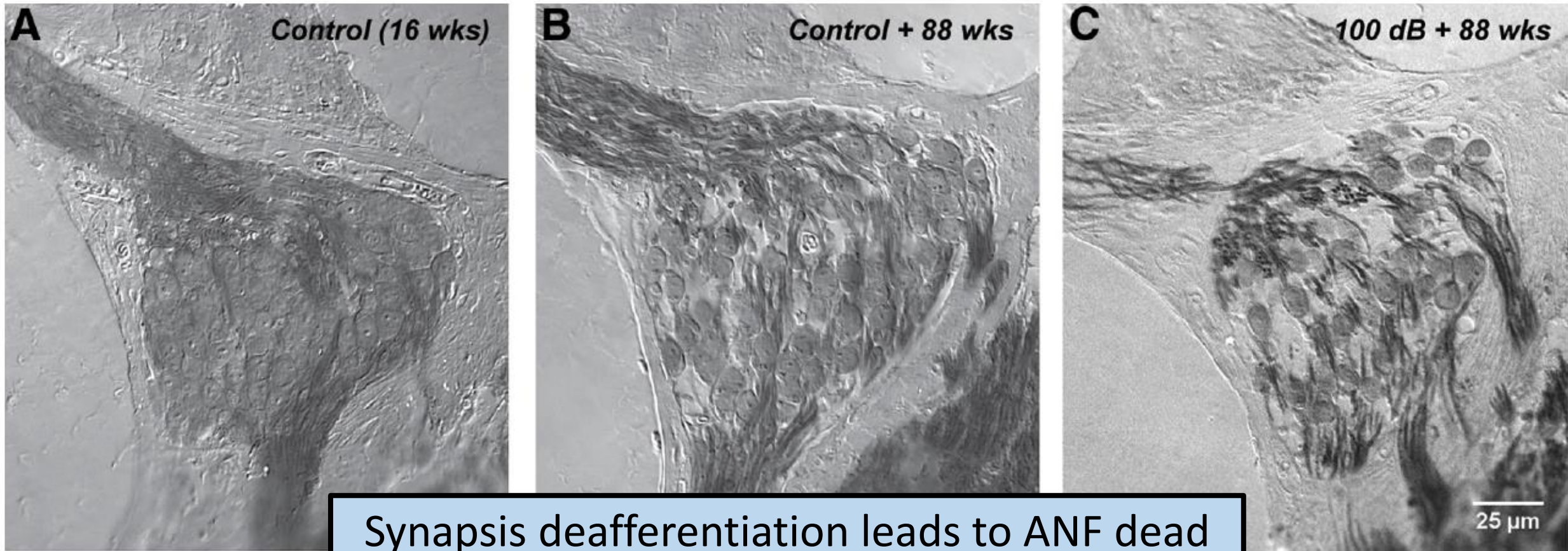




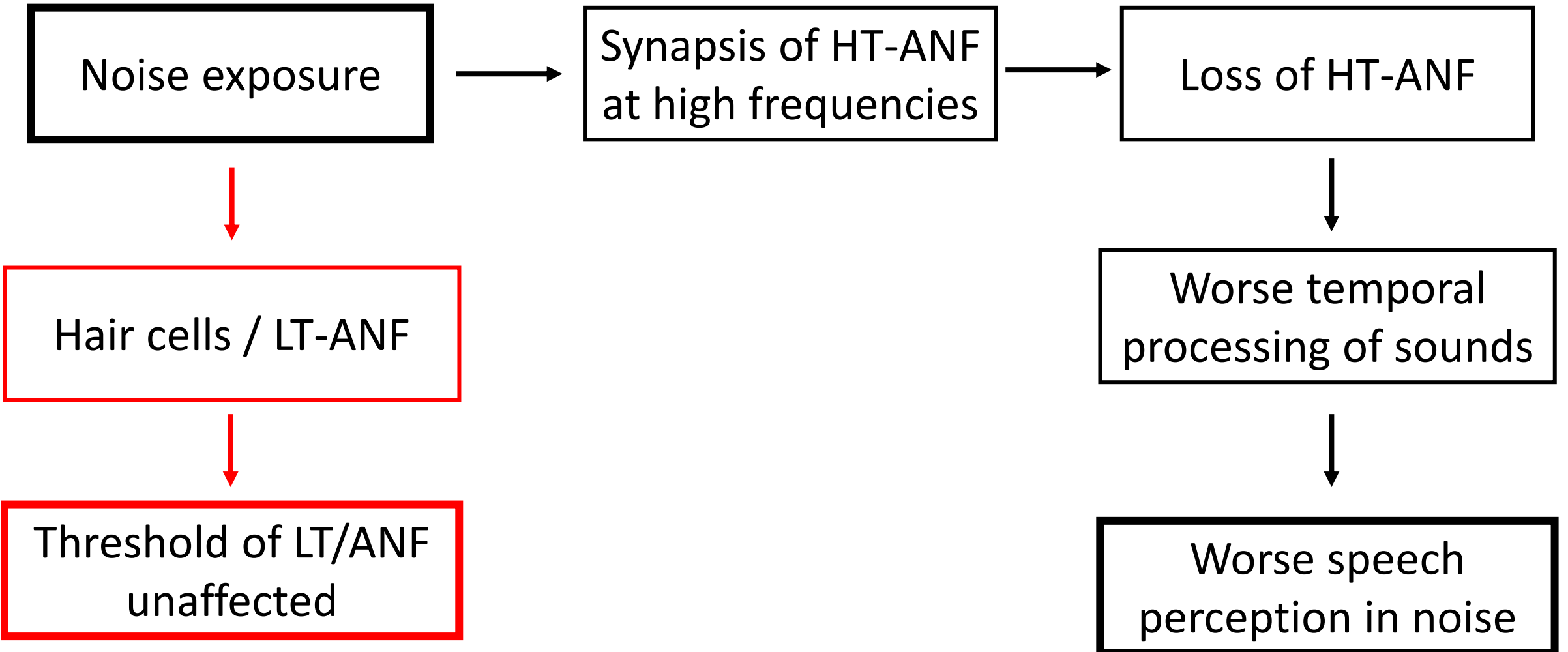
Noise exposure affects HT-ANF

Aging after Noise Exposure: Acceleration of Cochlear Synaptopathy in “Recovered” Ears

Katharine A. Fernandez,^{1,2} Penelope W.C. Jeffers,² Kumud Lall,^{1,2} M. Charles Liberman,^{1,2} and Sharon G. Kujawa^{1,2,3}



Animal model of Hidden Hearing Loss



Quiz

- What neurons participate mostly in understanding speech in noise?
 - High-Threshold / Low-Spontaneous Rate Auditory Nerve Fibers
- Who were the authors of a very relevant study that has influenced HHL research?
 - Sharon Kujawa & Charles Liberman
- In what year?
 - 2009
- According to this study, what happened to thresholds after noise exposure?
 - They recovered
- Does this mean that noise exposure is harmless?
 - No, it affects HT-ANF
- What is the consequence of losing HT-ANF?
 - Worse temporal processing of sounds, thus worse speech perception in noise

References

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- Furman AC, Kujawa SG, Liberman MC (**2013**). “Noise-induced cochlear neuropathy is selective for fibers with low spontaneous rates”. *Journal of Neurophysiology* 110: 577-586.
- Fernandez KA, Jeffers PWC, Lall K, Liberman MC, Kujawa SG (**2014**). “Aging after noise exposure: acceleration of cochlear synaptopathy in ‘recovered’ ears”. *The Journal of Neuroscience* 35(19): 7509-7520.
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Diagnosing HHL in humans

Dr. Joaquin Valderrama (joaquin.valderrama@nal.gov.au)

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Sydney, 13th July, 2021



■ **Why is it important?**

- ✓ Audiologists
- ✓ Society
- ✓ Industry

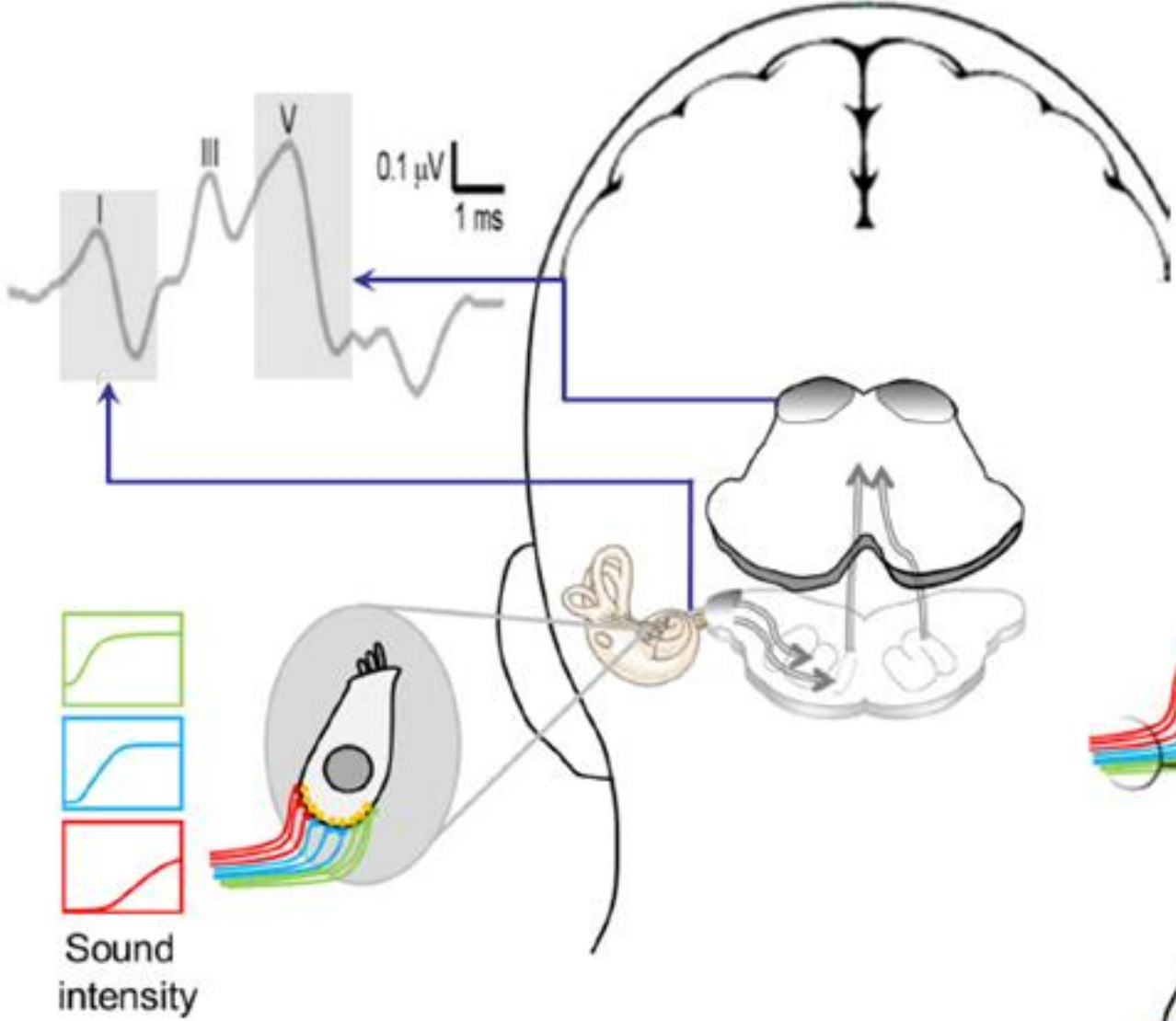
■ **What are the main indicators?**

- ✓ Auditory Brainstem Responses (ABR)
- ✓ Envelope Following Responses (EFR)

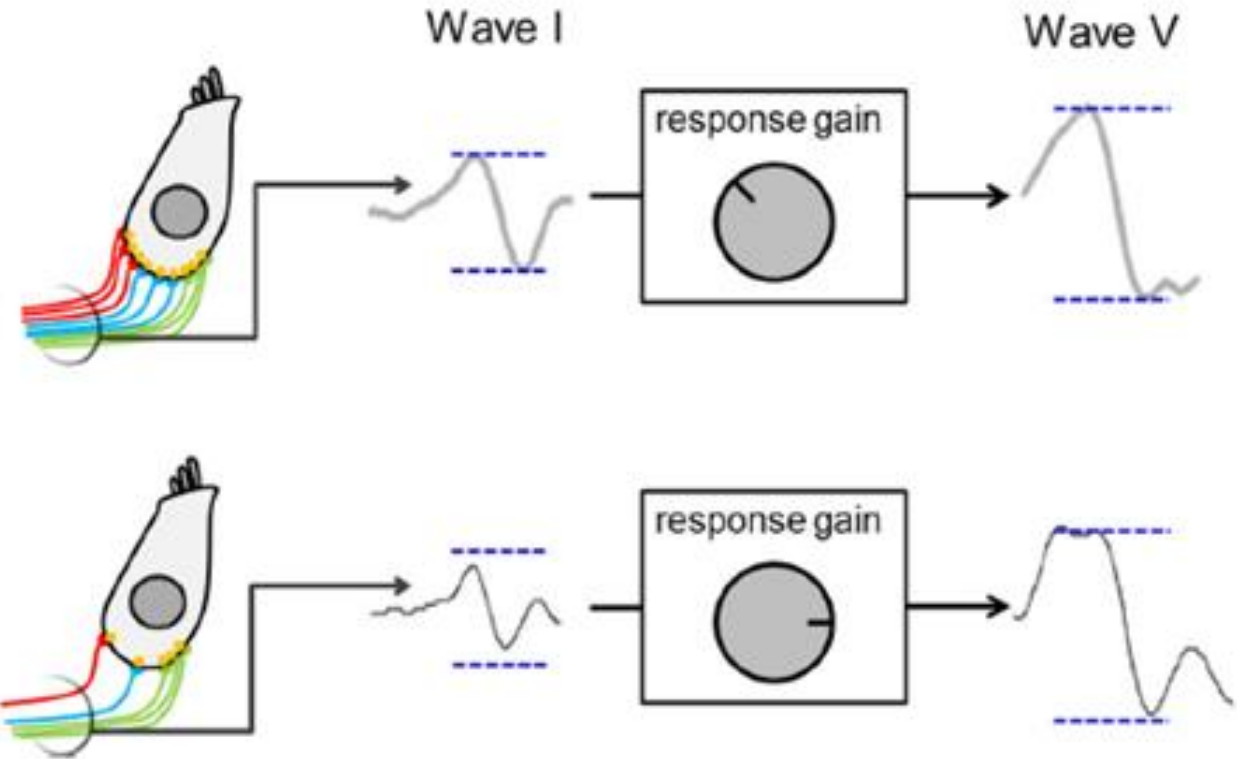
■ **What are the obstacles?**

- ✓ Intersubject variability
- ✓ Lack of validation

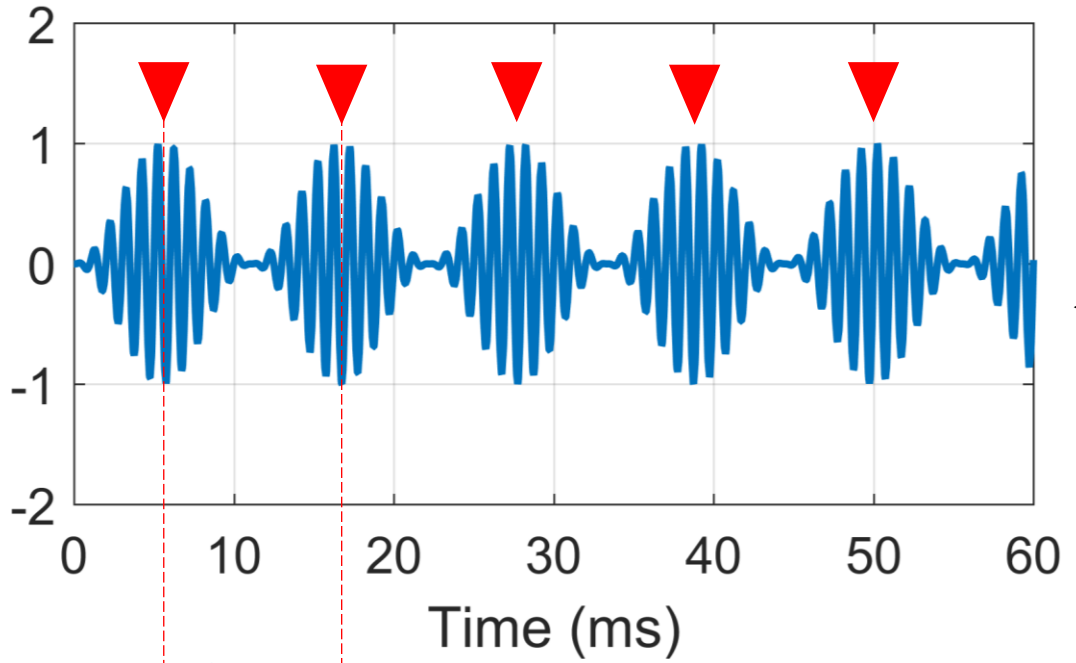
Auditory Brainstem Responses (ABR) – Hypotheses



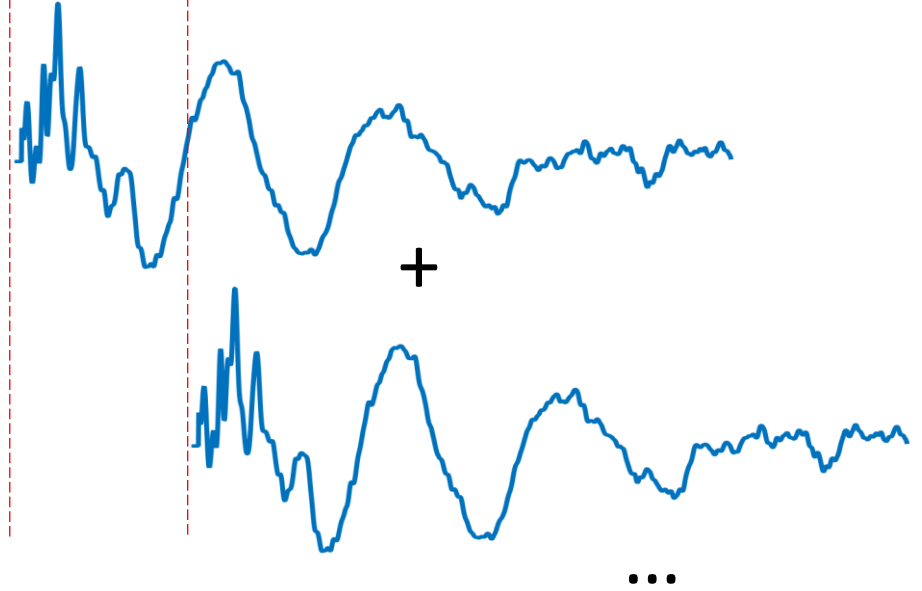
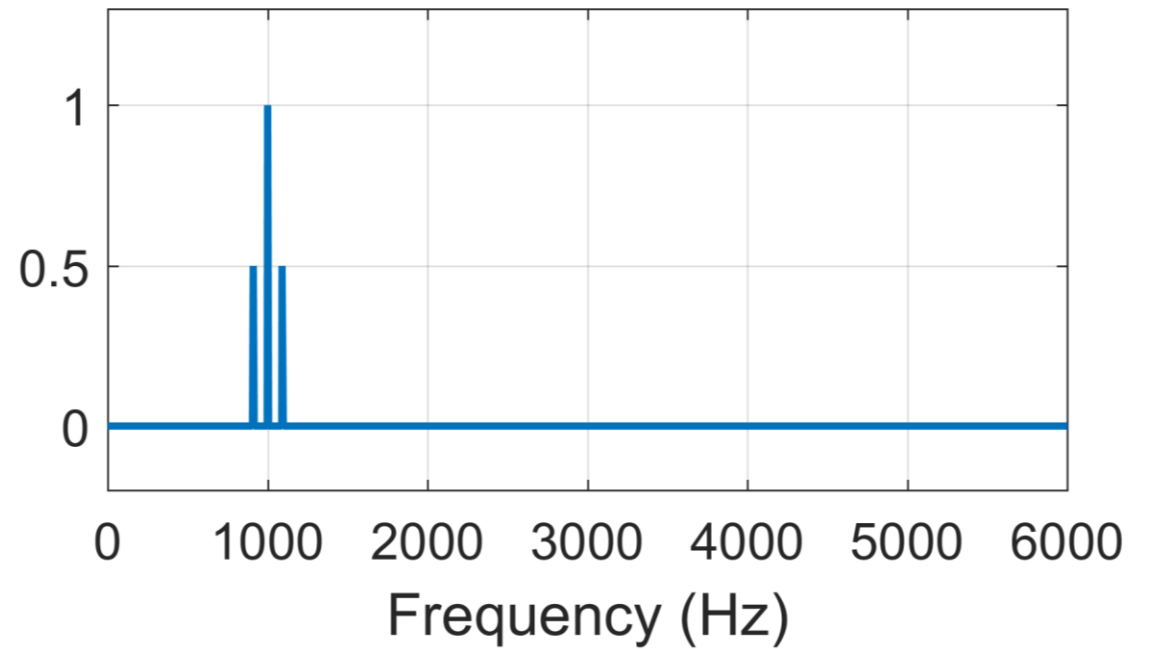
Central gain activation as indicator of cochlear neuropathy



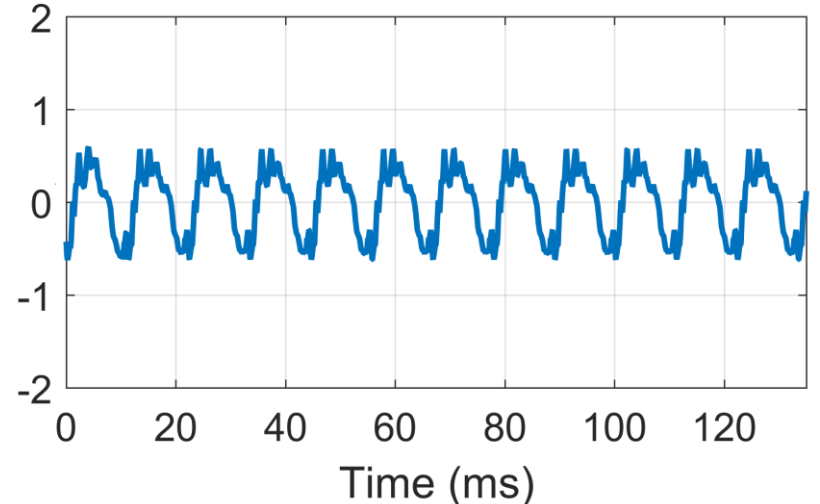
Envelope Following Responses (EFR) – Test



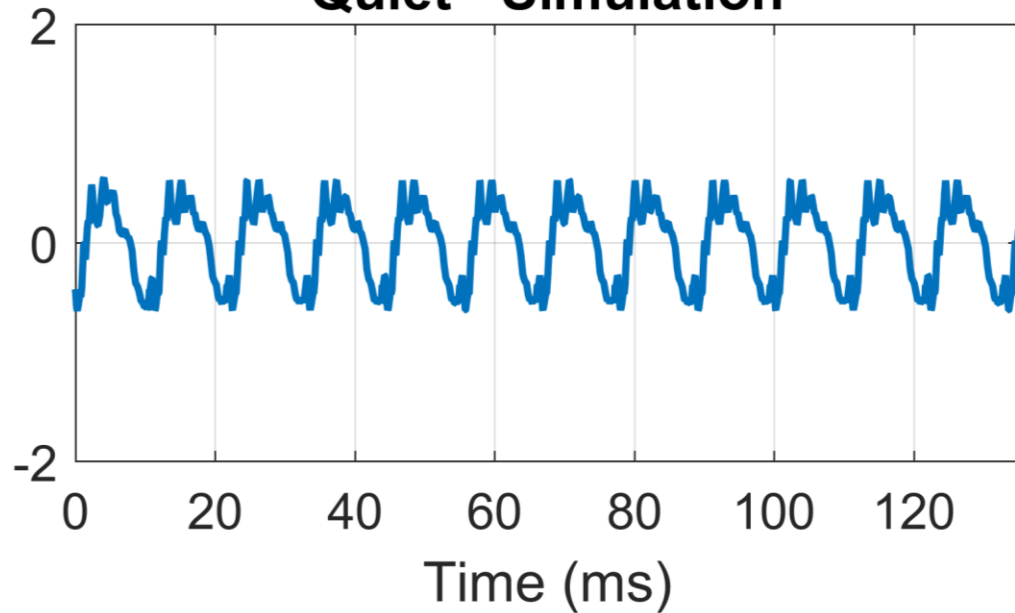
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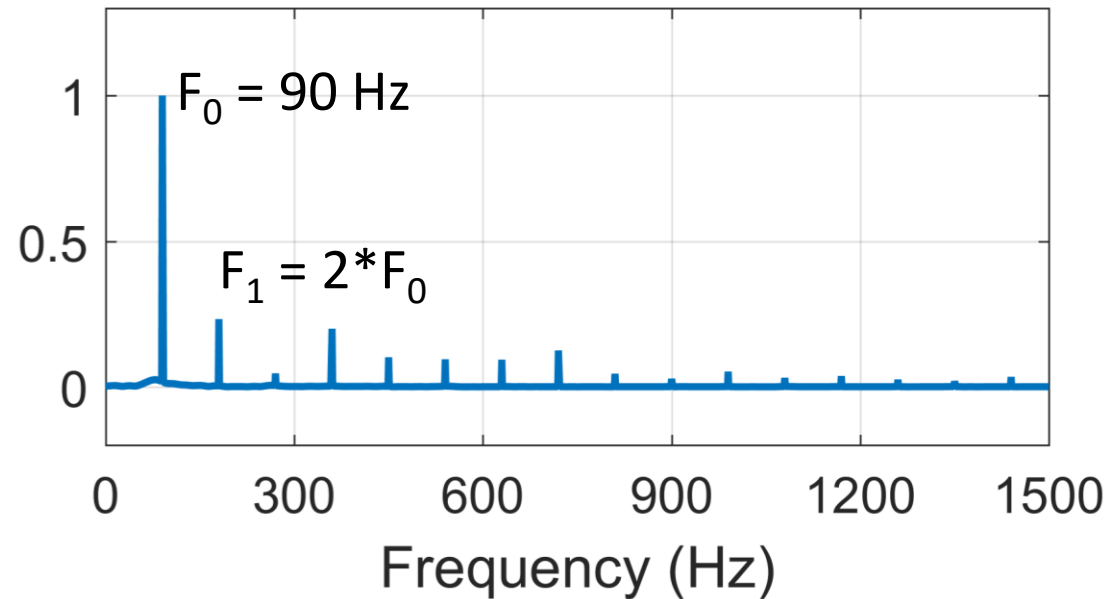
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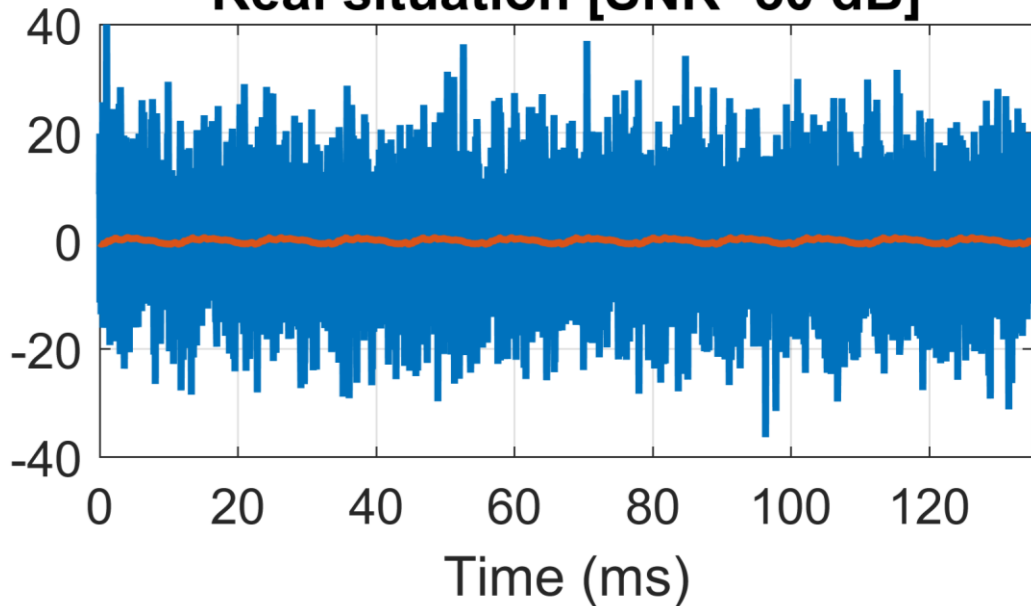
Quiet - Simulation



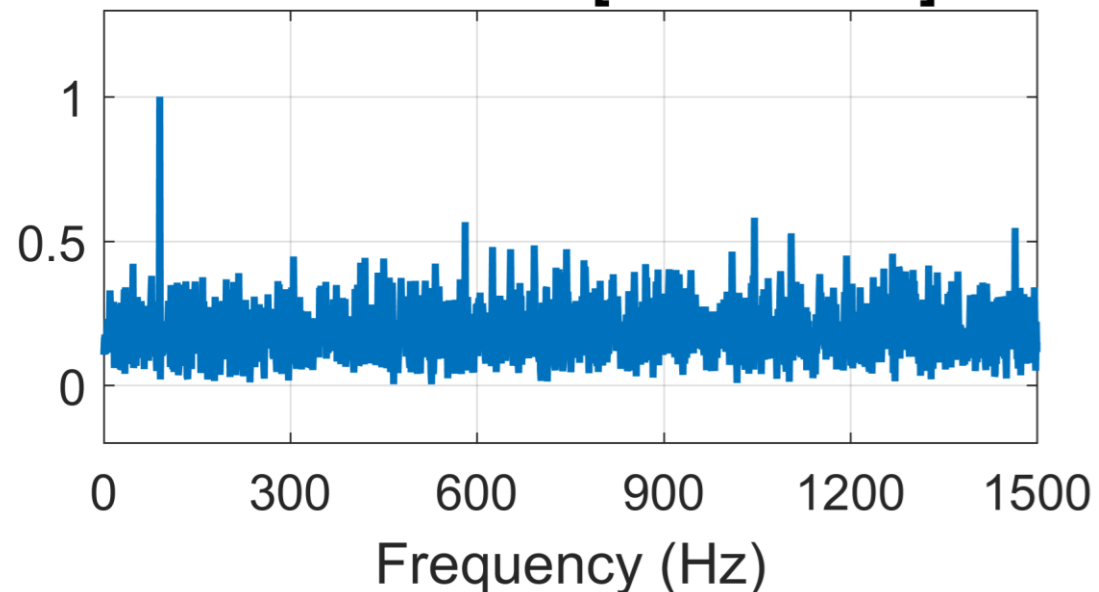
Quiet - Simulation



Real situation [SNR -30 dB]

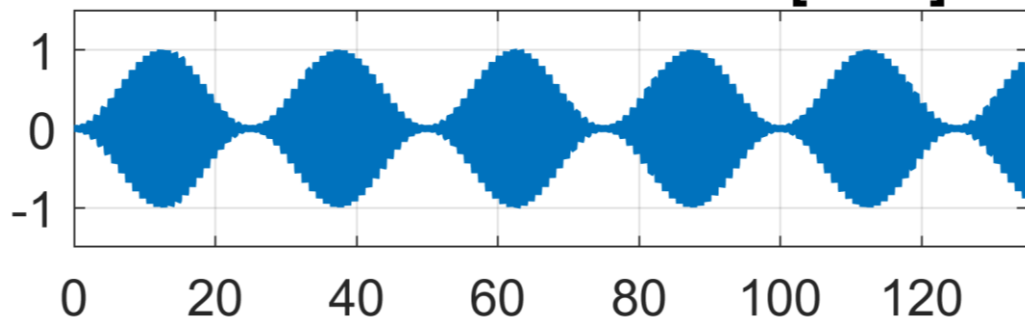


Real situation [SNR -30 dB]

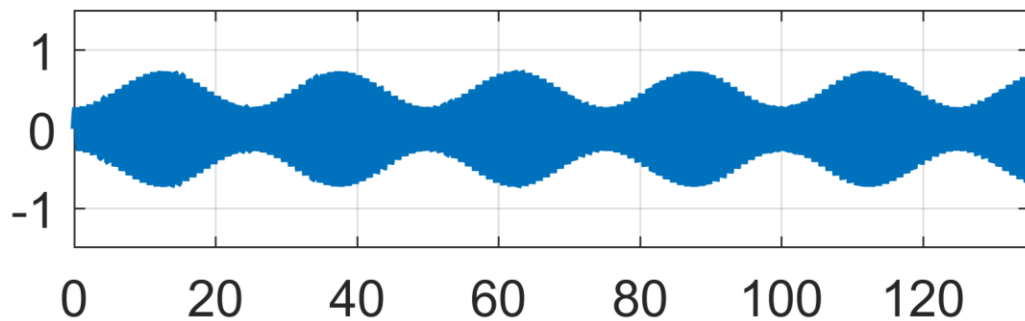


Hypothesis

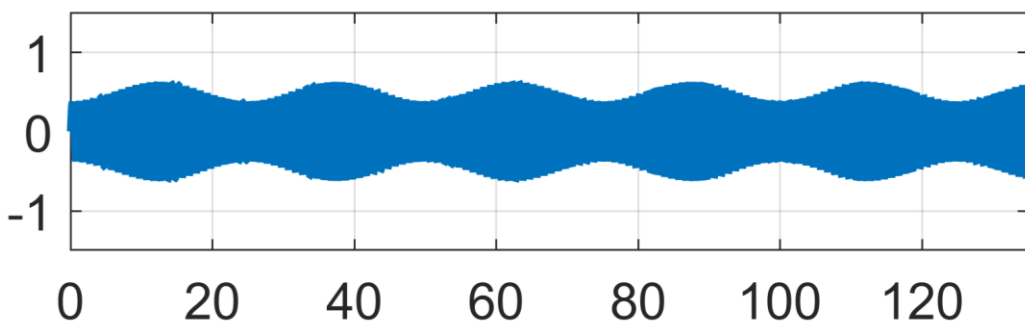
100% Modulation index [0 dB]



-4 Modulation index

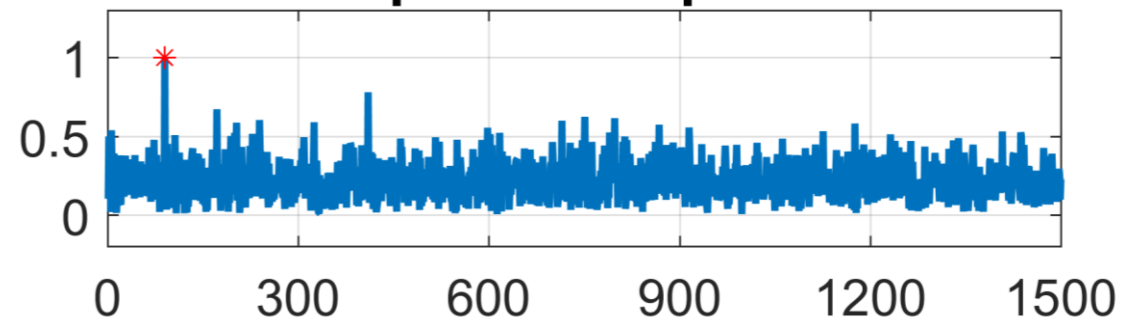


-8 dB Modulation index

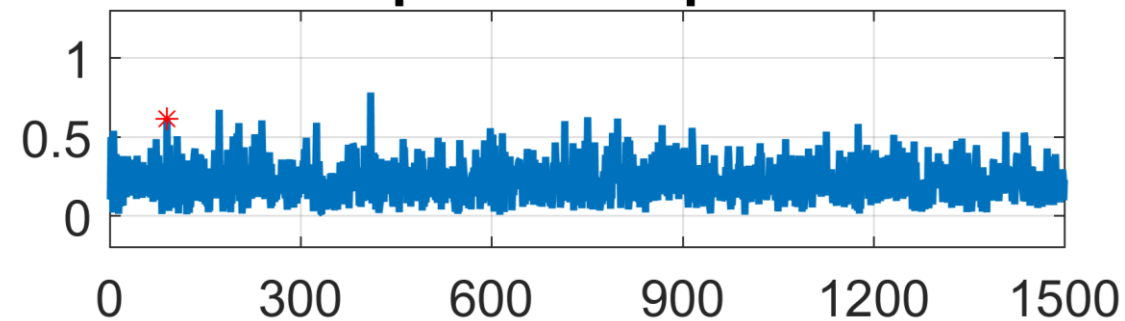


Time (ms)

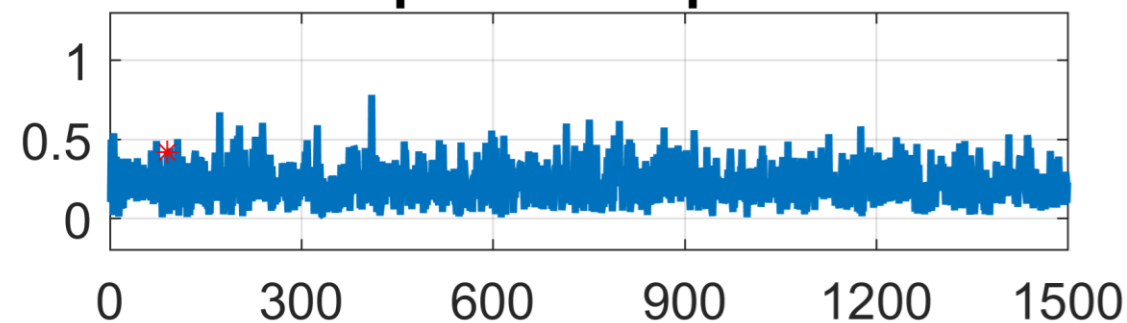
Expected response



Expected response

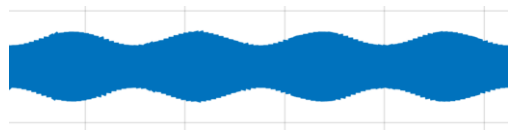
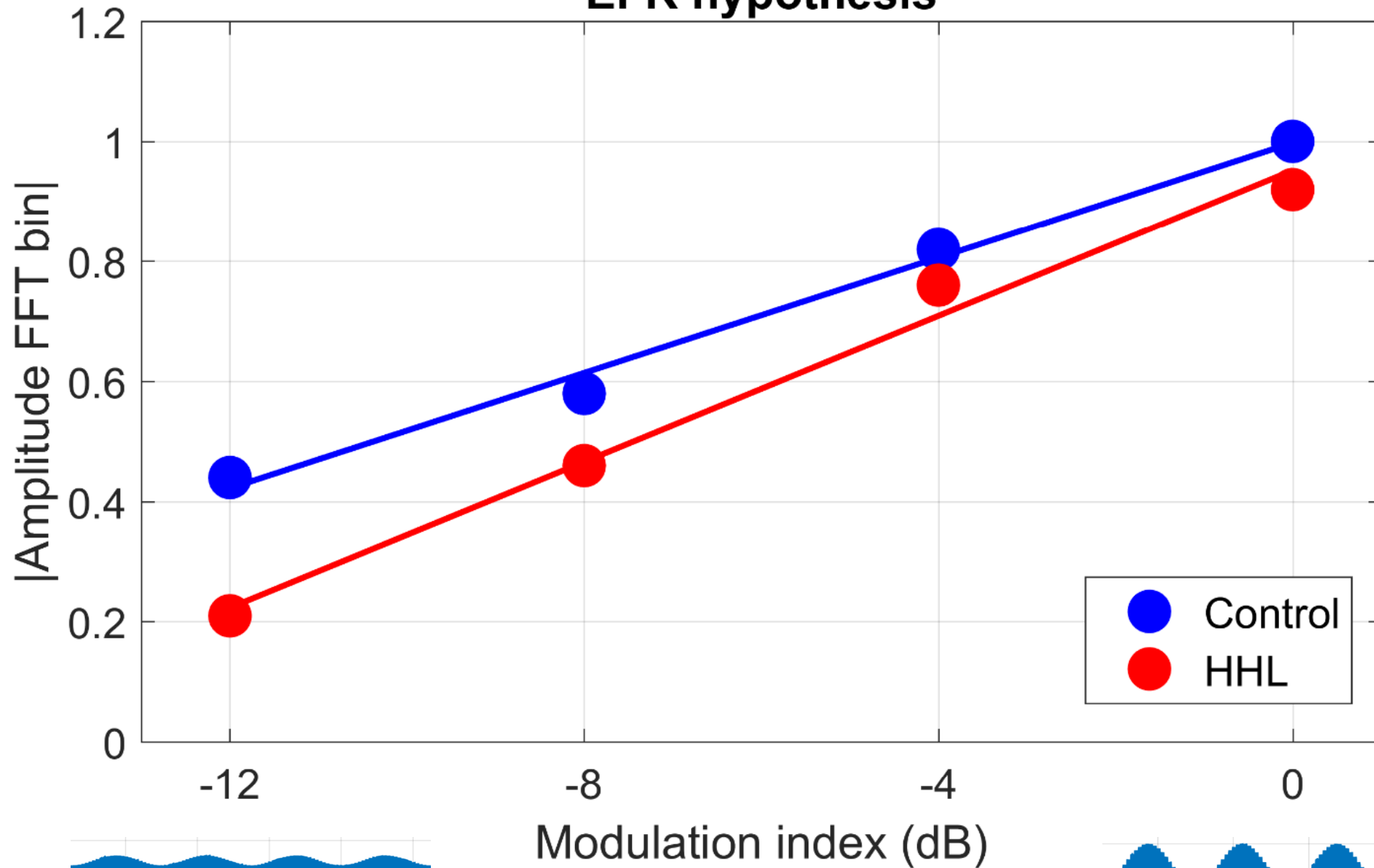


Expected response



Frequency (Hz)

EFR hypothesis

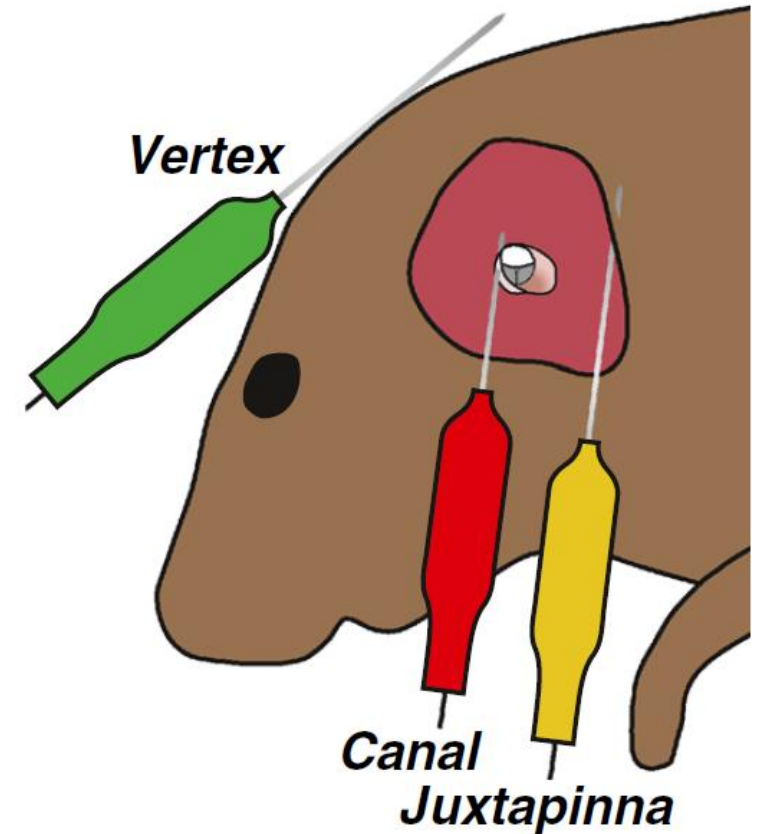
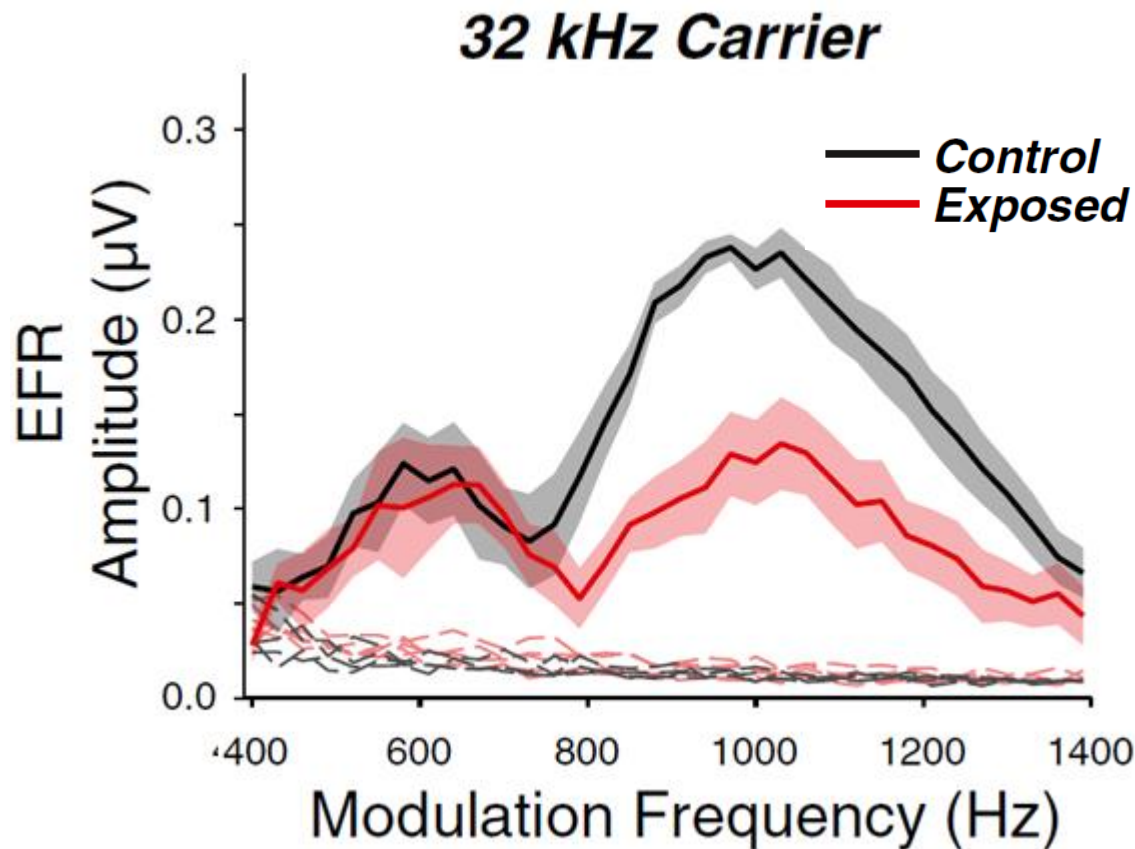




Research Article

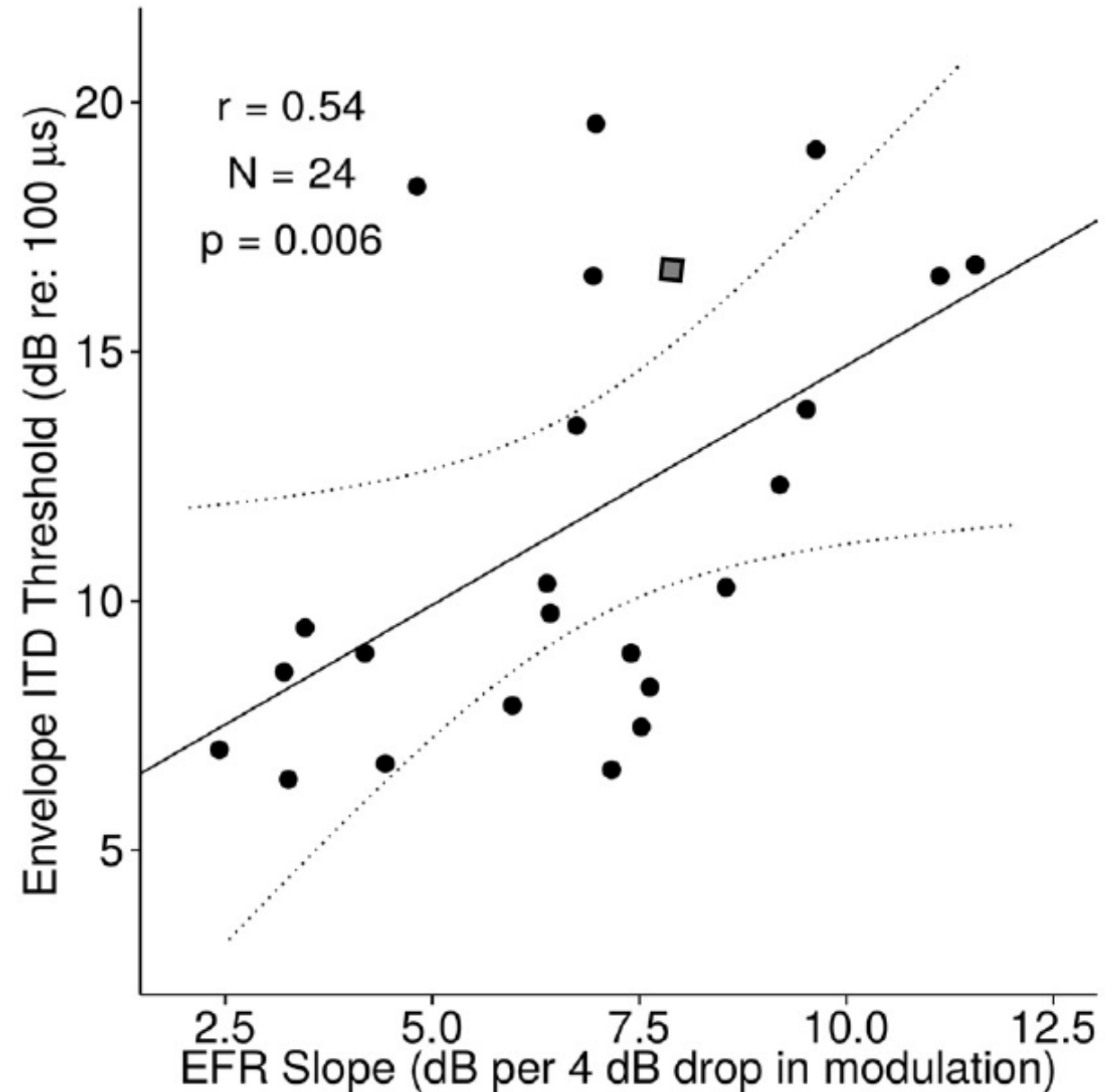
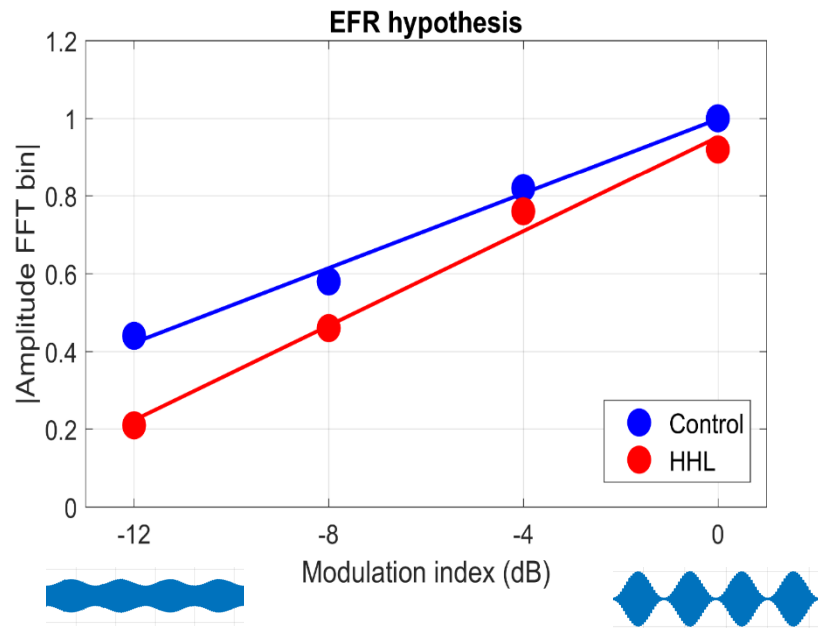
Towards a Diagnosis of Cochlear Neuropathy with Envelope Following Responses

LUKE A. SHAHEEN,^{1,2} MICHELLE D. VALERO,^{2,3} AND M. CHARLES LIBERMAN^{1,2,3}

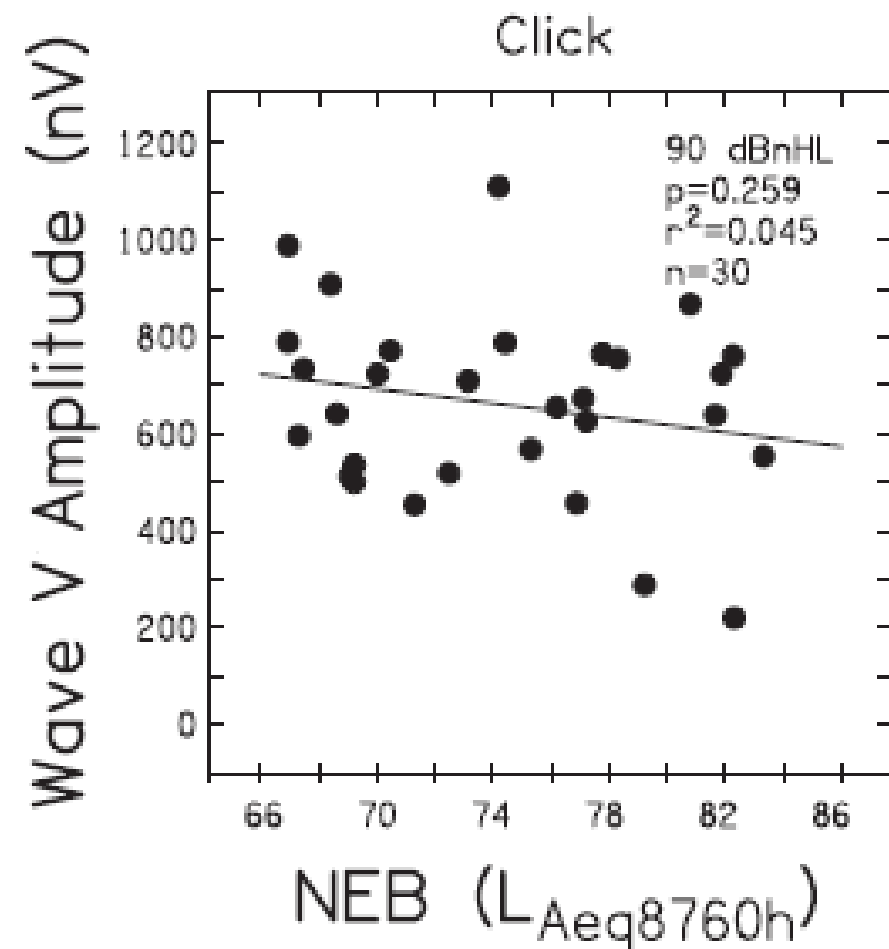
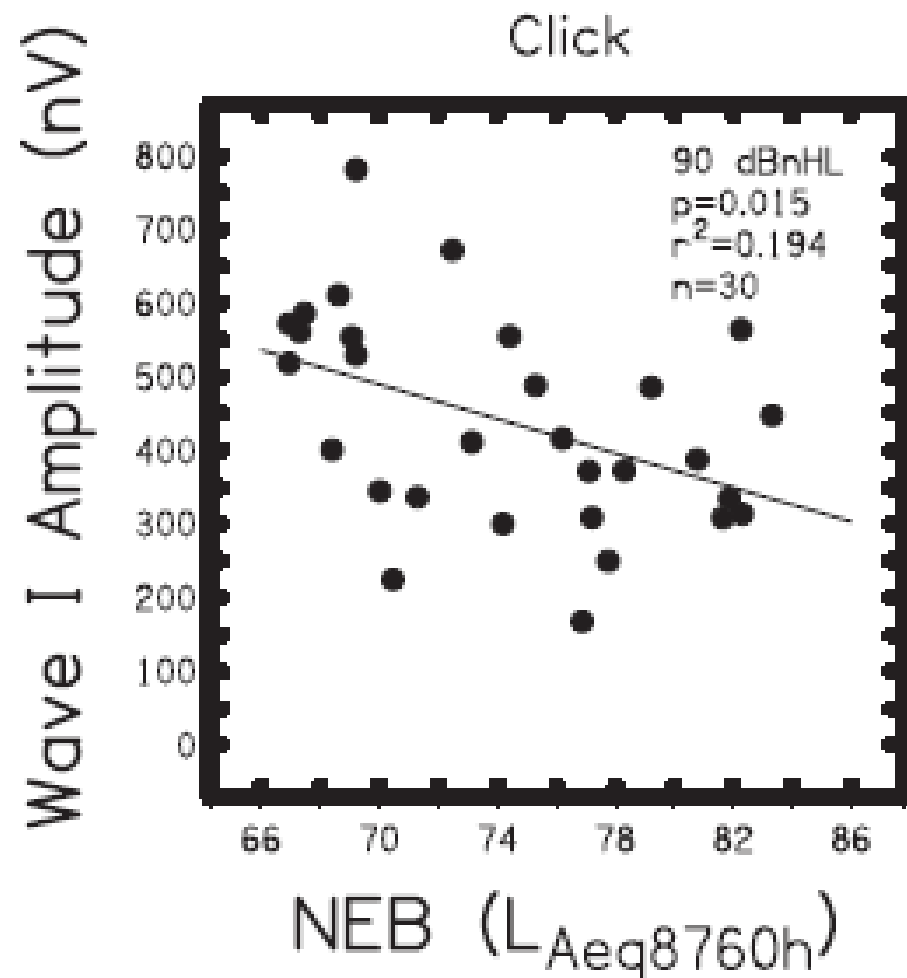
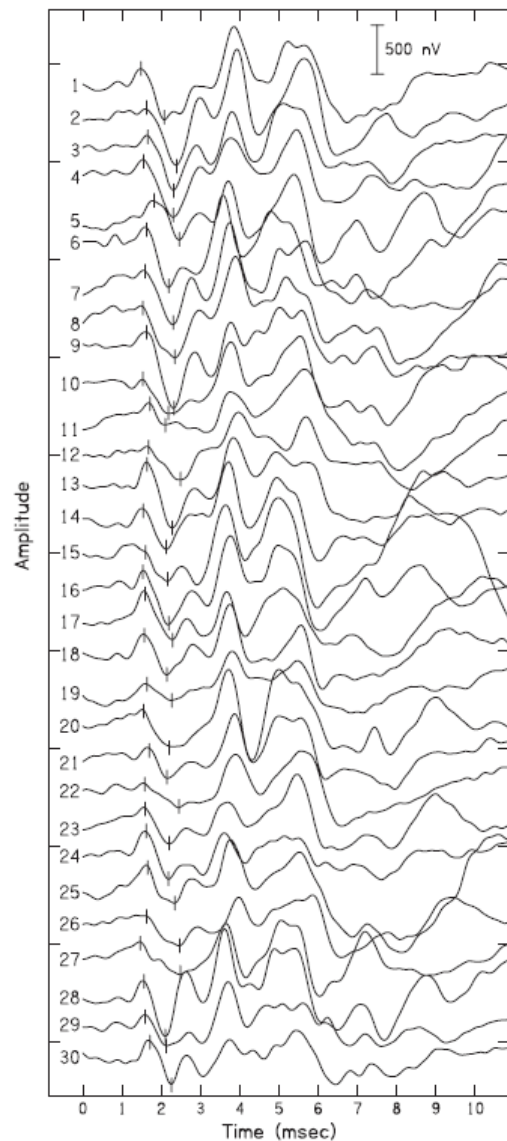


Individual Differences Reveal Correlates of Hidden Hearing Deficits

Hari M. Bharadwaj,^{1,2} Salwa Masud,^{1,2} Golbarg Mehraei,^{1,3} Sarah Verhulst,^{1,4} and Barbara G. Shinn-Cunningham^{1,2}

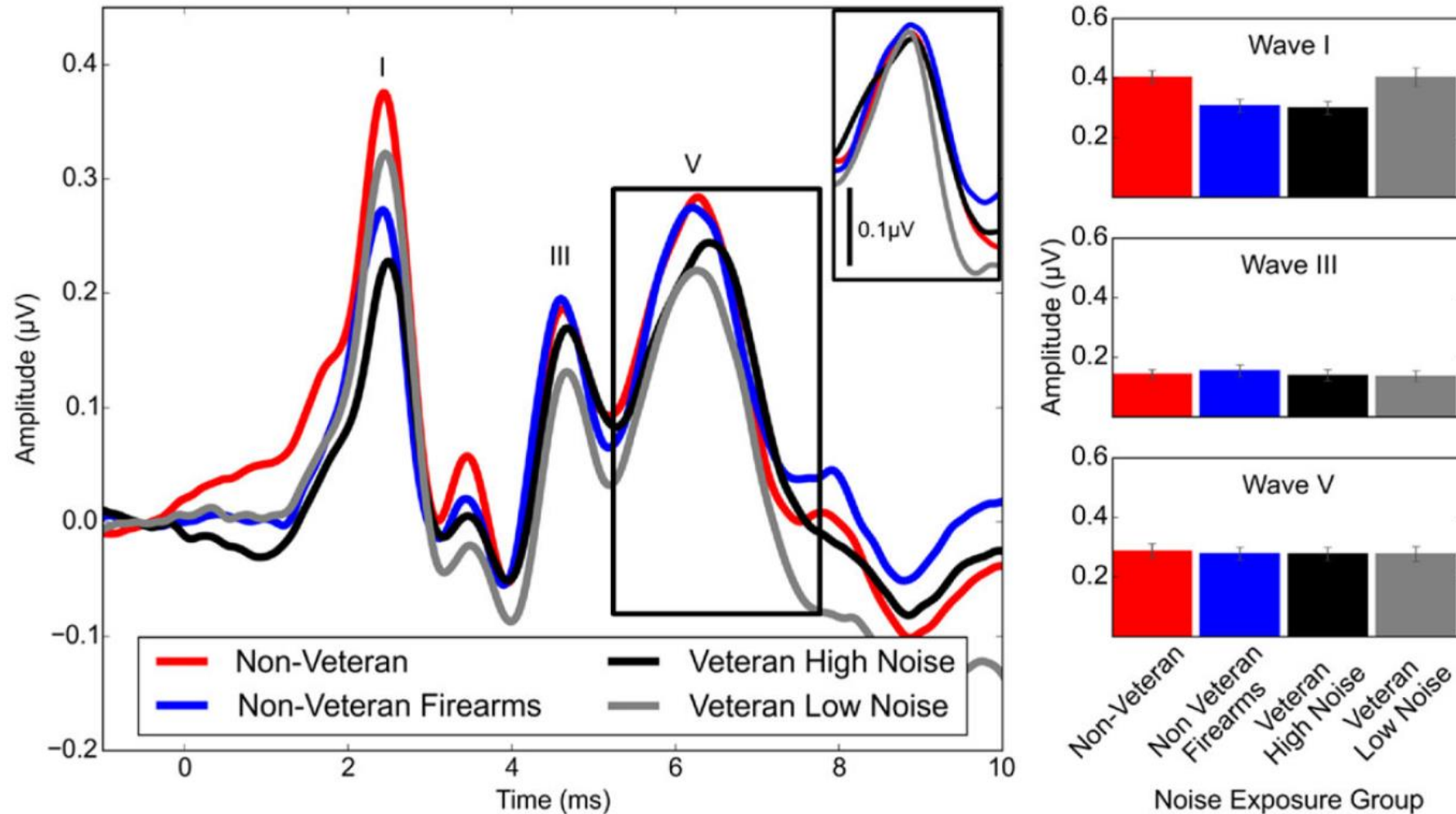


Auditory Function in Normal-Hearing, Noise-Exposed Human Ears



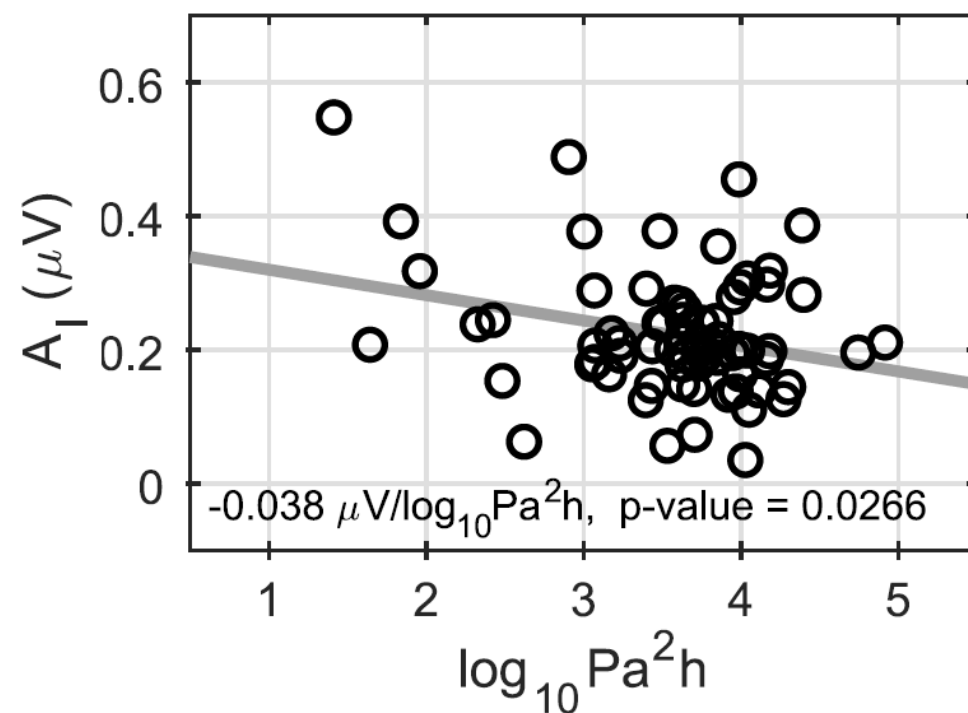
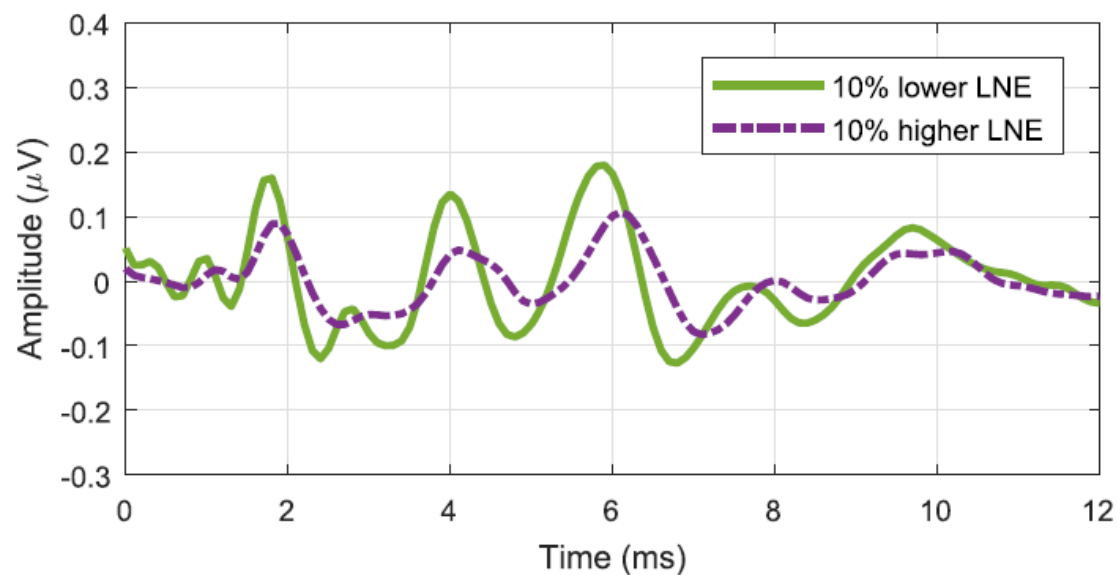
Auditory Brainstem Response Altered in Humans With Noise Exposure Despite Normal Outer Hair Cell Function

Naomi F. Bramhall¹, Dawn Konrad-Martin^{1,2}, Garnett P. McMillan¹, and Susan E. Griest^{1,2}



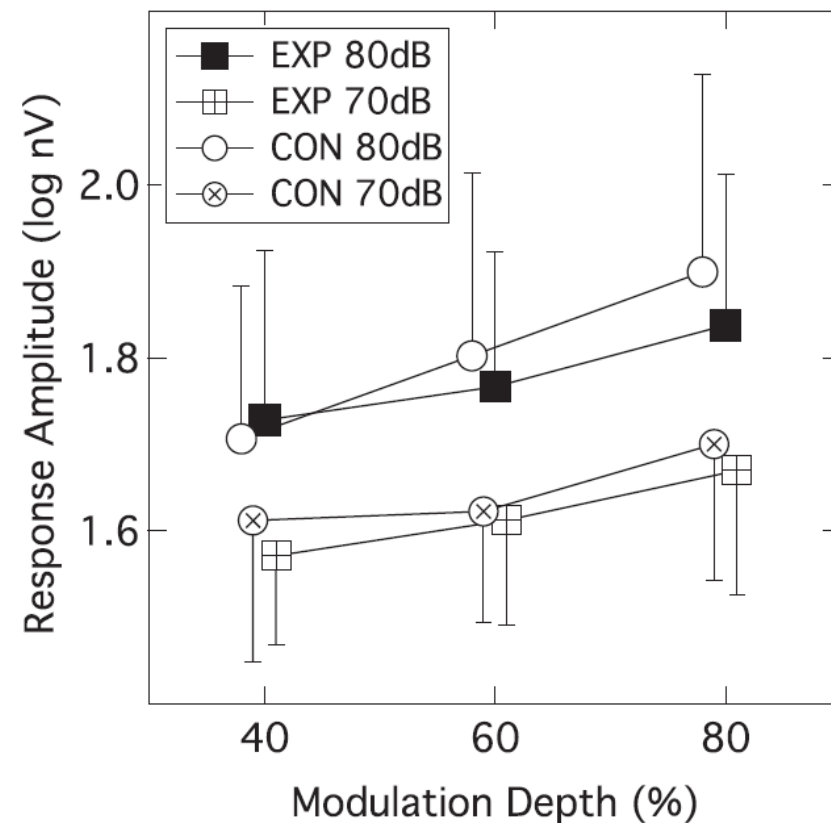
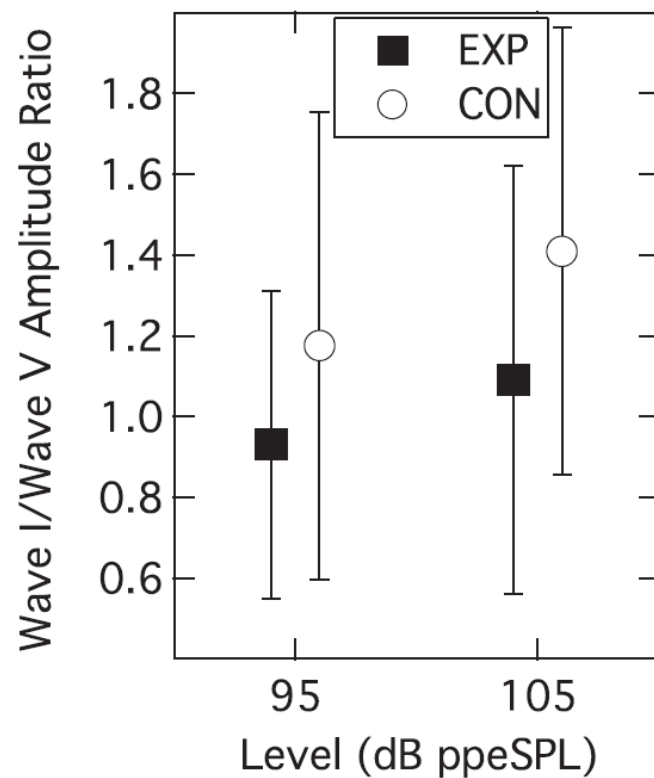
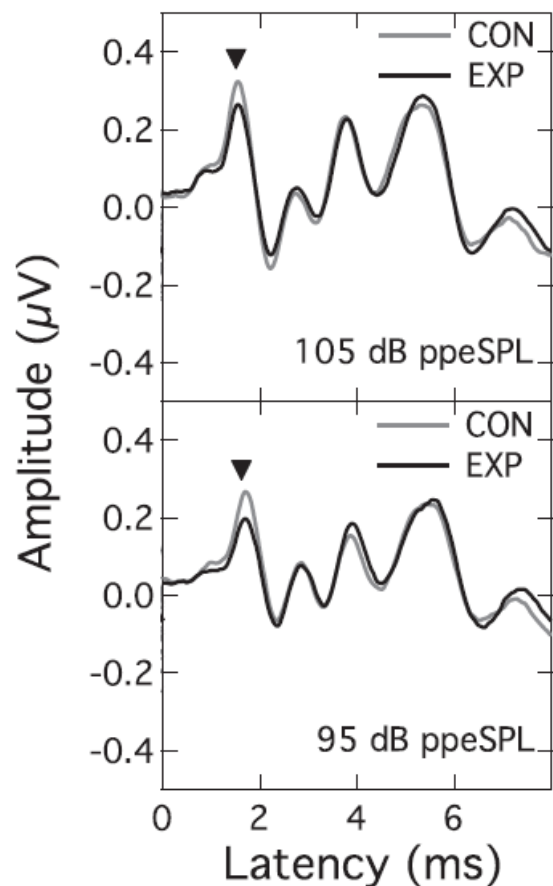
Effects of lifetime noise exposure on the middle-age human auditory brainstem response, tinnitus and speech-in-noise intelligibility

Joaquin T. Valderrama^{a, b, c, *}, Elizabeth Francis Beach^{a, c}, Ingrid Yeend^{a, b, c},
Mridula Sharma^{b, c}, Bram Van Dun^{a, c}, Harvey Dillon^{a, c}



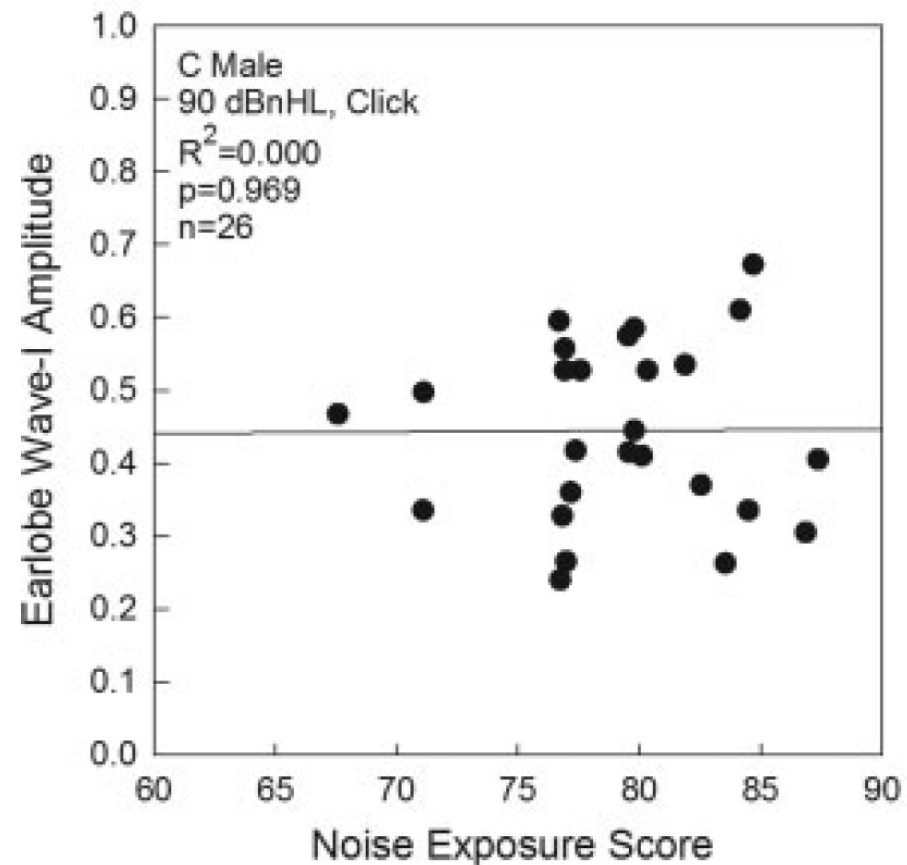
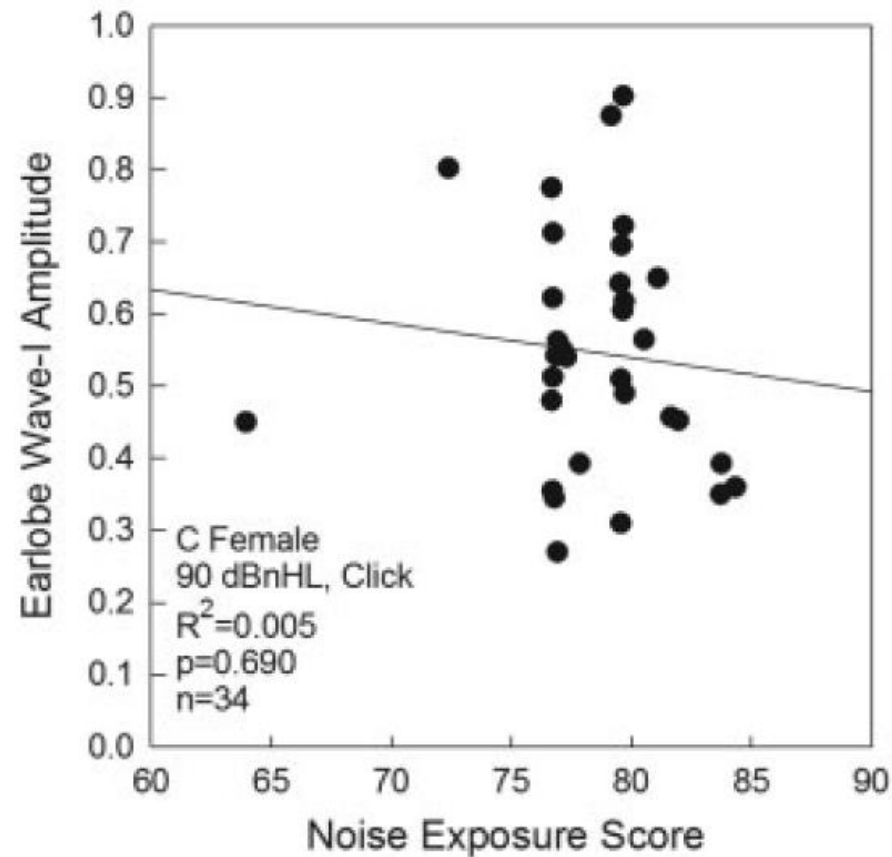
Loud Music Exposure and Cochlear Synaptopathy in Young Adults: Isolated Auditory Brainstem Response Effects but No Perceptual Consequences

John H. Grose¹, Emily Buss¹, and Joseph W. Hall III¹



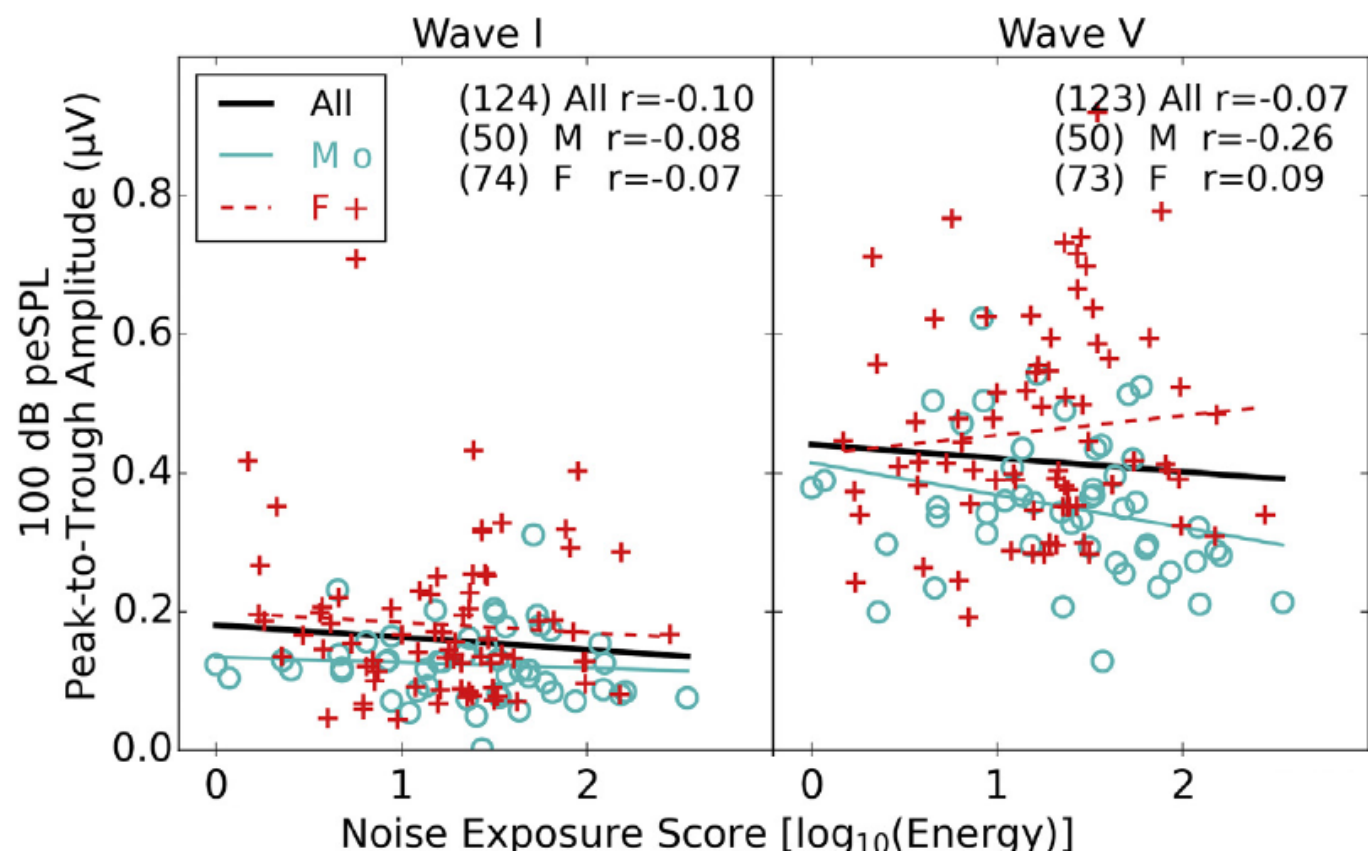
Effects of Recreational Noise on Threshold and Suprathreshold Measures of Auditory Function

Angela N.C. Fulbright, Au.D., Ph.D.,² Colleen G. Le Prell, Ph.D.,¹
Scott K. Griffiths, Ph.D.,² and Edward Lobarinas, Ph.D.¹



Effects of noise exposure on young adults with normal audiograms I: Electrophysiology

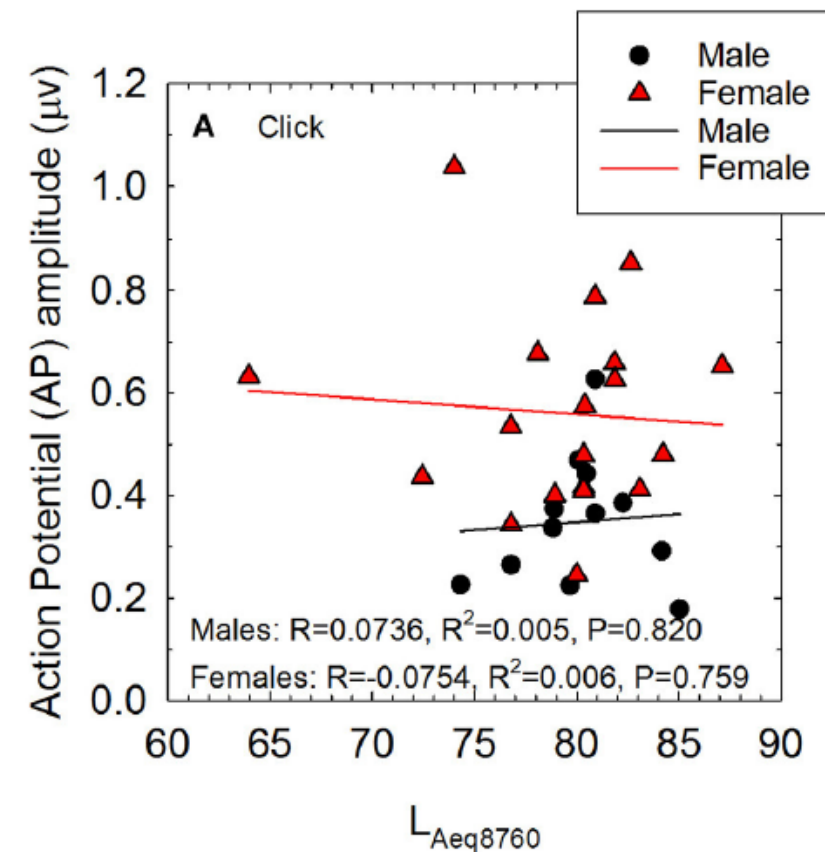
Garreth Prendergast ^{a,*}, Hannah Guest ^a, Kevin J. Munro ^{a,b}, Karolina Kluk ^a,
Agnès Léger ^a, Deborah A. Hall ^{c,d}, Michael G. Heinz ^e, Christopher J. Plack ^{a,f}





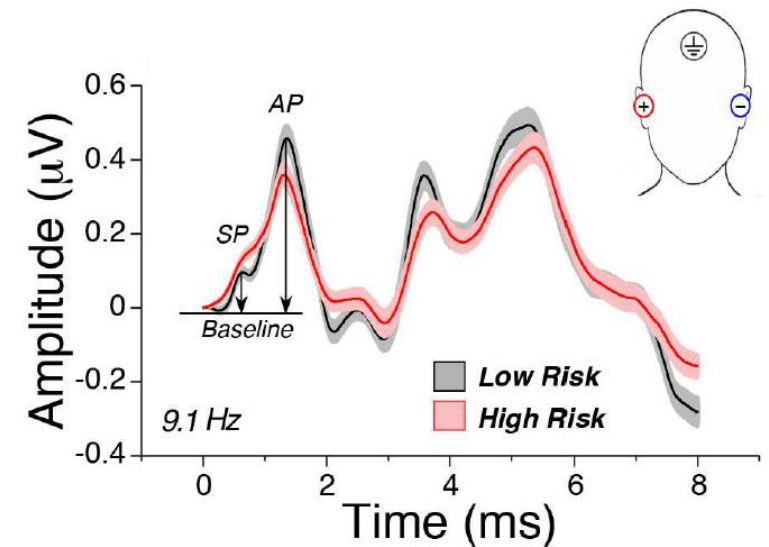
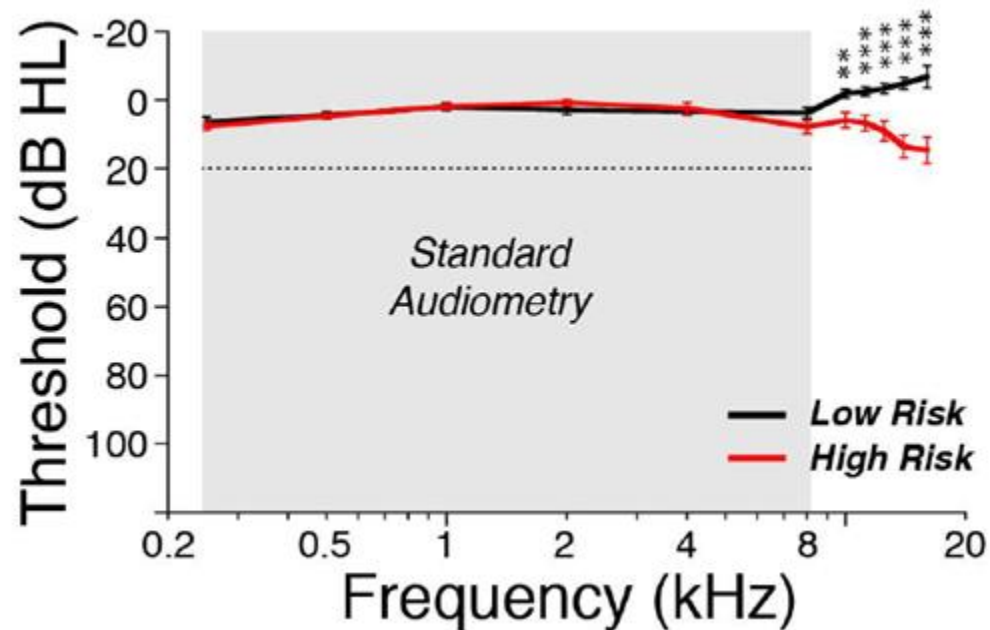
Hidden Hearing Loss? No Effect of Common Recreational Noise Exposure on Cochlear Nerve Response Amplitude in Humans

Sarah K. Grinn^{1,2}, Kathryn B. Wiseman¹, Jason A. Baker¹ and Colleen G. Le Prell^{1*}



Toward a Differential Diagnosis of Hidden Hearing Loss in Humans

M. Charles Liberman^{1,2,3}, Michael J. Epstein⁴, Sandra S. Cleveland⁴, Haobing Wang², Stéphane F. Maison^{1,2,3*}



OPEN

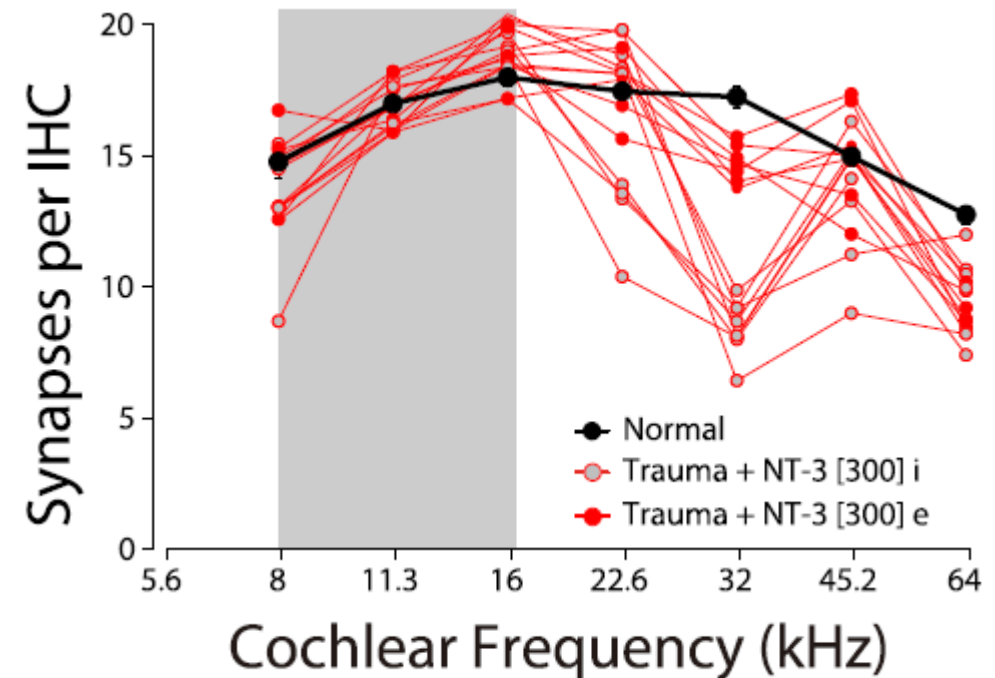
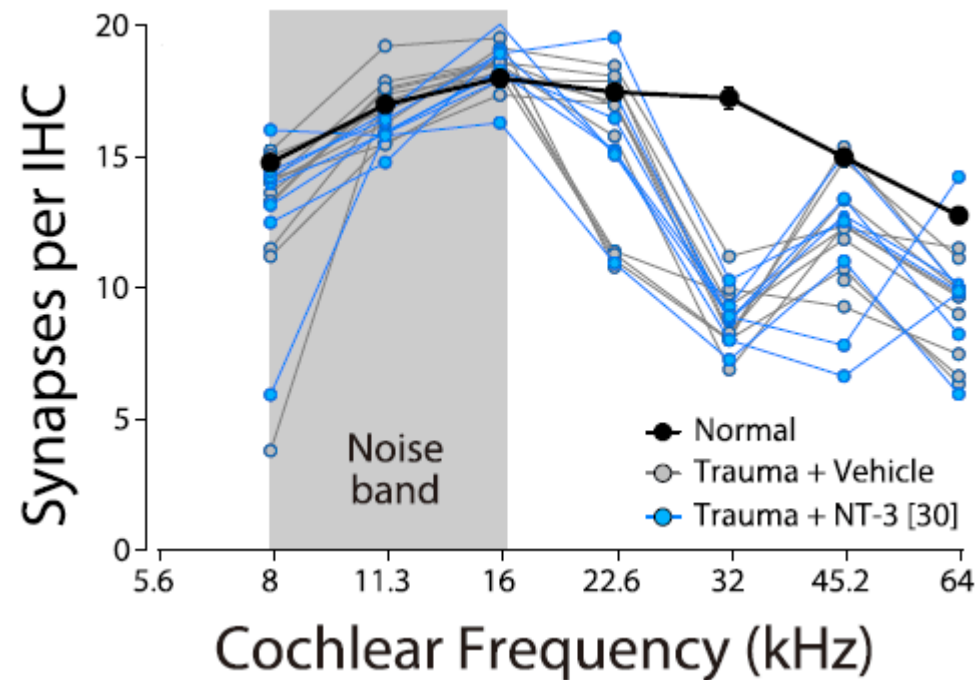
Round-window delivery of neurotrophin 3 regenerates cochlear synapses after acoustic overexposure

Received: 11 January 2016

Accepted: 04 April 2016

Published: 25 April 2016

Jun Suzuki^{1,2,3}, Gabriel Corfas⁴ & M. Charles Liberman^{1,2}



Summary

- ✓ Diagnosing HHL in humans is a hot topic
 - ✓ Large variability of results
- ✓ There are some evidences of HHL in humans
- ✓ Diagnosing HHL is not easy
 - Animal models may differ from humans
 - Non-invasive methods are subject to many confounding variables
 - Lack of validation
- ✓ Future
 - Results replication
 - Explore new diagnosis methods

References

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