Neural Envelope Coding in Middle-aged Humans with Normal Audiograms

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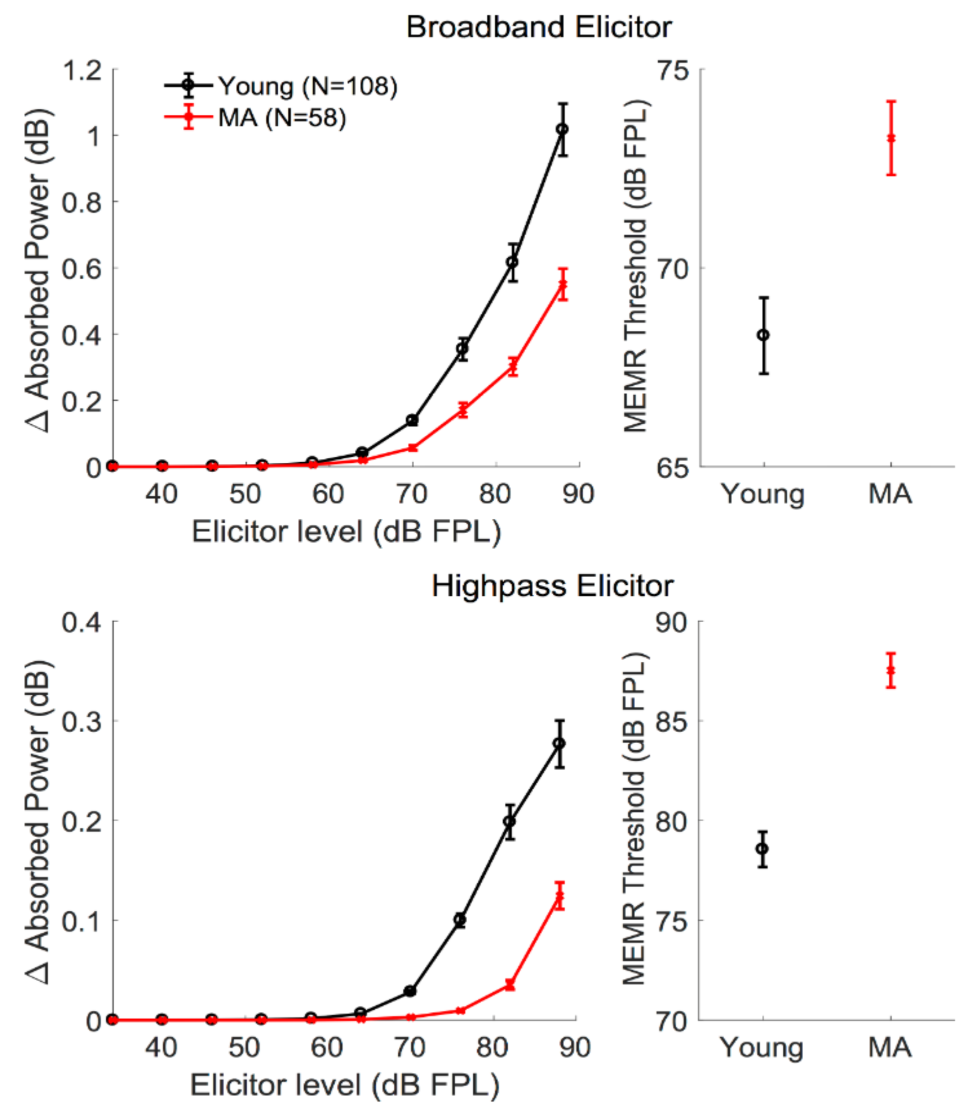
Background

- Emerging evidence from human postmortem temporal bones suggest that cochlear synaptopathy is a primary form of age-related hearing damage **[1]**. However the physiological and perceptual consequences of such damage is unknown.
- The present study sought to investigate envelope coding in middle-aged listeners with normal audiograms using Electroencephalography (EEG)-based Envelope-Following Responses (EFRs). Envelope coding is thought to be important to speech perception.
- A previous study from our lab **[2]** using Auditory Brainstem Responses (ABRs) and Middle-Ear Muscle Reflexes (MEMRs) **[see 3]** showed that middle-aged listeners (aged 36 – 60 years) showed reduced ABR wave I responses (not shown) and weaker MEMRs (shown below) despite audiograms matched in mean and median thresholds with a younger group. The present study was done on a subset of the same cohort of listeners.

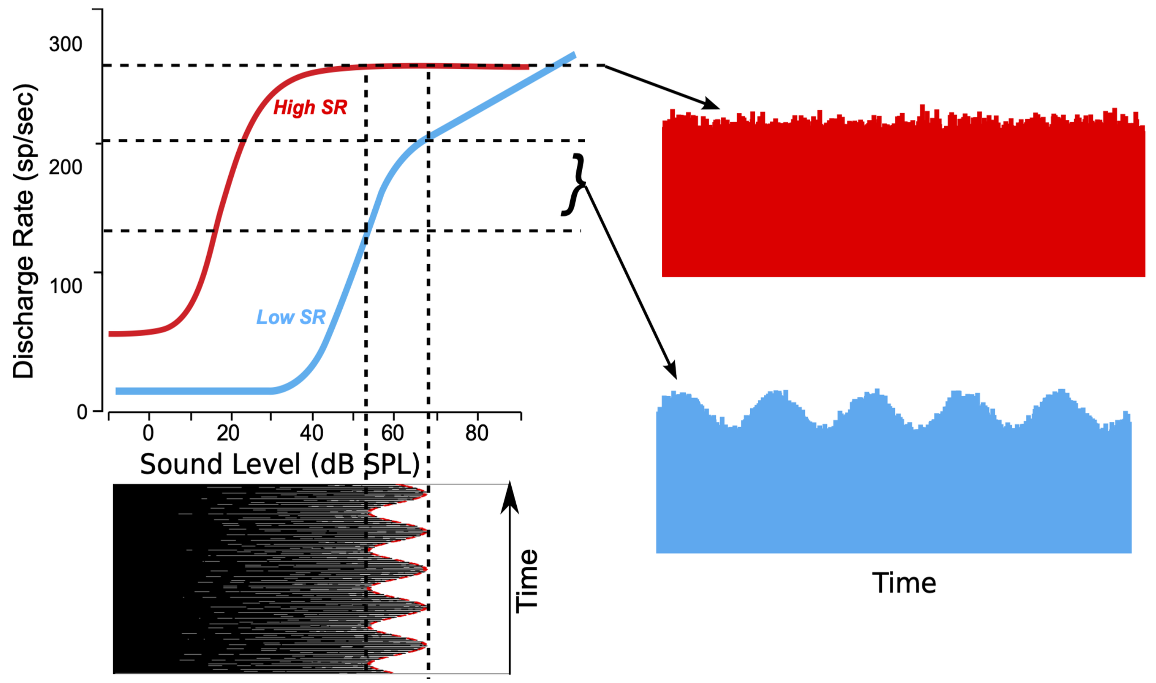
Data from Mai et al. (In Preparation)[2]



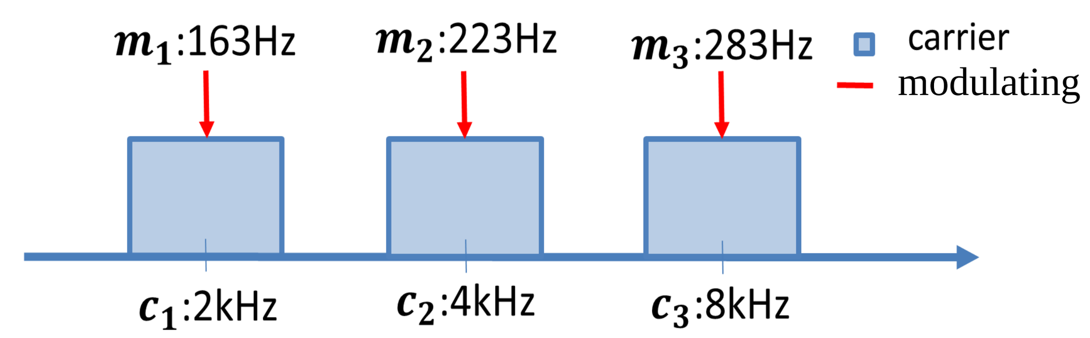
Hypothesis

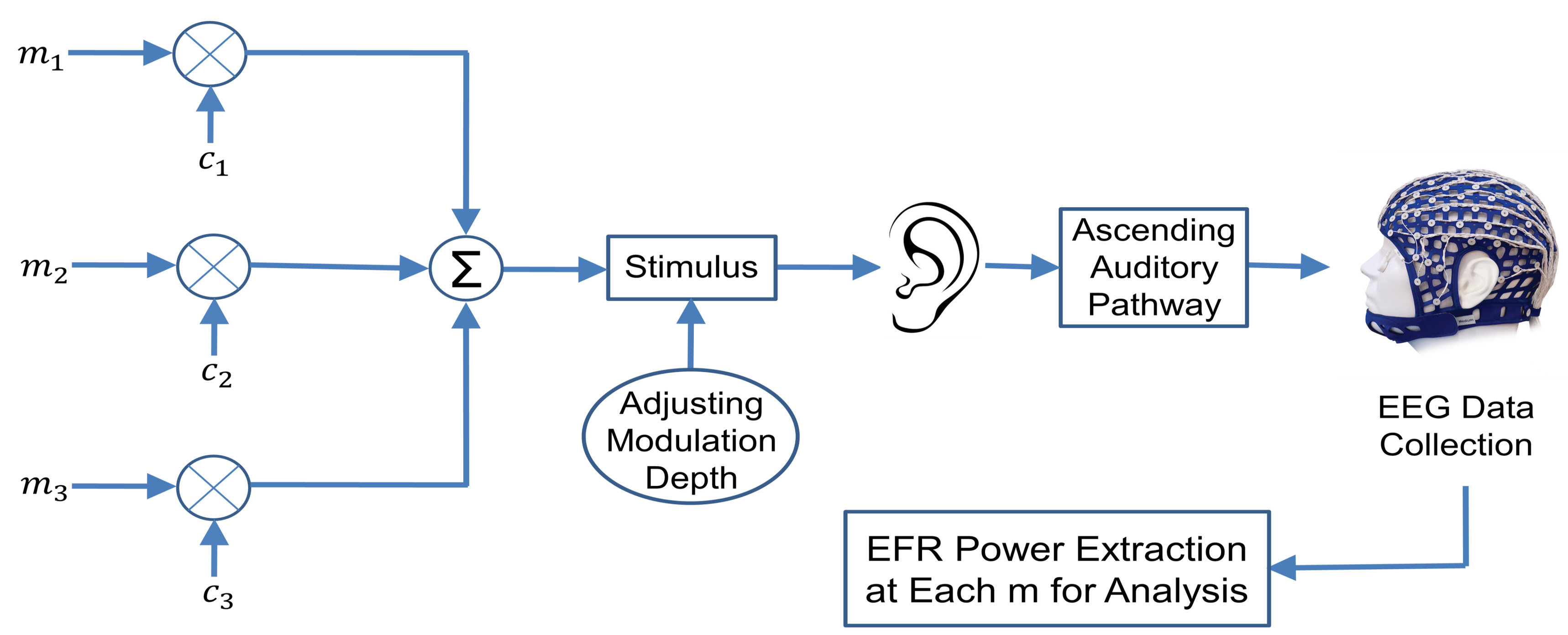
- Age-related cochlear synaptopathy can contribute to degraded coding of temporal information, particularly envelopes, in the ascending auditory pathway, even before symptoms of classic presbycusis are manifested.
- Based on the greater vulnerability of low-spontaneous rate auditory nerve fibers to synaptopathy **[4]**, **Bharadwaj et al. [5]** hypothesized that EFRs at moderate-to-high sound levels and shallow modulation depths may be particularly affected by synaptopathy.
- The present study thus sought to quantify the effect of changing modulation depth on the EFRs as a function of age.

Illustration of the hypothesis from Bharadwaj et al. [5]



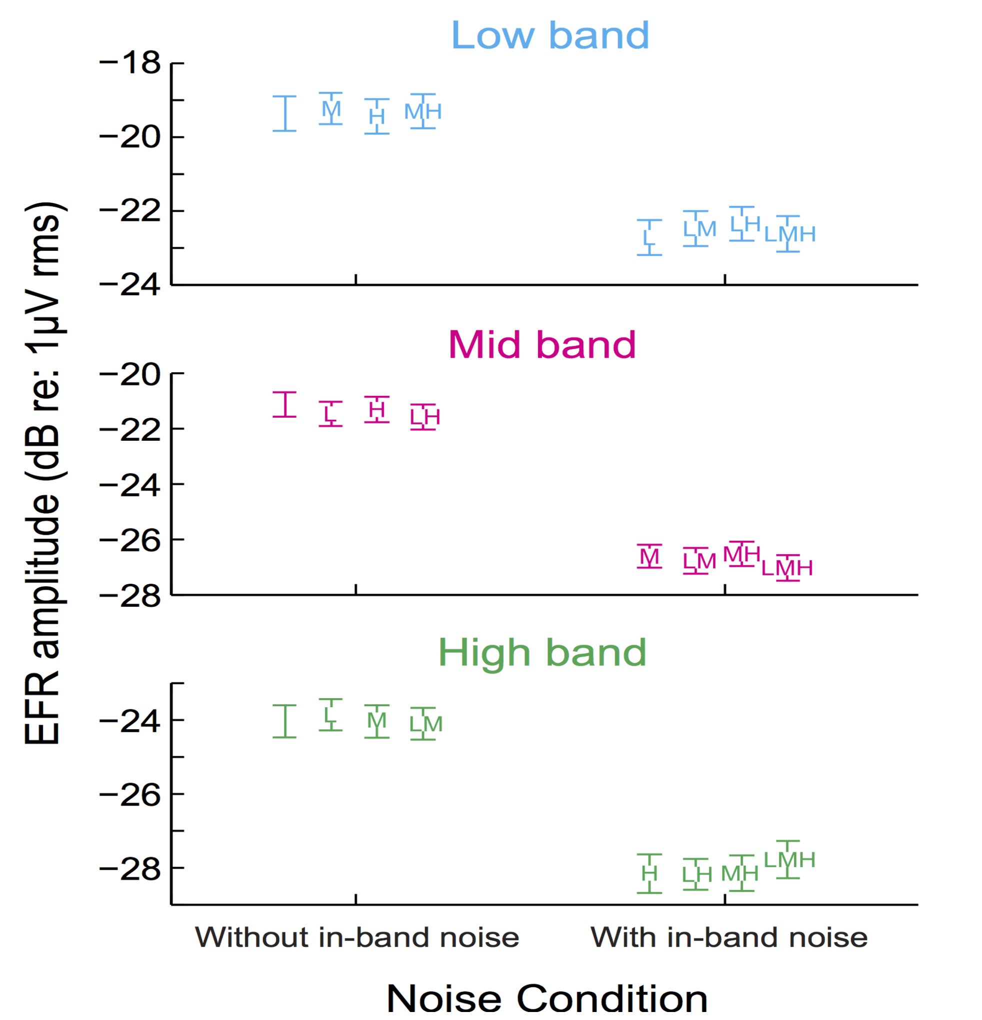
Stimulus and Experiment Design





- The design was inspired from previous study where multiband modulated tones was used to measure neural activity in a cochlear-place-specific manner, with minimal contributions from off-frequency locations **[6]**
- Stimulus was 1 second long with 0.1 second jitter and presented monaurally at an intensity level of 74.77dB SPL (70 dB SPL for each carrier band)
- Data was collected using 32 channel BioSemi EEG cap and EFR was extracted for analysis.

Data from Wang et al. Neurosci, 2019 (N=40)



Human Subjects

- Experiment was run in a cohort of listeners with a wide age range (18 – 60)
- The young (18 – 35 years) and MA (36 – 60 years) groups were matched in mean and median audiograms up to 8 kHz.
- For statistical analysis, age was treated as a continuous variable, whereas group-level data are shown for illustrations.

Summary & Future Work

- Decline in EFR was greater for shallower modulation depth for middle-aged humans is consistent with the loss of low-SR fibers. Changes in the central auditory system (e.g., midbrain) with age may also be a contributing factor.
- These results corroborate the previous ABR and MEMR findings in the same cohort that cochlear synaptopathy may be widespread in middle-aged humans.
- Ongoing work aims to characterize the effect of the degraded AM coding on speech perception for middle-aged individuals.

Acknowledgements

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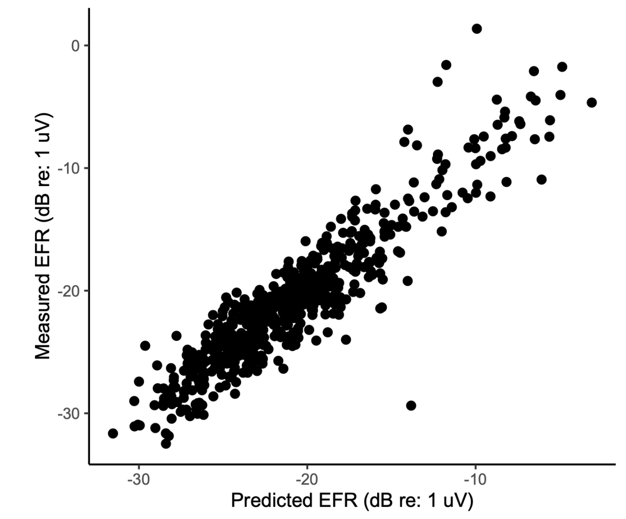
Results - EFR variations are well accounted for by age and stimulus factors

Mixed Effects Model Results
(Type II Wald F tests, with Kenward-Roger df)

Significance code: ***<0.001, **<0.01, *<0.05

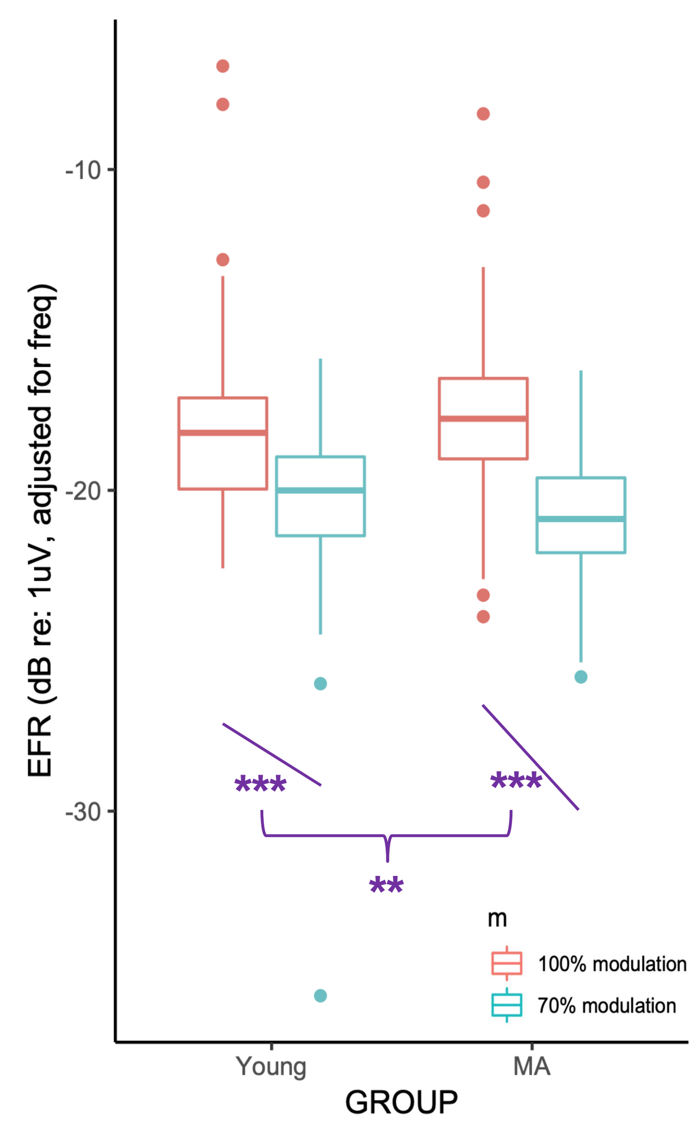
Variable	F	df	Denom. df	P
Audiogram	0.0909	1	560.18	0.763115
Frequency	88.0480	2	517.62	< 2.2e-16 ***
Age	1.1123	1	104.78	0.294000
Mod. Depth	219.1102	1	510.00	< 2.2e-16 ***
Age : Mod. Depth	7.0580	1	510.00	0.008138 **

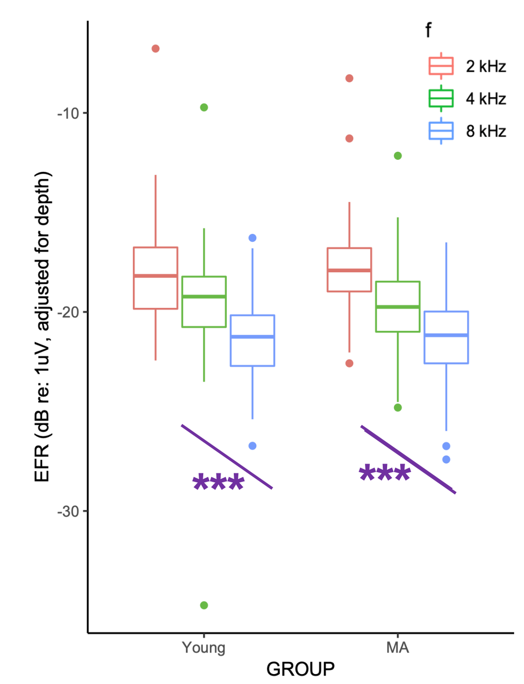
- The EFR was modeled as a function of audiometric thresholds, carrier frequency, age, modulation depth, and their interactions.
- This linear mixed model accounted for most of the variance in the EFR amplitudes across individuals and measurement conditions (R=0.92).



Result – Significant age-by-modulation depth interaction effects

N=103 ears, 79 individuals





- Decline in EFR from 100% to 70% modulation depth was greater for individuals in the MA group despite matching audiograms (and accounting for residual audiometric variations) and the effects of carrier/modulation frequency.
- Differences between young and MA individuals were similar across 2, 4 and 8 kHz, although EFRs were weaker in both groups at higher frequencies.

References

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