Decreased Temporal Fine Structure Encoding is Associated with Increased Listening Effort during Multi-talker Speech Perception

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Background

Middle-aged adults, including those with normal audiograms, continue to struggle with understanding speech in noisy environments, highlighting the critical limitations of current audiometric diagnostics primarily emphasizing hearing sensitivity[1,2].

Temporal fine structure (TFS) cues, encoded via phase-locked neural responses in the auditory pathway, are thought to be essential for sound localization, pitch perception and distinguishing speech from background noise[3-5]. Yet, how neural phase-locking of TFS cues aids in speech in noise perception is still unclear and hotly debated[6,7].

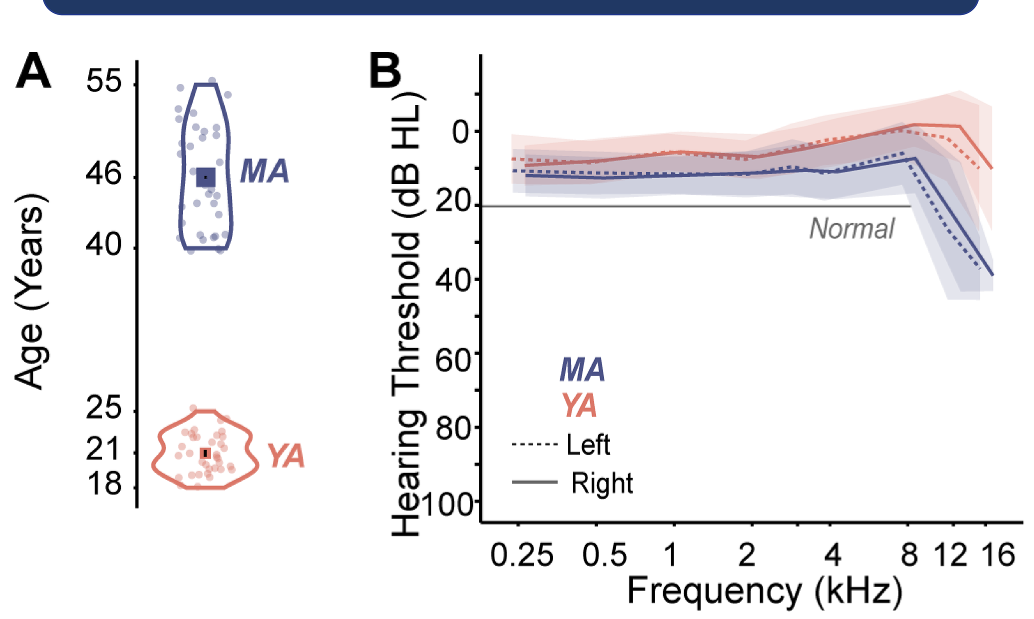
Psychophysical TFS measures may be confounded by envelope cues[6]. Here, we use our recently developed neurophysiological measure of TFS coding that also generalizes to predict speech in noise performance[1].

Additionally, behavioral accuracy alone underestimates perceptual deficits, while listening effort metrics such as pupillometry offer earlier and more sensitive indicators of TFS-related SPIN difficulties[1,8,9].

Here, we specifically investigate if

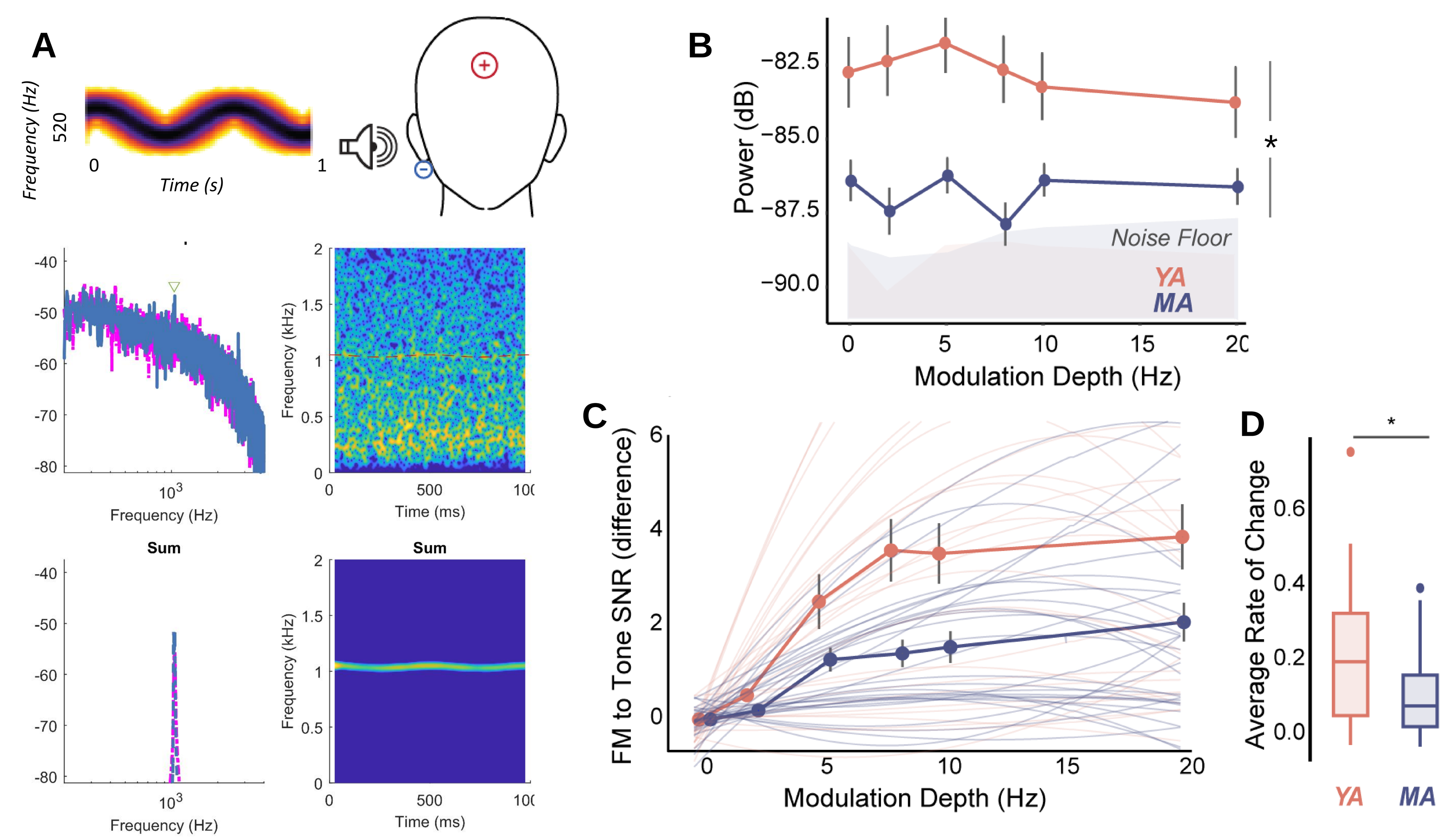
1. Neural coding of sTFS cues decreases with age
2. Middle-aged adults exhibit increased listening effort in multi-talker speech settings
3. Decreased sTFS coding is related to increased listening in multi-talker speech intelligibility

Participants



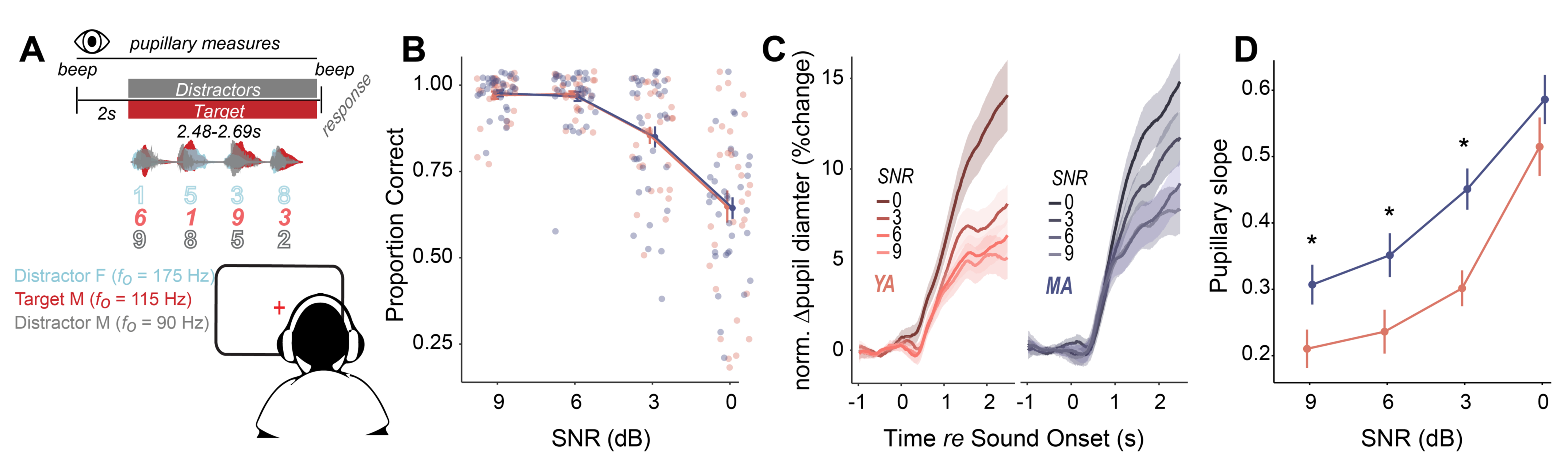
27 Young and 27 middle-aged participants completed the study **(A).** Participants had normal audiometric thresholds up to 8 kHz. Middle-aged adults showed some evidence of hearing threshold losses at extended high frequencies **(B)**. LDLs ≥ 80 dB, MoCA ≥ 25, No tinnitus.

Neural encoding of TFS cues decreases with middle-age



FMFRs assess TFS coding by measuring phase-locked neural activity to FM tones at 520Hz. Alternate-polarities minimize cochlear microphonics. Spectrally specific frequency demodulation removes spectral noise and focuses on power in desired frequency trajectory **(A)**. Middle-aged adults show significantly decreased pure-tone phase-locking at 520 Hz **(B)** as well as decreased discriminability of frequency modulation **(C)**, suggesting impaired neural representation of sTFS cues.

Listening effort increases with age and worsening SNR, despite matched behavioral performance

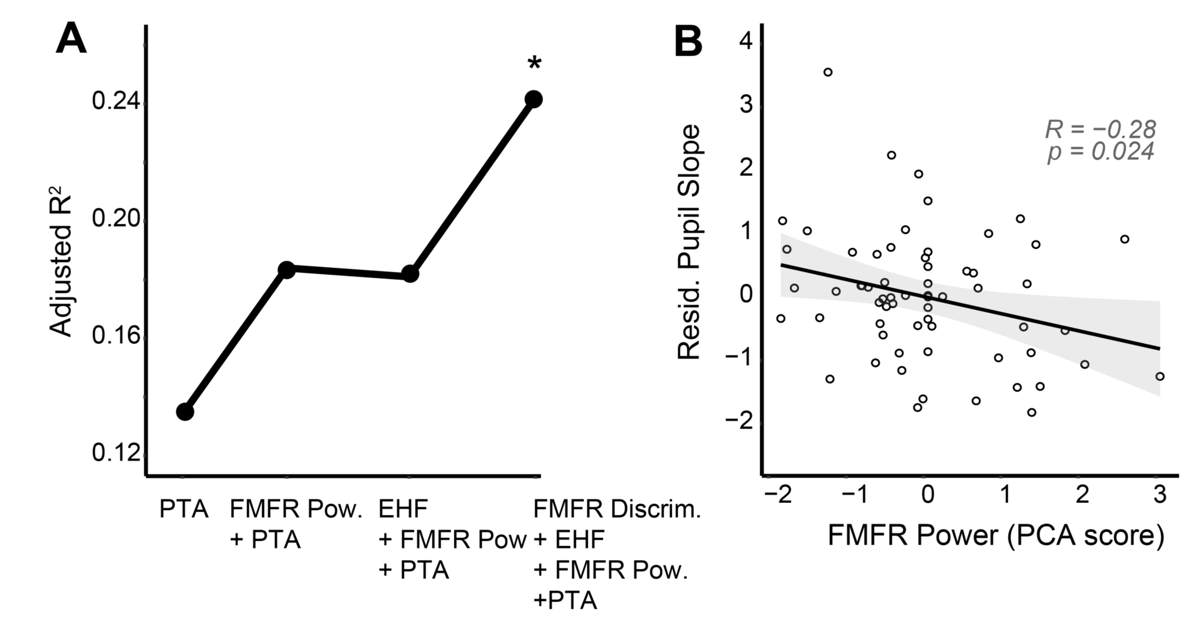


Isoluminous, task-related changes in pupil diameter was measured to index listening effort while subjects completed the digits-comprehension task **(A)**.

Behavioral performance on the multi-talker speech task was comparable across young and middle-aged participants **(B)**.

The MA group showed a significantly greater increase in listening effort with increasingly challenging SNRs compared to the YA group, despite matched behavioral performance **(C-D)**.

Decreased TFS coding predicts increased listening effort



Pure tone averages and TFS coding independently contribute towards variance in listening effort **(A)**. Lower TFS coding is associated with increased listening effort when accounting for individual variations in subclinical hearing thresholds **(B)**.

Summary

- Middle-aged adults with normal audiometric thresholds show decreased neural representation of TFS cues
- Middle-aged adults exhibit increased listening effort despite matched behavioral performance
- Decreased TFS coding predicts increased listening effort, when subclinical changes in hearing thresholds are accounted for.
- Parallel experiments are investigating the neural mechanisms underlying decreased sTFS processing using animal models
- Ongoing experiments are also investigating the causal relationship between TFS coding and effort in humans.

References

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