Investigating Contributions of Temporal Processing on Speech-In-Noise Understanding in Middle-Aged Adults

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Introduction

The ability to utilize sensory cues such as timing information contributes to the ability to separate speech from competing noise. While both animal and human research have demonstrated degraded temporal coding in older populations, it has been less studied in middle age—when speech-in-noise (SIN) difficulty is first reported. This study addresses this gap by measuring temporal processing in middle-aged adults and investigating the extent to which these measures contribute to speech-in-noise understanding.

Participants

76 participants (mean age = 39.5 years; 28 male) participated in this study (IRB: STU00215893). All participants were native English speakers and had bilateral thresholds ≤ 25dB across standard audiometric frequencies.

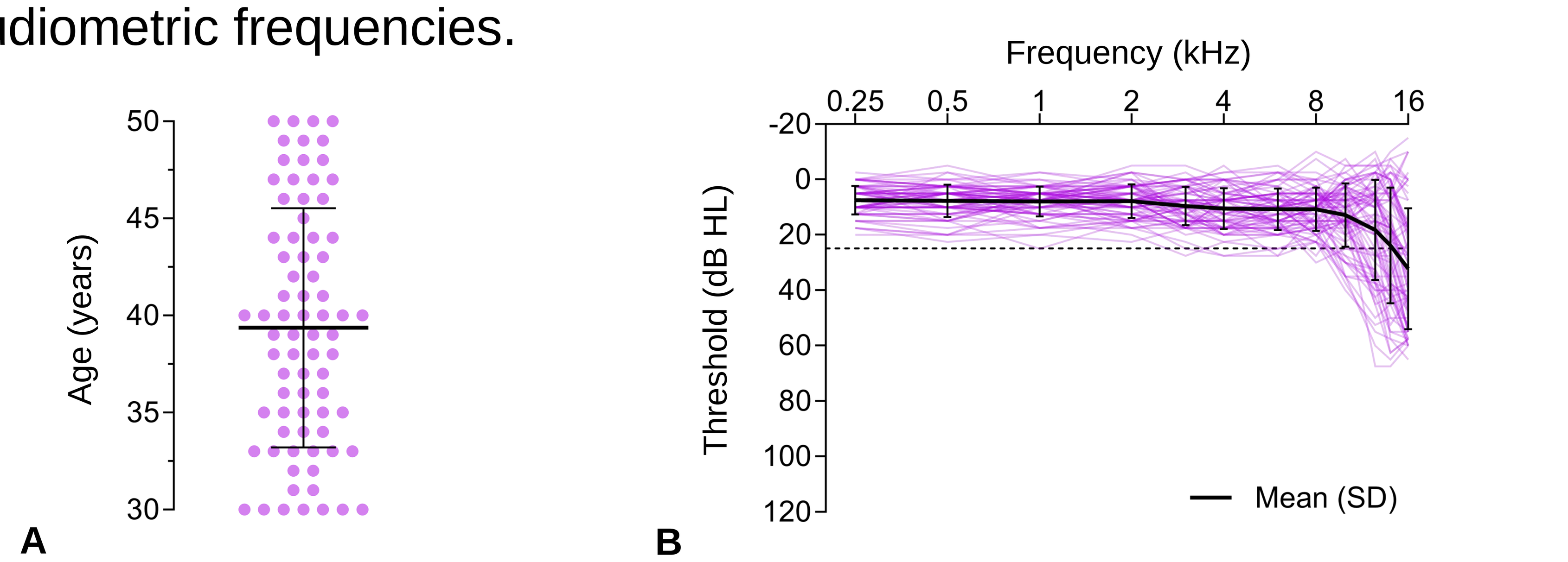

Figure 1. A) Age distribution of participants (n = 76), each represented as a purple dot. Horizontal lines = mean age bracketed by 1 standard deviation. **B)** Thresholds from 0.25-16 kHz averaged across ears. Individual audiograms represented by purple lines. Black line = mean thresholds bracketed by 1 standard deviation.

Speech-in-Noise Testing

AzBio Sentence Lists

- Low-context sentences
- Target: 2 female, 2 male talkers
- Maskers: 10-talker babble
- Co-located condition only

Spatial Release from Two Talkers

- Coordinate Response Measure Corpus
- Target: Male talker
- Masker: 2 male talkers
- Co-located and Separated (maskers ±45°)

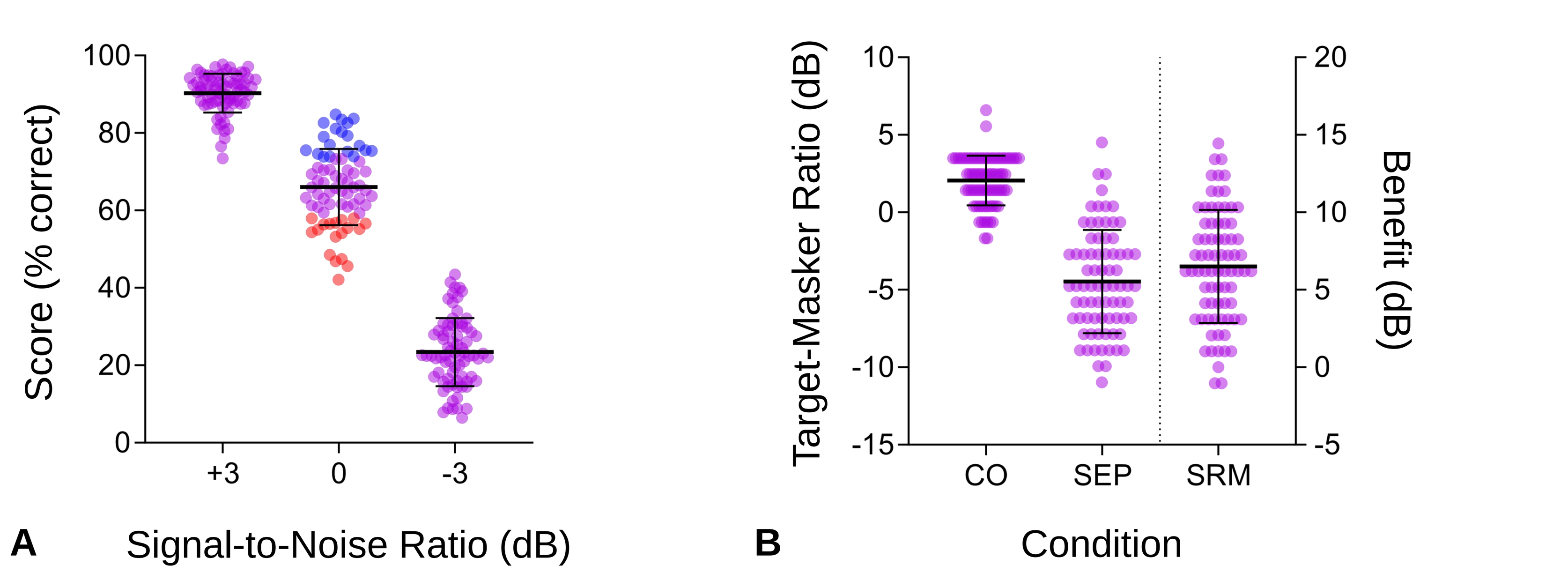

Figure 2. A) AzBio performance distribution across the 3 SNRs tested. 0 SNR was chosen for primary analyses. Top (75th percentile) and bottom (25th percentile) scores represented by blue and red dots, respectively. **B)** SR2 performance (target-to-masker ratios; TMR) across conditions (CO = co-located; SEP = maskers separated from target by ±45°). SRM = spatial release from masking, calculated by subtracting SEP TMR from CO TMR.

Tests of Temporal Processing

Electrocochleography

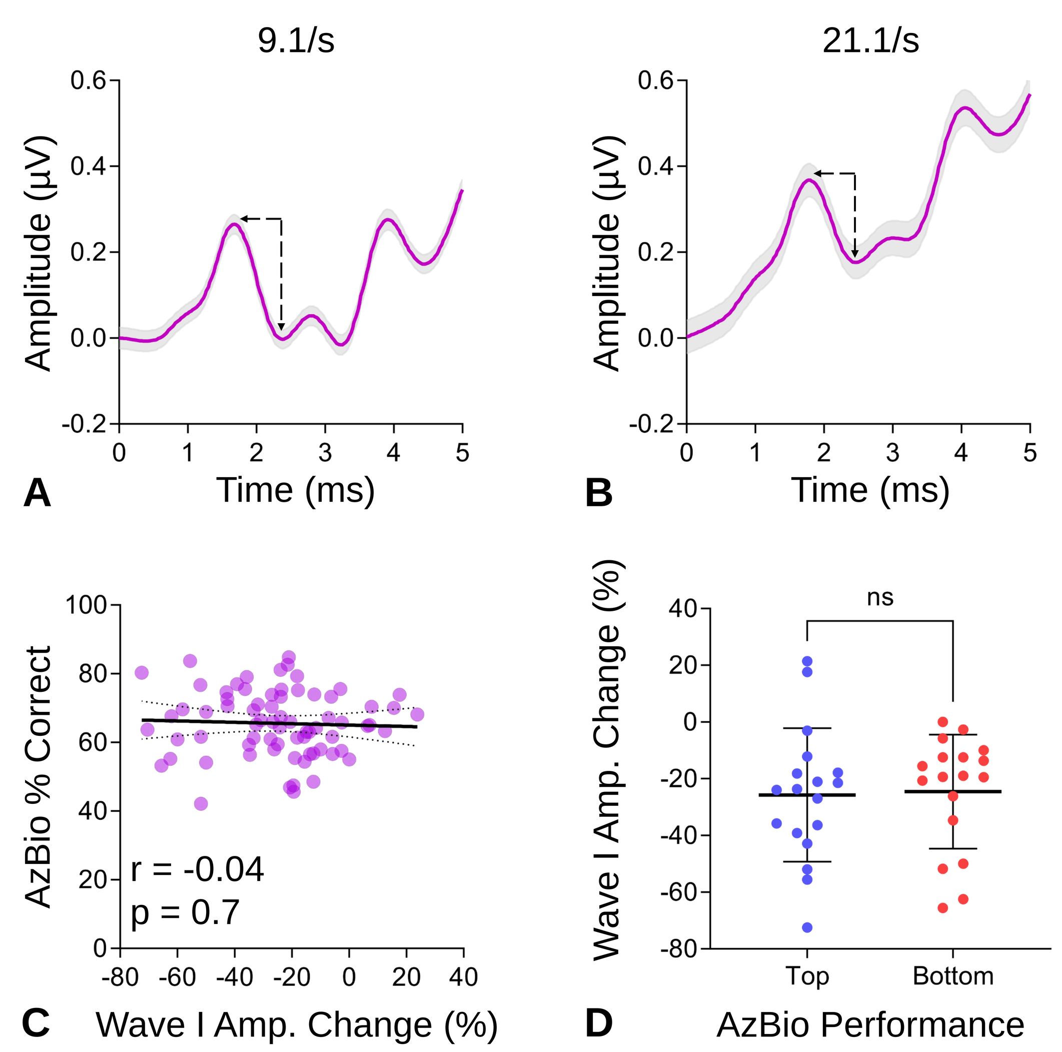

Figure 3. Grand average traces to broadband 100-μs click presented at **A)** 9.1/s and **B)** 21.1/s. Grey shading around trace = SEM. Dashed arrows indicate peak and successive trough used to measure amplitude. **C)** Correlation between wave I amplitude change (from 9.1/s to 21.1/s) and AzBio 0 SNR performance. **D)** Comparison of wave I amplitude change between top (75th percentile) and bottom (25th percentile) scores on AzBio 0 SNR. ns = non-significant.

Frequency Following Response

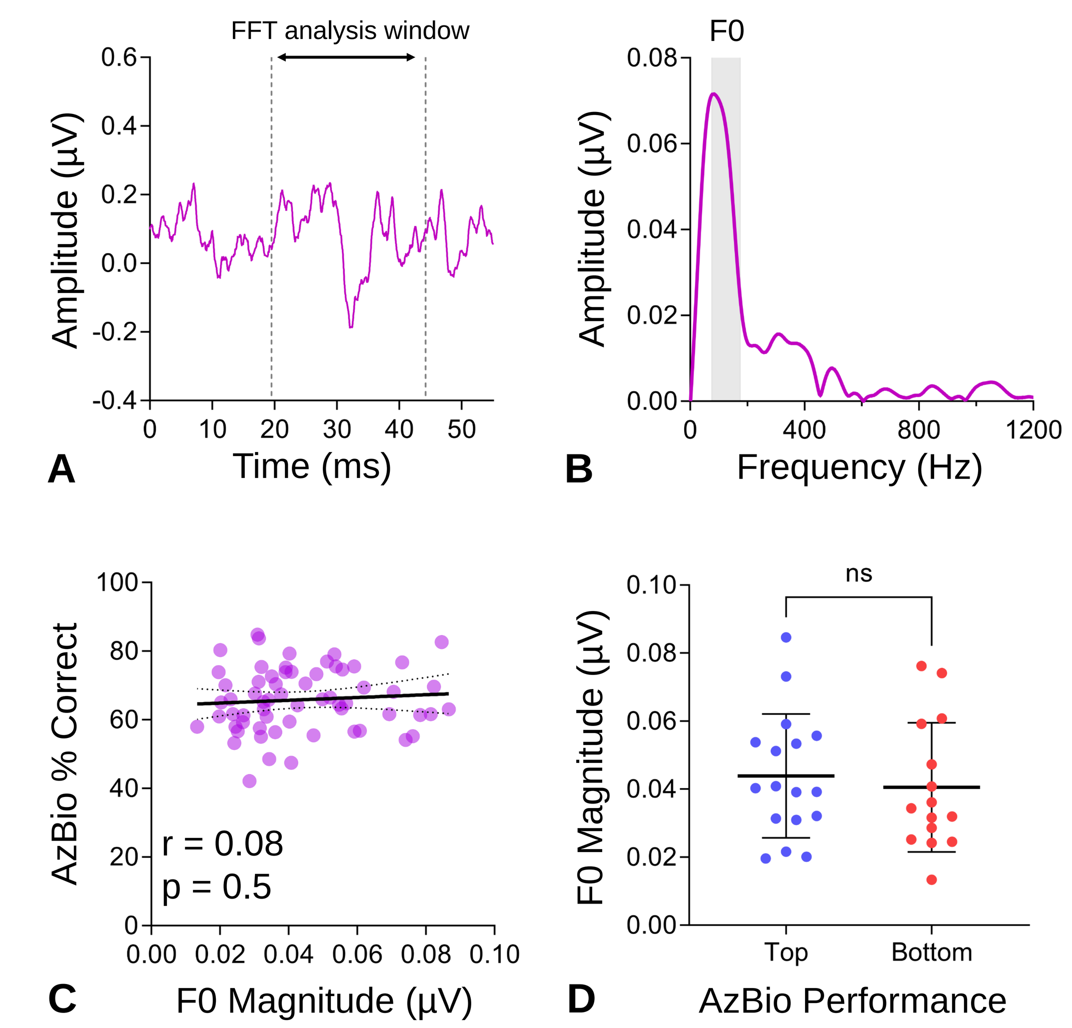

Figure 4. A) Representative trace of FFR to 40-ms /da/. Vertical dashed lines indicate time window used for Fourier analysis (19.5-44.2 ms). **B)** Fast Fourier transform (FFT) of the FFR in panel A. Grey area = frequency range analyzed for F0 response (75-175 Hz). **C)** Correlation between F0 response magnitude and AzBio 0 SNR performance. **D)** Comparison of F0 magnitude between top (75th percentile) and bottom (25th percentile) scores on AzBio 0 SNR. ns = non-significant.

Dichotic FM Detection

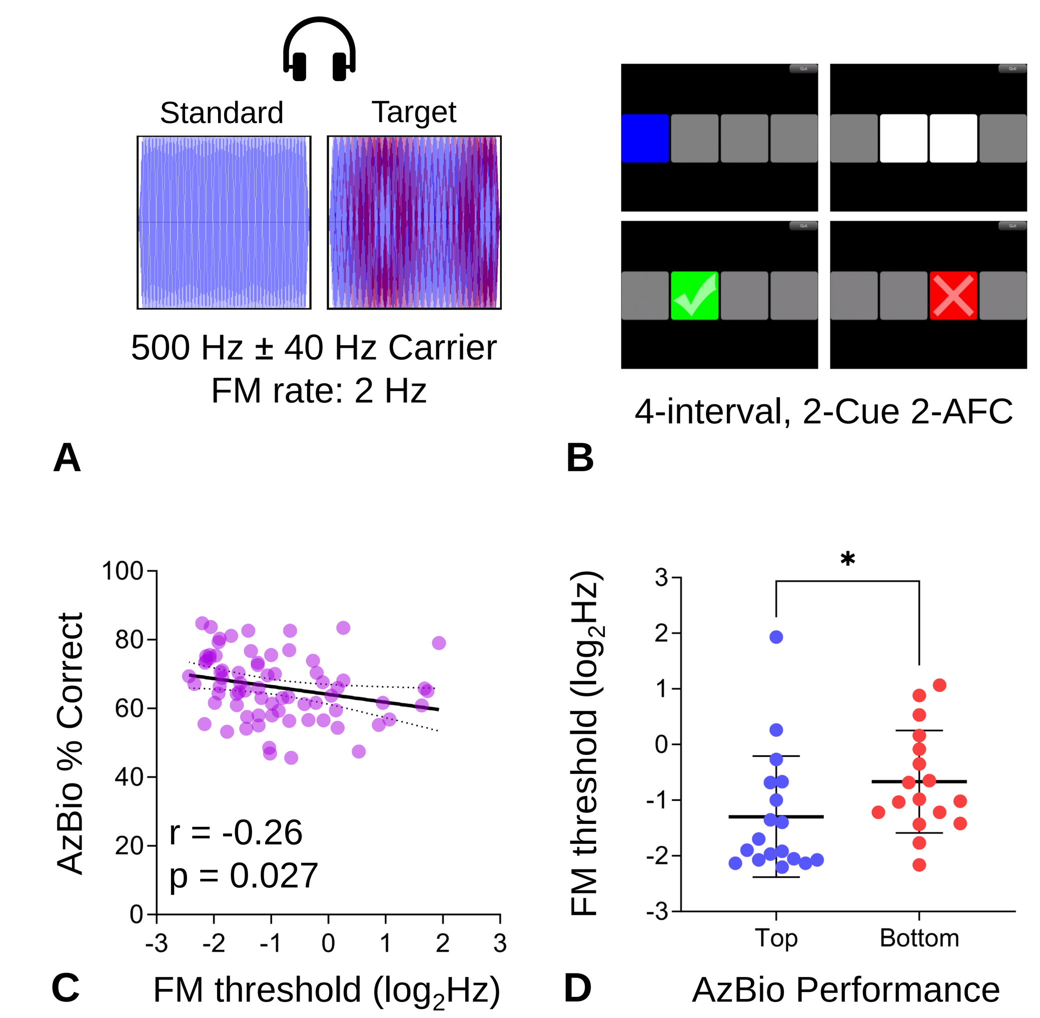

Figure 5. A) Envelope for dichotic FM standard and target stimuli. **B)** Schematic of dichotic FM task. Stimulus intervals successively highlighted in blue. Choices highlighted in white. Response feedback indicated by green or red. **C)** Correlation between dichotic FM threshold and AzBio 0 SNR performance. **D)** Comparison of dichotic FM threshold between top (75th percentile) and bottom (25th percentile) scores on AzBio 0 SNR. *p<0.05.

Contribution of Temporal Processing Varies Based on Masker Characteristics

Dominant Masking Type	Informational →					Energetic
	SR2-CO	**SR2-SRM**	**SR2-SEP**	**AzBio 0 SNR**	**AzBio -3 SNR**	**AzBio +3 SNR**
Wave I amplitude change	r = -0.03 p = 0.7	r = 0.12 p = 0.27	r = -0.15 p = 0.17	r = -0.04 p = 0.7	r = 0.05 p = 0.6	r = 0.09 p = 0.4
F0 magnitude	r = 0.18 p = 0.15	r = 0.14 p = 0.25	r = -0.07 p = 0.5	r = 0.08 p = 0.5	r = 0.06 p = 0.6	r = 0.08 p = 0.5
Dichotic FM Threshold	r = 0.07 p = 0.5	r = -0.17 p = 0.13	r = 0.22 p = 0.05	**r = -0.26 p = 0.027**	r = -0.15 p = 0.2	r = -0.07 p = 0.5

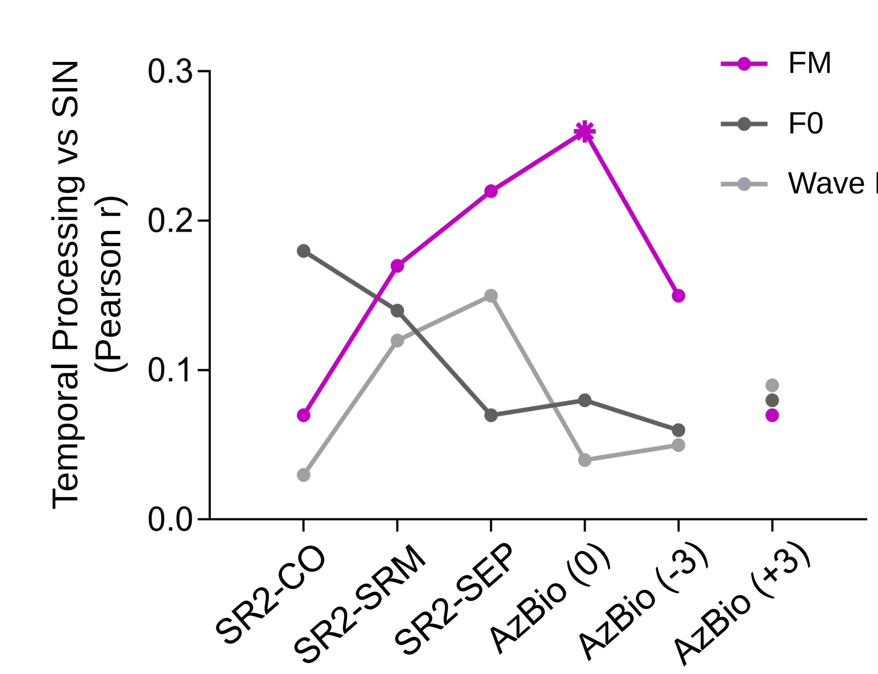

Figure 6. Relationship (Pearson r) between temporal processing and SIN perception plotted as a function of dominant masker type. Reveals TFS sensitivity (FM task; purple) is least utilized when informational masking is highest, is more utilized as informational masking dissipates, and becomes less effective as energetic masking dominates. AzBio +3 SNR condition represents minimal masking, thus plotted separately.

Conclusions

The current study assessed the extent to which temporal processing explains differences in speech-in-noise perception (SIN) in middle-aged adults with normal hearing. Dichotic FM detection, a perceptual measure of temporal fine structure (TFS) sensitivity, was the only measure of temporal processing that associated with performance on a SIN task; a relationship that appeared to be mediated by the level of informational masking present. The variance explained by FM detection was significant yet minimal, suggesting other factors must be considered. Future work should continue to explore the extent to which sensory and cognitive mechanisms influence SIN perception in middle-aged adults.

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