

Pitch Encoding and Short-Term Memory in Cognitively Healthy Adults

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Introduction

Memory for autobiographically relevant music is often preserved in dementia, suggesting a degree of spared processing for the basic features of music (Groussard et al., 2019).

Pitch is the psychological correlate of a sound's fundamental frequency (F0) and forms the basis of melodies and harmonies.

Harmonic complex tone: Evokes a clear pitch. All frequency components are integer multiples of the F0 (F0 pitch).

Inharmonic complex tone: Evokes a weaker pitch; frequency components are not multiples of the F0 (spectral pitch).

Pitch discrimination worsens when the silent delay between the tones increases, demonstrating limitations of short-term auditory memory (Clément et al., 1999; Harris, 1952). The rate of decay is faster for inharmonic relative to harmonic complex tones (McPherson & McDermott, 2020).

Older adults have worse pitch perception than younger adults, even in the absense of hearing loss (Moore & Peters, 1992).

Hypothesis: Processing for harmonic tones over several seconds will be differentially spared from aging relative to inharmonic tones.

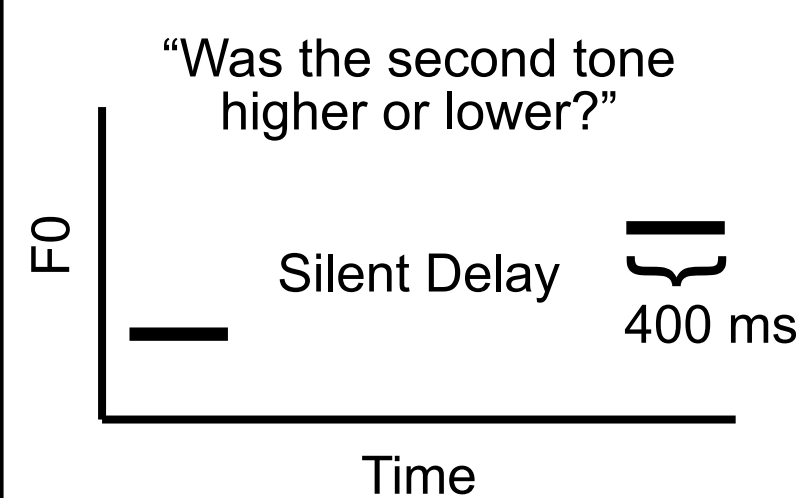
Alternative Hypothesis: Older adults will have worse perception regardless of harmonicity or short-term memory load.

Methods

Participants

Younger: n=24, ages 19-32 (19 F); Older: n=26, ages 56-74 (17 F)

Stimuli & Task



Silent Delay: 0, .5, 3, & 5 s

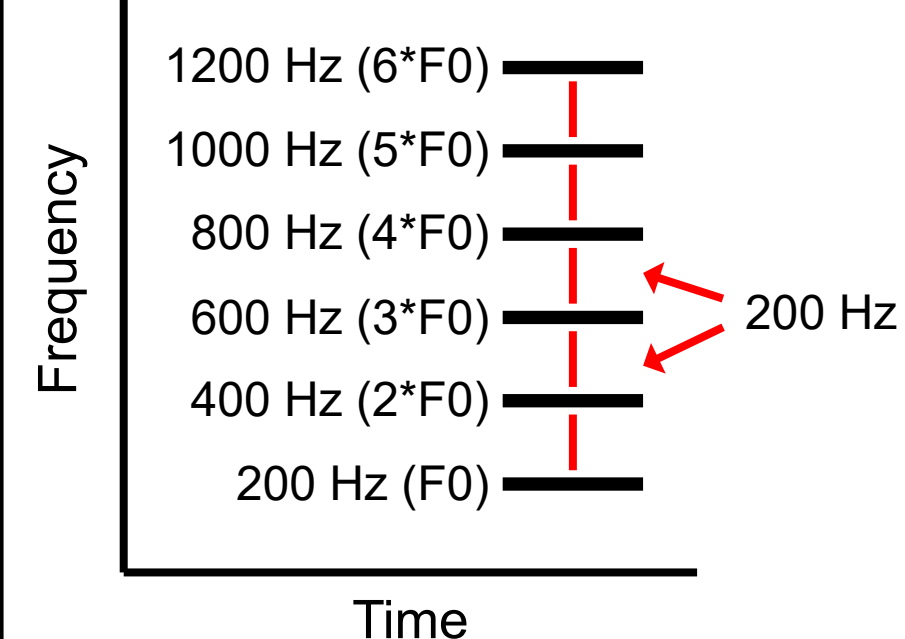
Harmonicity: Harmonic, inharmonic, & inharmonic-fixed

F0 1st tone: 200 - 250 Hz

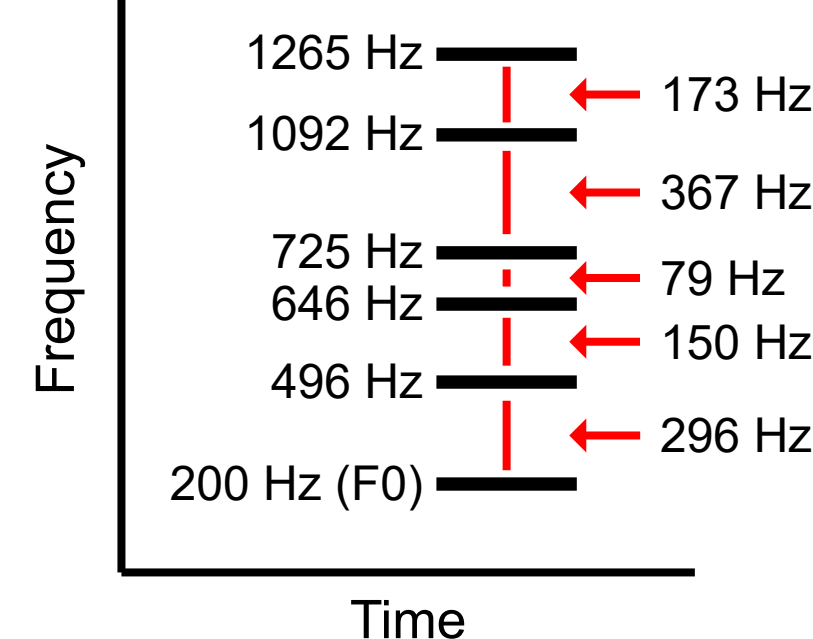
F0 2nd tone: Up to +/- 50%

F0 difference adapted with performance. Threshold corresponds to the 79.4% correct point of the psychometric function.

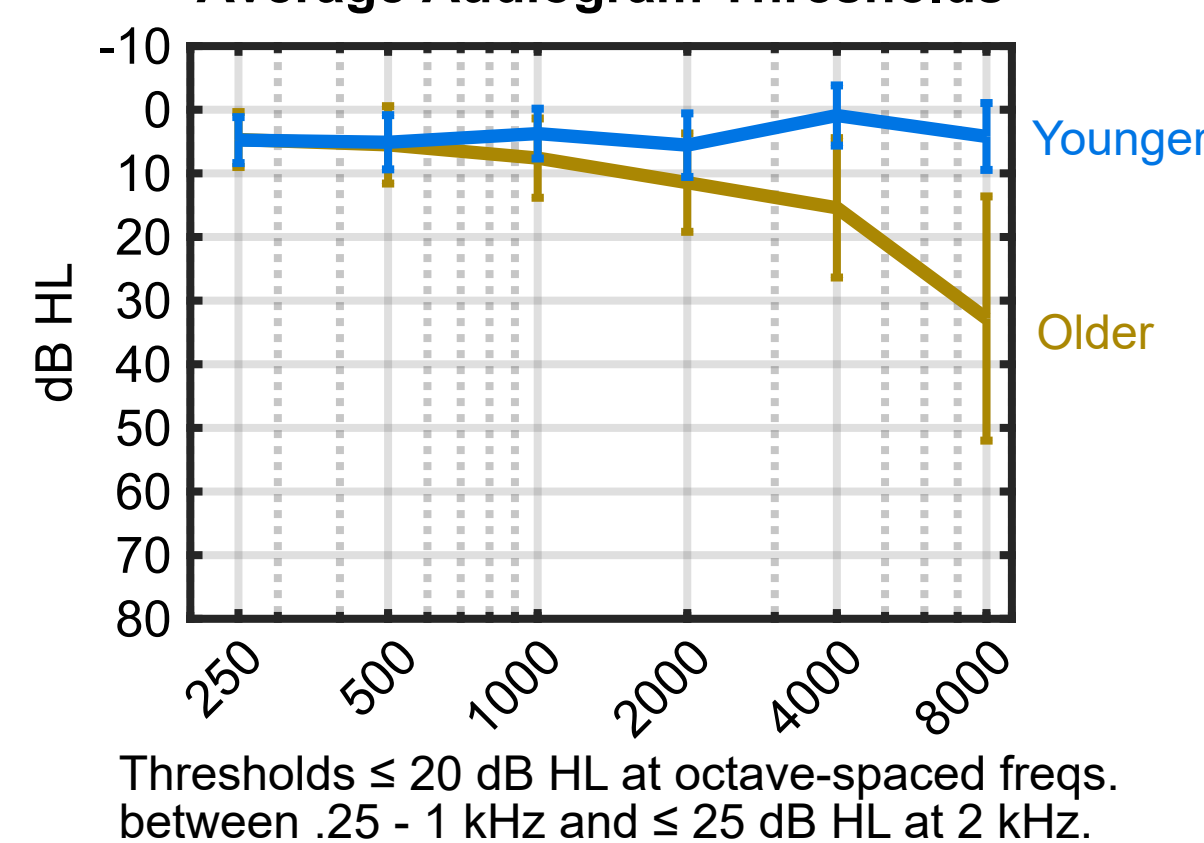
Harmonic Tone



Inharmonic Tone



Average Audiogram Thresholds



Harmonic: All components are integer multiples of the F0.

Inharmonic: Components jittered up to +/- 50% of the F0. New jitter selected for each trial.

Inharmonic-Fixed: Same jitter across trials within a run (fixed timbre).

Stimulus Filter

Log-gaussian spectral envelope
Center: 1 kHz; SD: .5 octave

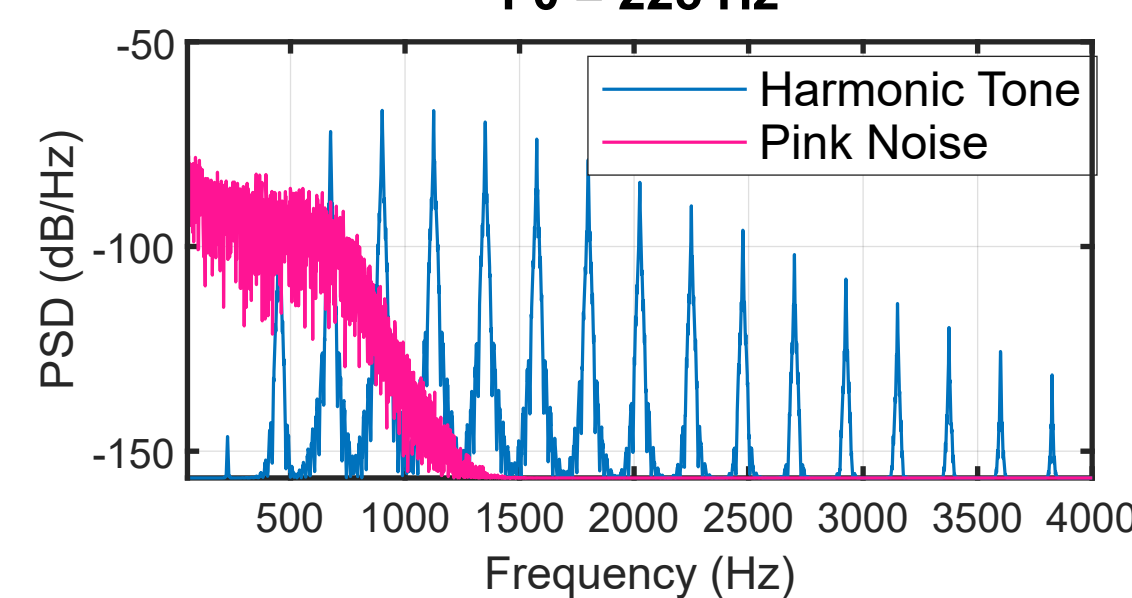
Stimulus Overall Level: 65 dB SPL

Pink Noise Level

Noise power in a Gaussian spectral window centered at the higher-note F0 was 10 dB below mean power of the three harmonics closest to 1 kHz

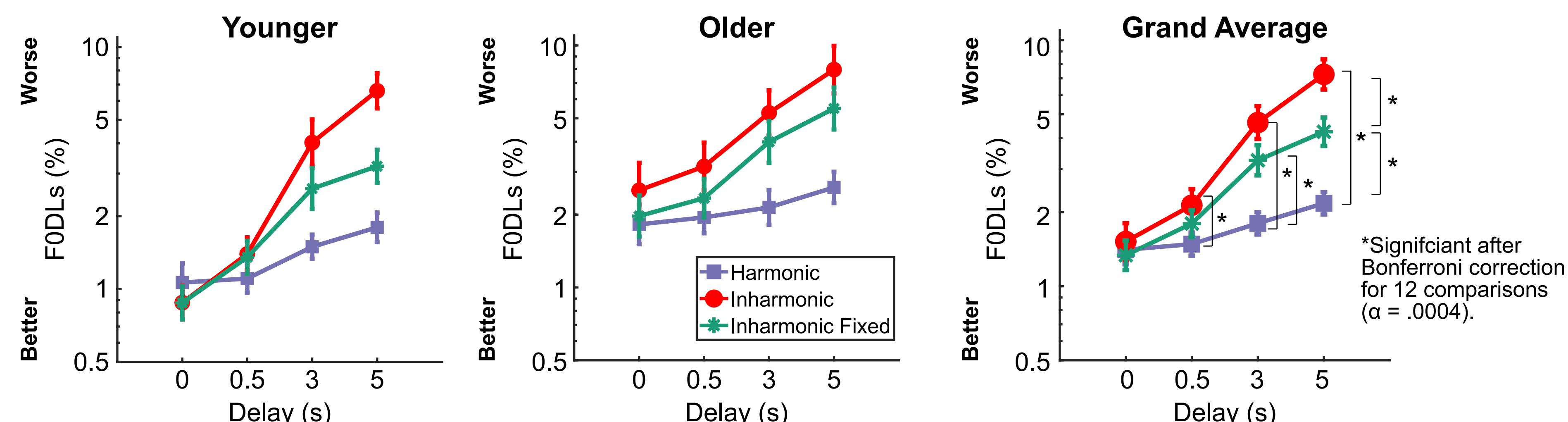
Frequency Domain

F0 = 225 Hz



Results: Effects of Pitch Strength

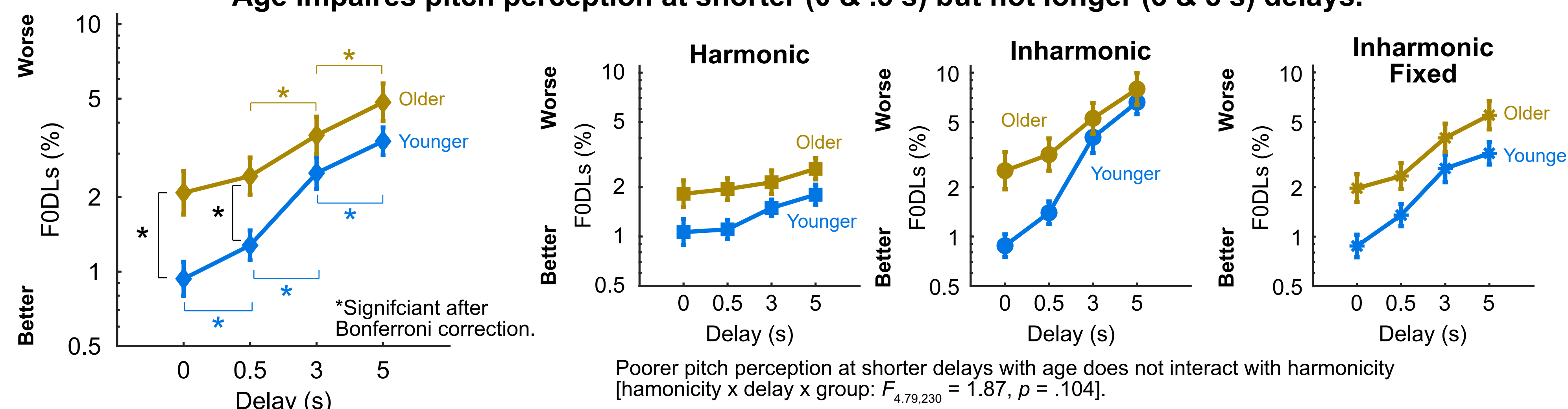
Harmonic pitch is more robust to short-term memory decay for younger and older adults.



Consistent with McPherson & McDermott (2020), pitch perception worsens with increased delay, with the greatest impairments for inharmonic tones [harmonicity x delay: $F_{2,09,100} = 15.1, p < .0001$]. Effects involving harmonicity are not significantly different between older and younger adults [harmonicity x age: $F_{1,75,84} = .879, p = .406$; harmonicity x delay x group: $F_{4,79,230} = 1.87, p = .104$].

Results: Effects of Age and Timing Offset

Age impaires pitch perception at shorter (0 & .5 s) but not longer (3 & 5 s) delays.



Poorer pitch perception in older adults only at shorter delays [Group x Delay: $F_{2,09,100} = 4.53, p = .012$] may reflect degraded peripheral encoding (e.g., temporal fine structure coding). Alternatively, it could reflect age-related changes in processing speed (e.g., Salthouse, 1996), which would be most prominent at shorter delays, where the pitch change occurs rapidly in time. Comparable pitch discrimination between groups at longer delays suggests preserved abstracted representation for both F0 pitch (clear pitch) and spectral pitch (weak pitch) with age.

Discussion

Short-term memory for pitch over several seconds may be stored more efficiently for harmonic tones (F0 pitch) compared to inharmonic tones (spectral pitch), as shown previously by McPherson & McDermott (2020).

Consistent with prior work (Moore & Peters, 1992), older adults have worse pitch discrimination than younger adults. However, age effects are only present for shorter delays, and this effect did not interact with harmonicity. This may suggest that short-term memory for F0 and spectral pitch is robust to aging.

Age effects at short delays may reflect impaired temporal fine structure coding in older adults or slower processing speed.

Future Directions

Complete data collection (n=30 per group).

Conduct follow-up study that eliminates pitch direction labeling so that the task can more feasibly be run in adults with mild cognitive impairment.

Test whether pitch encoding and memory relate to level of blood-based biomarker present (e.g., pTau-217) across the predementia continuum.

References

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Acknowledgements

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