Resting State Theta Power as Marker of Successful Language Comprehension across the Lifespan

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Introduction

- High-level language processing is deficient in older compared to younger adults [1]
- May result from verbal working memory decline across age [2]: Successful encoding of verbal information is the basis of language comprehension [3]
- Working memory and language comprehension have been associated with slower oscillatory networks [4]
- Better verbal working memory is associated with lower resting state (RS) theta power in young adults [5]
- RS theta power declines with age [6,7]
- **Paradox**: although RS theta power declines with age, verbal working memory and language comprehension do not improve with age — but deteriorate instead

Question

Do age-related decreases in RS theta power indicate a deterioration of the working memory basis for language comprehension?

Methods

Participants

Final three age groups

- 19 young adults (9 males, age range: 22–28 years, mean age: 25 years)
- 19 middle-aged adults (9 males, age range: 40–48 years, mean age: 43 years)
- 19 older adults (8 males, age range: 61–70 years, mean age: 65 years)

Matching criteria: education (≥ 14 years); Mini-Mental State Examination 2 (≥ 27), hearing threshold (≤ 25 dB)

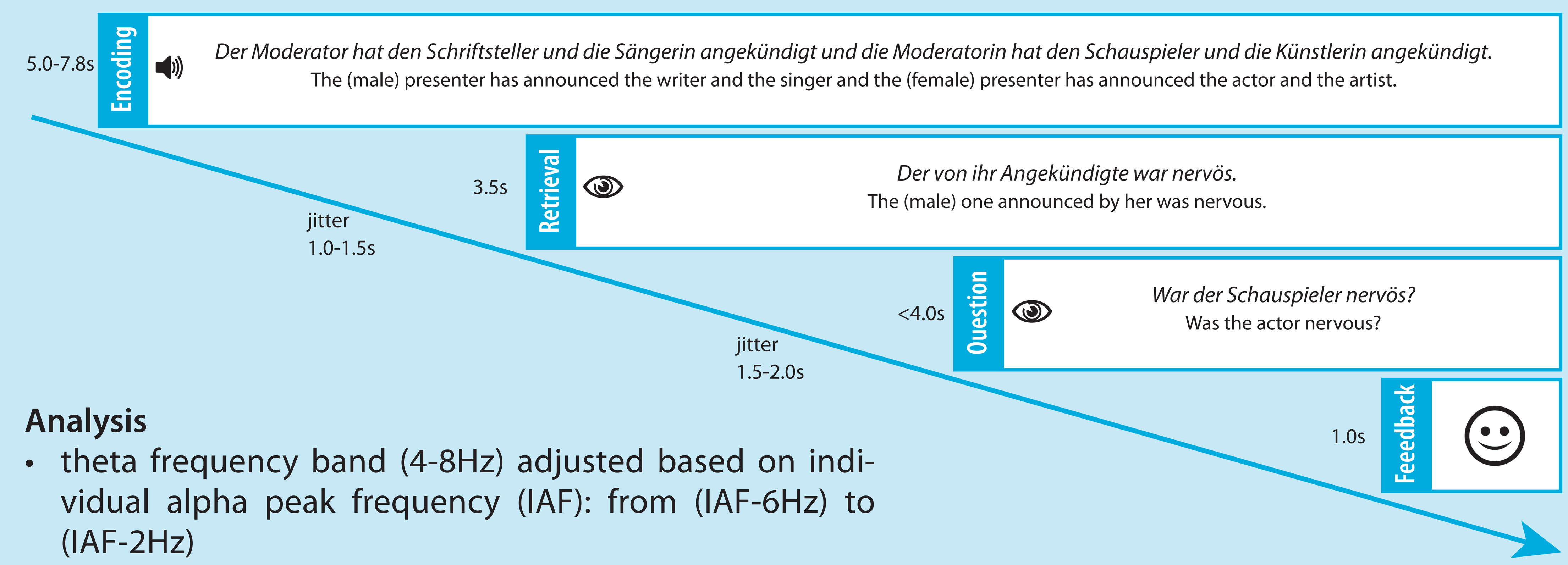
Excluded one young and one older adults (> 40% artifacts)

Electrophysiological Measure

RS EEG (5 min eyes closed, 5 min eyes open)

Behavioral Measure

Memory-intensive sentence comprehension task

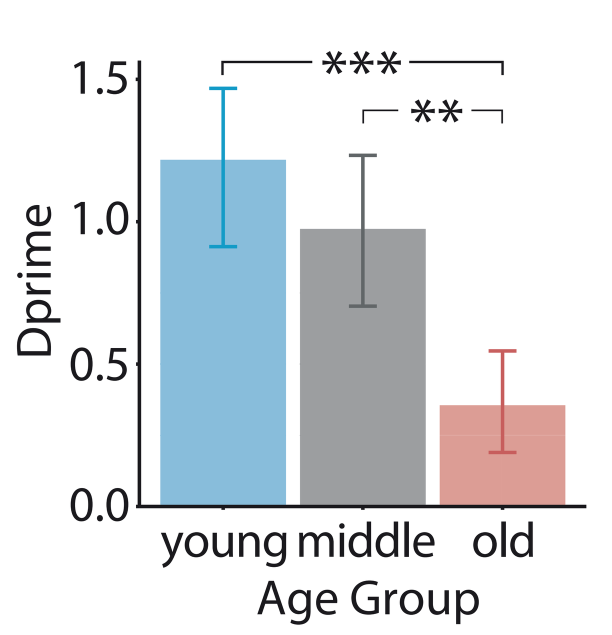


Analysis

- theta frequency band (4-8Hz) adjusted based on individual alpha peak frequency (IAF): from (IAF-6Hz) to (IAF-2Hz)
- Frequency analysis: FFT, Hanning window
- Source localization: BEM model (MNI template), DICS beamformer

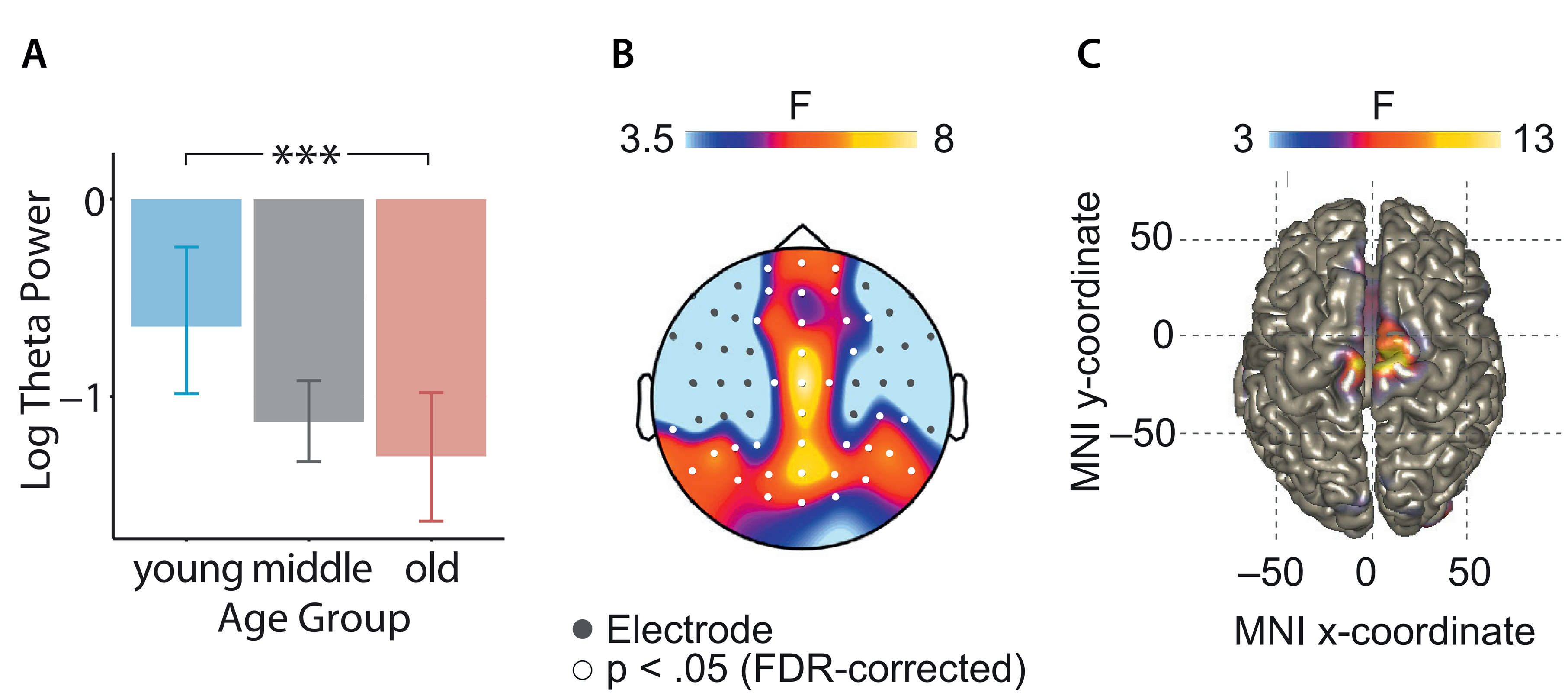
Results

1 Age-Related Decline in Language Comprehension



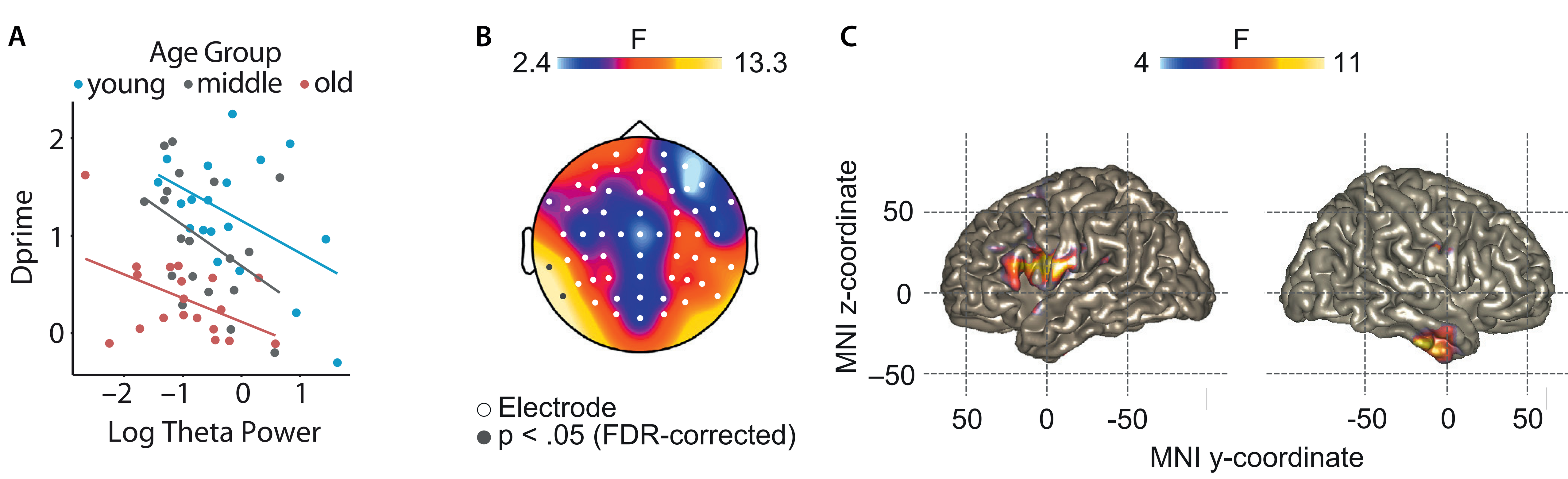
Language comprehension declines with age, $F(2,54) = 11.74$, $p < .001$

2 Age-Related Decline in Resting State Theta Power



Age-related decrease in RS theta power in bilateral midline regions ($p < .05$, FDR-corrected; white elec- trodes in topography)

3 Resting State Theta Power Predicts Language Comprehension



Low RS theta power in dorso-frontal language network associated with good language comprehension ($p < .05$, FDR-corrected; white electrodes in scalp topography)

Discussion

Spatially distinct RS theta oscillations dissociate a language-specific from a domain-general mechanism differentially so across the age trajectory

Paradox – disentangled into two spatially distinct networks. On the one side, the performance-related decrease in RS theta power over left frontal brain regions is maintained within all age groups. While the volume of frontal brain regions decreases with age [8], functional activation is shifted from posterior to anterior brain regions [9]. This may preserve the functionality but does not explain the decline in language comprehension.

On the other side, the age-related decrease in RS theta power over bilateral midline regions has been linked to variations in verbal working memory known to support language comprehension. This may result from an age-related volume decrease of the hippocampus [10] which is known as one generator of theta [11].

In sum, the results suggest that declines in language comprehension are not language-specific but rather domain-general.

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