

Resting EEG Alpha-Theta Balance as a Marker of Cognitive Vulnerability and Accelerated Biological Aging in Healthy Adults

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Higher resting EEG alpha/theta ratio was associated with lower odds of cognitive vulnerability and accelerated blood-based biological aging in cognitively intact adults.

INTRODUCTION	METHODS	RESULTS	CONCLUSIONS	REFERENCES / NOTES																		
- Cognitive aging varies among adults without overt impairment. - Resting-state EEG is non-invasive, inexpensive, and physiologically informative. - Reduced alpha relative to theta activity reflects neurophysiological slowing. Objective: To test whether resting EEG alpha/theta ratio is associated with domain-specific cognitive vulnerability and accelerated biological aging in healthy adults. Mean MoCA: 26.4 ± 1.9 Cognitively intact cohort	- Cross-sectional analysis of 379 community-dwelling adults aged 41–83 years from a healthy-aging cohort. - Participants underwent eyes-closed resting EEG, neurocognitive assessment, and routine blood-based biological age estimation. - Primary EEG exposure: standardized alpha/theta ratio, calculated from relative spectral power averaged across retained electrodes. - Cognitive outcomes included NeuroTrax verbal memory, attention, executive function, and Montreal Cognitive Assessment (MoCA). - Biological age acceleration was defined using a bias-corrected blood-based DeltaAge. - Linear regression models tested associations with vulnerability outcomes. - Logistic regression models tested associations with vulnerability outcomes. - Lowest-quartile verbal memory, attention, and executive function were used to define cognitive vulnerability. - Accelerated biological aging was defined as corrected DeltaAge ≥3 years. - NeuroTrax models were adjusted for sex only; MoCA models were adjusted for chronological age, sex, and education; biological aging models were adjusted for chronological age and sex.	Participants had preserved global cognition overall. In adjusted linear models, higher alpha/theta was associated with better verbal memory ($\beta=1.92$, 95% CI 0.68–3.16, $p=0.003$, FDR $q=0.013$), while associations with executive function and corrected DeltaAge were nominal. In logistic models, higher alpha/theta was associated with lower odds of lowest-quartile verbal memory, attention, executive function, and accelerated biological aging. The association with MoCA <26 was directionally similar but not statistically significant. <table><tr><th>Outcome</th><th>Odds Ratio (95% CI)</th><th>OR (95% CI)</th></tr><tr><td>Lowest-quartile verbal memory</td><td></td><td>0.58 (0.42, 0.81)</td></tr><tr><td>Lowest-quartile executive function</td><td></td><td>0.66 (0.49, 0.88)</td></tr><tr><td>Lowest-quartile attention</td><td></td><td>0.72 (0.55, 0.94)</td></tr><tr><td>MoCA <26</td><td></td><td>0.77 (0.58, 1.02)</td></tr><tr><td>Corrected DeltaAge ≥3 years</td><td></td><td>0.52 (0.31, 0.90)</td></tr></table> Odds Ratio (log scale) - Lowest-quartile verbal memory: OR 0.58 (95% CI 0.42–0.81), FDR $q=0.007$ - Lowest-quartile attention: OR 0.72 (95% CI 0.55–0.94), FDR $q=0.024$ - Lowest-quartile executive function: OR 0.66 (95% CI 0.49–0.88), FDR $q=0.012$ - MoCA <26: OR 0.77 (95% CI 0.58–1.02), not statistically significant - Accelerated biological aging: OR 0.52 (95% CI 0.31–0.90), FDR $q=0.024$ These findings suggest that alpha/theta may be more sensitive to domain-specific vulnerability than to global cognitive screening performance.	Outcome	Odds Ratio (95% CI)	OR (95% CI)	Lowest-quartile verbal memory		0.58 (0.42, 0.81)	Lowest-quartile executive function		0.66 (0.49, 0.88)	Lowest-quartile attention		0.72 (0.55, 0.94)	MoCA <26		0.77 (0.58, 1.02)	Corrected DeltaAge ≥3 years		0.52 (0.31, 0.90)	- Resting EEG alpha/theta balance was associated with both domain-specific cognitive vulnerability and accelerated blood-based biological aging in adults who were largely cognitively intact. - This simple spectral measure may provide a scalable functional readout of subtle brain-aging variation and may complement cognitive testing and systemic biomarkers. - Longitudinal studies are needed to clarify prognostic value and temporal direction. - alpha/theta should be viewed as a promising supportive biomarker rather than a stand-alone clinical tool. - Supports alpha/theta as a candidate early vulnerability marker - Links functional brain physiology with systemic aging biology - Requires longitudinal validation - Not a stand-alone clinical biomarker	- Background literature on resting EEG, cognitive aging, and biological age available upon request. - Study design: cross-sectional. - Disclosure: No conflicts of interest to disclose. - The EEG device was loaned by QuantalX; no study-specific external funding was provided. CONTACT Abigail Goshen, PhD Sheba Longevity Center Sheba Medical Center, Israel avigailgoshen@gmail.com
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