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EEG Microstate-specific Functional Connectivity analysis During Health Aging

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Extended Abstract

The process of aging is accompanied by a myriad of changes in brain function and structure, which have significant implications for an individual's cognitive abilities and overall quality of life[1]. The electroencephalogram (EEG) microstates and functional connectivity analysis have provided valuable insights into the dynamic nature of brain networks and their alterations related to aging and cognition changes[2], [3]. Nonetheless, a comprehensive analysis of microstate-specific functional connectivity (MSFC) during healthy aging is still lacking in the existing literature. We hypothesize that the connectivity patterns vary across microstate classes, and the integrated MSFC analysis can yield more meaningful information in healthy aging studies compared to standard connectivity analysis.

In this study, we propose a MSFC analysis method based on a microstate approach to explore the functional connectivity patterns associated with each microstate class during healthy aging. We segmented EEG data into discrete sequences of successive alternating microstates[4], delineated the microstate windows for each class, and calculated the inter-channel phase-locked values (PLV) across different frequency bands within representative microstate windows. Our investigation is based on resting-state EEG from the publicly Mind-Brain-Body study[5], which consist of two groups: a healthy young group with participants age ranging between 20 and 35 years (N = 153, 45 females, mean age = 25.1 years, SD = 3.1) and an elderly group with age ranging between 59 and 77 years (N = 74, 37 females, mean age = 67.6 years, SD = 4.7).

Results demonstrate that MSFC, compared to normal functional connectivity, can provide more significant differences in distinguishing healthy young adults from healthy elderly (for example, 0.25 ± 0.11 vs. 0.20 ± 0.11, $p < 0.001$ for MSFC PLV of beta band in microstate E, and 0.25 ± 0.10 vs. 0.20 ± 0.12, $p < 0.01$ for normal PLV of beta band). Furthermore, to uncover the relationship between MSFC and alterations in cognitive performance during aging, we divided all subjects into high and low attention groups, high and low memory groups, and high and low cognitive flexibility groups according to their average score performance on the three cognitive tests, respectively. The results surprised that the ratio of high-frequency to low-frequency PLV of specific microstates could predict cognitive performance better (for example, $r = -0.36$, $p < 0.001$ between cognitive flexibility and PLV(Gamma/Theta) in Microstate A, and $r = -0.33$, $p < 0.001$ between cognitive flexibility and normal PLV(Gamma/Theta)). The findings of this study may contribute to the identification of novel biomarkers for early detection and tracking of age-related cognitive decline, emphasizing the potential of MSFC as a powerful tool in healthy aging research.

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