Lifespan Brain Dynamics and Early Cognitive Change: A Microstate-Based Approach

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About the topic

Early detection of cognitive decline is a major challenge in neuroscience and public health, as behavioural symptoms often emerge only after substantial neurophysiological alterations have already occurred. Community-based screening tools provide accessible first-line identification of individuals at risk, but they lack specificity regarding underlying neural mechanisms and early functional brain changes. Non-invasive functional neuroimaging methods, including electroencephalography (EEG), offer sensitive, scalable, and increasingly mobile approaches for detecting subtle alterations in brain function before overt clinical impairment develops. Among these methods, resting-state EEG microstates represent a promising functional biomarker, reflecting the temporal dynamics of large-scale brain network activity. Age-related changes in microstate properties, including duration, occurrence, and transition probabilities, may reflect gradual alterations in neural network organization across the lifespan. However, the sensitivity, reproducibility, and translational integration of these functional biomarkers remain insufficiently synthesized. A key challenge is to establish how behavioural screening measures and functional neural markers can be integrated into a coherent framework for early detection and monitoring of cognitive change.

What will be done?

We will conduct a systematic literature review following PRISMA guidelines. This review will synthesize existing evidence on age-related changes in resting-state EEG microstate dynamics across the lifespan. We will include studies investigating healthy individuals across different age groups, as well as studies examining populations at risk for cognitive decline or with early cognitive impairment.

The review will address the following objectives:

1. To characterize lifespan trajectories of EEG microstate parameters, including duration, occurrence, coverage, and transition dynamics.
2. To identify which microstate features are most sensitive to age-related functional brain changes.
3. To assess the potential of EEG microstates as functional biomarkers for early cognitive change.

The project will result in a systematic review protocol and subsequently a review paper suitable for publication in a peer-reviewed neuroscience journal.

What will you learn?

- How to conduct a systematic review following PRISMA guidelines.
- How resting-state EEG microstates reflect large-scale brain network dynamics.
- How microstate properties change across the lifespan and during cognitive ageing.
- How functional neurophysiological biomarkers can support early detection of cognitive decline.
- How to critically evaluate methodological approaches in EEG microstate research.

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