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Are dynamic brain state transitions during rest reliable markers of individual neuropsychological and behavioral differences in preschoolers?

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The recurrent activation over time of distinct cortical networks, also known as brain states (BSs), plays a crucial role in supporting cognitive control (CC) performance across the lifespan. Hidden Markov Models (HMMs) have emerged as a valuable tool for identifying BSs. However, studies utilizing HMMs in developmental populations are relatively limited. In this study, we employed high-density electroencephalography (HD-EEG) to identify BSs during rest in a cohort of typically developing, preschool-aged children. Additionally, we computed individual switching rates (SR), entropy, and probabilities of transitions between BSs. Our primary objective was to explore the potential relationships between these individual neurofunctional indices and the participants' neuropsychological and behavioral profiles. A total of 39 neurotypical children, aged 4 to 6 years, participated in two separate resting-state sessions with HD-EEG. They also completed a computerized cognitive task assessing reactive/proactive CC and underwent a battery of executive function tests. Our model identified discrete spatiotemporal patterns mimicking well known resting-state networks, including the anterior and posterior default-mode, temporo-parietal, occipital, sensorimotor, frontal and fronto-temporal circuits. Interestingly, we observed a gender-related difference, with boys and girls spending more time in default-mode-like and fronto-temporal BSs, respectively. Furthermore, we found that a higher probability of transitioning into fronto-temporal states was associated with better scores in questionnaires assessing executive functioning in everyday life, behavioral difficulties and emotion regulation abilities. These findings highlight the importance of resting-state brain dynamics as functional scaffolds for behavior and cognition and suggest new methodological tools for assessing individual neurocognitive differences in typical and potentially atypical development.

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