HOW DO BRAINS LEARN? ANALYSIS IN ELECTROENCEPHALOGRAPHIC RECORDINGS FROM YOUNG CHILDREN AND APPLICATION TO EARLY CARE

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Context

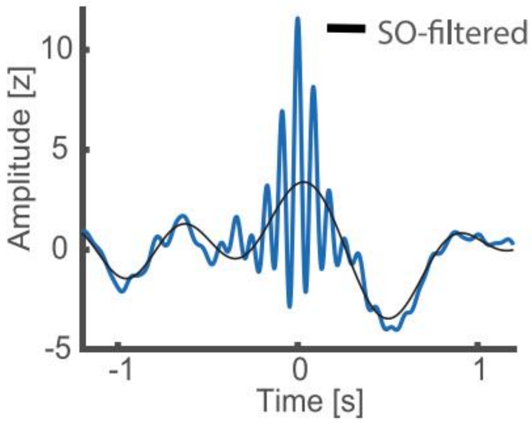
Unraveling the neurophysiological bases of high-level cognitive functions in children is a challenge of high importance, not only for basic research but also for early care in children at risk for learning disabilities. Shedding light on the cognitive difficulties frequently experienced across childhood may, in turn, help the development of therapeutic avenues and appropriate clinical care in pediatrics.

The challenges are twofold: First, developing age-appropriate electrophysiological or neuroimaging tasks suitable for children and assessing complex cognitive abilities frequently found atypical in neurodevelopmental disorders. Second, identifying the neurophysiological bases and mechanisms associated with these cognitive functions in typically and atypically developing children.

In this context, the proposed work focuses on short-term encoding and long-term consolidation of new memories in children.

Animal and intracranial human EEG studies demonstrated that both short-term encoding and long-term consolidation of new memories are associated with complex cross-frequency coupling (CFC) mechanisms involving cortical and/or deep brain sources such as the hippocampi [1]–[3]. For instance, empirical data suggest that multiple items are being maintained in short-term [3], [4], or long-term [2] memory by neural assemblies in the hippocampus, through the synchronization of fast frequencies (i.e., <70 Hz) locked to consecutive phase ranges of oscillatory activity in slow frequencies (i.e., <15Hz). Furthermore, such CFC mechanisms might predict individual memory performance in adults [5] or could explain memory impairments in clinical populations such as autism spectrum disorder (ASD) [5] or epilepsy [3].

In parallel, the precise temporal coordination between sleep spindles and slow oscillations (SOs) during sleep has been reported to index declarative memory network development or gross motor learning abilities [6], [7].



Individual features of discrete SO and sleep spindle events [6]

There is, therefore, a crucial need to study these processes in young children not only as they learn at a rapid pace and have to consolidate huge amounts of information quickly, but also as it may improve early care in children at risk for learning disabilities (e.g., childhood-onset epilepsy).

Work

The proposed work will address a tool for analyzing electroencephalographic (EEG) recordings and providing learning process indicators. Sleep EEG recordings from children during the memorizing process (i.e., after a learning task) will be provided.

The student will:

- Understand the key elements in the EEG recording related to memorization.
- Propose an algorithm to detect sleep spindles and slow oscillations in an EEG recording.
- Analyze the precise temporal coordination between sleep spindles and slow oscillations.
- Detect interictal discharges (i.e., elements in an EEG recording related to epilepsy) in an EEG recording.
- Analyze the impact of interictal discharges on the temporal coordination between sleep spindles and slow oscillations to address its impact on memorization.

References

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