Abstracts

Effects of Interictal Epileptiform Discharges on Cognitive Performance and Pupillometry in Pediatric Epilepsy: A Multimodal Deep Learning Approach

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Rationale:
Pediatric epilepsy often leads to cognitive impairments that significantly affect quality of life and psychosocial functioning (Nickels et al. 2016). The pupillary response, which reflects the interaction of sensory information and cognitive processes, offers a unique non-invasive window into cognitive load and attention (Strauch et al. 2022). However, the specific contributions of different cognitive processes to pupillary dynamics, and how executive functions modulate these responses in pediatric epilepsy, remain unclear. Further, the impact of interictal epileptiform discharges (IEDs) on these relationships has not been thoroughly investigated.

Methods:
This study leveraged deep learning techniques to integrate multiple data modalities — cognitive performance metrics, pupillometry, and stereoelectroencephalography (sEEG) — collected from 21 pediatric epilepsy patients (age range: 8-17) at the Hospital for Sick Children. This approach aimed to reveal relationships between pupil size, brain activity, and behavioral outcomes in the presence and absence of IEDs. We

employed time-resolved hierarchical mixed-effects modeling to investigate how pupil dynamics correlate with cognitive performance and neural activity across different task stages, both with and without the occurrence of IEDs.

Results:

Our analysis revealed two main findings:

Deep learning models trained on IED-absent trials demonstrated robust performance when applied to trials containing IEDs. Overall, model performance did not significantly decline in the presence of IEDs during the peri-stimulus period (-500 ms to 500 ms around time of stimulus presentation), demonstrating that the brain-pupil relationship is not significantly disrupted by IEDs (max. Spearman's *R* decreased from 0.49 to 0.44) (Fig. 1A).

The relationship between pupil size and cognitive performance was found to be task-stage dependent, maintaining consistency even in the presence of IEDs (Fig. 1B). IEDs were associated with lapses in attention, as indicated by longer reaction times ($p < 0.02$) but did not significantly disrupt pupillary dynamics ($p > 0.206$) (Fig. 1C). This suggests that while IEDs impair cognitive performance, they do not significantly disrupt the underlying processes that govern pupil size.

Conclusions:

These findings provide insights into the complex relationship between cognitive processing, pupillary responses, and IEDs in pediatric epilepsy patients. The preserved relationship between pupil size and task performance in the presence of IEDs highlights the potential of pupillometry as a reliable measure of cognitive function in pediatric epilepsy patients. Our results have significant implications for understanding cognitive deficits in epilepsy and may inform the development of non-invasive cognitive monitoring tools for this population.

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