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Group-based four-dimensional brain mapping of executive control

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Rationale: Humans utilize executive control processes to carry out non-automatic tasks. These tasks require coordination from higher brain centers to both suppress inappropriate behaviors and initiate correct responses. The goal of this study is to generate a novel, dynamic brain atlas to visualize and understand the network dynamics underlying executive control.

Methods: We studied 547 non-epileptic intracranial electrode sites sampled from seven patients with focal epilepsy. Each patient performed two types of verbal tasks: word-reading and Stroop color-naming. Mixed model analysis compared high-gamma cortical activation prior to response onset between the word-reading and Stroop color-naming tasks. Based on mixed model analysis, we visualized the white matter connectivity between the brain regions exhibiting simultaneous high-gamma augmentation.

Results: In the Stroop color-naming task, mixed model analysis showed more high-gamma augmentation 600 to 400 ms pre-response onset in the prefrontal region (e.g., left caudal middle-frontal gyrus; $p = 0.0054$; figure 1 arrowhead). Conversely, in the word-reading tasks, more high-gamma augmentation was seen in the occipitotemporal region (e.g., left posterior fusiform gyrus; $p = 0.0002$; figure 1 arrow). Dynamic tractography in the Stroop color-naming task showed functional connectivity enhancement between prefrontal regions 500 to 400 ms pre-response onset (figure 2 arrow). On the other hand, functional connectivity in the word-reading tasks was enhanced between occipitotemporal regions from 500 ms pre-response onset to 50 ms post-response (figure 2 arrowhead).

Conclusions: Prefrontal regions were activated during tasks requiring higher executive control, whereas occipitotemporal regions supported word reading.

Keywords (maximum of 10 keywords):

Intracranial electroencephalography (EEG) recording, executive control, physiological high-frequency oscillations (HFOs), neuroimaging, functional connectivity, diffusion tensor imaging (DTI), pediatric epilepsy surgery