

Downregulation of Frontal Midline Theta with Neurofeedback – easier said than done?

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Background: Frontal midline theta (FMT; 4–8 Hz) oscillations are closely linked to cognitive control, performance monitoring, and feedback-based learning. While the upregulation of FMT via neurofeedback (NF) is well established, successful FMT downregulation remains a challenge. We therefore aimed at testing the feasibility of FMT downregulation using a multi-session NF protocol.

Methods: Five healthy, right-handed participants completed six FMT-inhibition NF sessions within 14 days. Each session included a pre-training resting-state baseline, followed by five NF runs. Participants received real-time visual feedback of FMT activity at Fz and were instructed to increase the height of a bar by changing their mental activity. They were not told that the bar reflected inverted FMT power, such that lower FMT produced more positive feedback. Each run also included one transfer trial, during which participants attempted to continue regulation without feedback. Offline EEG analyses focused on FMT power at Fz and compared resting-state, full-feedback, and transfer conditions using linear-mixed models.

Results: Contrary to the intended training direction, FMT activity increased significantly during full-feedback NF as compared to resting-state baseline ($\beta = 0.14$, $SE = 0.05$, $z = 2.83$, $p = .0046$). FMT also increased during transfer trials relative to baseline ($\beta = 0.10$, $SE = 0.05$, $z = 2.11$, $p = .035$). The increase was smaller during transfer than full-feedback trials, direct comparison showed significantly lower FMT activity in transfer trials than in full-feedback trials ($\beta = -0.22$, $SE = 0.07$, $z = -3.32$, $p < .01$).

Conclusion: These pilot findings suggest that FMT downregulation via NF may be challenging, even in a multi-session protocol. Instead of decreasing, FMT increased during both feedback and transfer conditions. This increase could be explained by task engagement during NF processing which may influence FMT activity independently of the intended training direction. Although limited by the small sample size, the study provides initial evidence that NF for FMT inhibition may require more fine-tuned protocols which attenuate the effects of the task.