Decoding the language of 'now': EEG microstates in experienced meditators, from letters to grammar

ABSTRACT:

Background
The topographic distribution of brain's electrical activity measured by electroencephalogram (EEG) is characterised by the periods of quasi-stable spatial distribution referred to as EEG microstates. Four canonical microstate classes of resting-state EEG have been reliably identified, A, B, C, and D. The functional significance of these canonical microstates remains unclear. Microstate sequences ('words') might be more informative in separating populations and cognitive processes than single microstates ('letter').

Aims
The main aims of the proposed research were to further understand: 1) the functional significance of EEG-resting state microstates by manipulating factors previously shown to affect microstate parameters, such as a) processing modality and b) modes of attention; and 2) complex structure and regularities of microstate syntax.

Method
A cross-sectional experimental design was employed, comparing experienced meditators (N=20) and age-matched meditation naïve-participants (N=20). The EEG data were recorded from all participants during three conditions (mind-modes): mind-wandering, verbalisation, and visualisation to address aim 1. To address aim 2, epsilon-machine analysis methods were developed and employed to understand the syntactic structure of EEG sequences separating two groups and three mind-modes.

Results
Our main finding is that when the groups and mind-modes cannot be distinguished using traditional EEG parameters (duration, occurrence, coverage, and transition probabilities), this can be achieved using epsilon-machines modelling the syntax and 'word'-level dynamics of EEG microstate sequences.

Conclusions
The epsilon-machines are able to capture differentiating aspects of neurodynamics in EEG data beyond what it is possible to detect with traditional methods, supporting our overall approach.

Keywords
EEG microstates, Mindfulness, Meditation, Attention, Open presence

Published Work:

Antonova, E., Holding, M., Chak Suen, H., Sumich, A., Maex, R., & Nehaniv, C. (2022). EEG microstates: Functional significance and short-term test-retest reliability. *NeuroImage, 2*(2): 100089. doi: 10.1016/j.ynirp.2022.100089

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Nehaniv, C., & Antonova, E. (2017). Simulating and reconstructing neurodynamics with epsilon-automata applied to electroencephalography (EEG) microstate sequences. *Proceedings of the IEEE Symposium on Computational Intelligence, Cognitive Algorithms, Mind, and Brain (IEEE CCMB'17)* (pp. 1753-1761). Honolulu, USA: IEEE. doi: 10.1109/SSCI.2017.8285438

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