*Letter to Editor*

# Nonlinear Electroencephalogram (EEG) Analysis in Sleep Medicine

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There are three main views in computational neuroscience including deterministic, stochastic, and nonlinear approaches. In the deterministic approach, the human brain is considered a linear and stationary system with determined parameters. For instance, fast fourier transform (FFT), which is based on this view, is now used in several clinical applications e.g., sleep medicine. The second view, which considers brain a stochastic system, employs statistical analysis. In the third view, electroencephalogram (EEG) signals, which are assumed to be nonlinear, chaotic, and coupled, are generated by the brain which is inherently nonlinear, complex, dynamic, self-organized, and emergent with almost unknown interactions between its components. As we can see, the third view is more realistic. In the first and second approaches, which follow reductionism and are more appropriate for man-made systems and not biological ones, complex interactions between the brain's elements are negligible, and the human brain is viewed as a linear stationary system (1, 2).

Brain as a dynamic nonlinear biological system can create complex human behavior and abilities such as perception, emotion regulation, memory consolidation, dreaming, etc. Human brain is neither a fully deterministic system, nor it acts as a fully stochastic system. Instead, it works on the edge of chaos which results in complicated and unique characteristics and robustness.

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Complex unique brain abilities are due to the complex interactions between its components. Simple neurons' responses create complex brain properties when they interact and work as a network. It indicates that it is more accurate to employ chaotic nonlinear processing methods to analyze EEG signals. Nonlinear EEG processing helps us to extract meaningful reliable information (1, 2).

Sleep stage detection, dream content analysis, sleep disorder recognition, etc. are the most well-known applications of EEG processing in sleep medicine. Numerous studies have reported that EEG nonlinear analysis is quite effective. Sleep stages follow nonlinear and complex patterns as do recorded EEG signals. Dreaming, for instance, is almost the most mysterious part of sleep about which we have limited knowledge. For years, scientists have been trying to explore this unknown world. According to what was mentioned above, we need to utilize EEG nonlinear analysis in our future studies to push our limits and find more in sleep medicine. Thanks to advanced high-tech devices and neuro-imaging techniques, it is now possible to think out of the box, employ high-density EEG signals as well as nonlinear EEG processing methods in our future studies. Some studies like Ma et al. have introduced nonlinear EEG processing methods in a way that does not require mathematical sophistication which is why they can be employed in clinical applications (3). In conclusion, we need dedication of our future studies to introduce novel nonlinear EEG measures to sleep medicine.

## Conflict of Interests

Authors have no conflict of interests.

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