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Simultaneous Stomach–Brain Electrophysiology for Assessment of Sleep Quality and Continuity

Stanford researchers have developed a non-invasive electrophysiological system and method that characterizes gastric–cortical coupling during human sleep using simultaneous electroencephalography (EEG) and electrogastrography (EGG), yielding an objective physiological marker of sleep quality that conventional polysomnography and heart-rate variability cannot capture.

Existing sleep monitoring technologies such as clinical polysomnography, consumer wearables, and HRV-based trackers can measure only cortical and cardiac signals, leaving the visceral contribution to restorative sleep unmeasured. Objective sleep metrics consequently remain weakly correlated with how rested individuals actually feel. The Stanford team addressed this gap by identifying, for the first time, an infraslow oscillation intrinsic to the gastric rhythm (0.02 Hz), together with signal-processing pipelines to extract it from surface EGG recordings.

Companion algorithms quantify multiscale stomach–brain interactions using phase–amplitude coupling, von Mises phase concentration, cross-correlation against EEG sigma-band power, slow-wave oscillations and spindles, and linear mixed-effects modeling. Variance in gastric infraslow amplitude uniquely explains subjective sleep quality beyond standard polysomnographic and cardiac measures, establishing the stomach as a peripheral oscillator in the regulation of sleep continuity and interoceptive stability. Because EGG signals can be acquired from leads compatible with DC-coupled EEG or ECG hardware, the technology can be deployed as a software and algorithm upgrade to existing platforms with minimal additional sensing.

Applications

- Sleep diagnostics: wearable or bedside systems integrating EEG and EGG sensing to monitor restorative physiology
- Consumer sleep tracking: algorithms for headbands, chest patches, smart mattresses, and other home devices delivering personalized sleep-quality metrics
- Clinical decision support: identification of autonomic fragmentation in insomnia, PTSD, and disorders of gut–brain interaction
- Objective biomarkers for pharmaceutical and neuromodulation trials, including vagal stimulation, sleep aids, and gut–brain therapeutics
- Software and algorithm licensing to device manufacturers as an upgrade to existing DC-coupled EEG or ECG platforms

Advantages

- First validated framework for quantifying stomach–brain coupling during sleep
- First discovery of the gastric infraslow oscillation, together with a method for its extraction
- Provides a biomarker of sleep quality that is independent of cortical EEG features
- Outperforms conventional HRV and polysomnographic measures in predicting perceived restfulness
- Compatible with existing DC-coupled EEG and ECG hardware, requiring minimal additional sensors
- Extensible to vagus-nerve and gut-based neuromodulation applications

Publications

- Rao, A., Dresler, M., Rebollo, I., Zeitzer, J., Schoch, S. F., & Coleman, T. P. (2025). Dynamic stomach-brain electrical coupling in human sleep. *bioRxiv.* https://www.biorxiv.org/content/10.1101/2025.11.13.686572v2.

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