Machine Learning detection of arousals from at-home sleep EEG device demonstrates high reliability compared to experts

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What is the Methodological Issue Being Addressed? Sleep fragmentation is a common feature of disrupted nighttime sleep across multiple neurological and psychiatric disorders. Often, fragmented sleep manifests as brief bouts of cortical arousal that are not captured in standard hypnogram-based sleep scoring. Scoring arousals from in-lab polysomnography (PSG) by expert readers is the gold standard, but is burdensome, labor-intensive, and subject to significant inter/intra-rater variability. This work addresses the methodological challenge of objective quantification of arousals in more accessible real-world settings, possibly enabling more efficient evaluation of sleep therapies and future diagnostic applications. Here, we conducted a validation study in the sleep lab to compare the detection of arousals from PSG to simultaneous recordings from a wireless EEG wearable that is designed for remote, at-home use and captures cortical arousals and other sleep metrics.

Introduction Cortical arousals provide insights into sleep pathologies and sleep quality through relationships to daytime impairment, respiratory event related arousals (RERAs), and hyperarousal patterns in patients with various sleep and psychiatric conditions. Although the gold-standard for scoring arousals is from in-lab PSG by expert readers, this is labor intensive, highly prone to inter/intra-rater variability and burdensome on the patient. Here, we compare the detection of arousals from PSG to simultaneous recordings from an at-home, wireless EEG wearable device that captures cortical arousals and other sleep metrics.

Methods PSG and wearable EEG were simultaneously recorded from 36 individuals (ages 25-65, 69% female) overnight. Arousals were scored by 5 Registered PSG Technologists (RPSGT) following AASM guidelines using PSG signals, only to serve as ground-truth for algorithm evaluation. Arousals on the wearable EEG device were separately detected by a machine-learning algorithm trained on over 15k nights. Performance was evaluated by computing the Intraclass correlation coefficient (ICC) of the model's Arousal index (ArI, arousals per hour sleep) to the scorers' ArI, as well as by comparing 30-second epochs with or without arousals to the scorers' majority vote to compute Cohen's Kappa.

Results The mean ArI ICC between pairs of human scorers was 0.74 (SD=0.107, range: 0.58-0.88). The mean ICC between the wearable EEG ArI and individual scorers was 0.80 (SD=0.039, range: 0.74-0.85). Comparing the wearable EEG ArI to the average ArI of all scorers resulted in an ICC of 0.89 (95% CI: 0.84-0.94). The 95% bootstrapped confidence interval of the difference of the average wearable EEG to the average scorer ArI ICC resulted in a lower bound of 0.006, demonstrating superiority of wearable EEG to score ArI over the average expert. The wearable EEG's epoch-level kappa of 0.59 (95% CI: 0.55-0.62) exceeded most experts' agreement (0.44 to 0.61, based on other raters' majority vote).

Conclusion An at-home sleep EEG device with an associated machine learning algorithm is able to detect arousals with a high epoch-level agreement and provides an estimate of arousal index with high reliability compared to human experts in our study. These findings demonstrate the potential for scalable, objective quantification of sleep fragmentation in real-world settings, possibly enabling more efficient evaluation of therapies and future diagnostic applications.

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Keywords

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Guidelines I have read and understand the Poster Guidelines

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