

# Reduced sleep time is associated with increases in frontal sleep-like activity and emotion regulation failures

Giulia Avvenuti<sup>1</sup>, Davide Bertelloni<sup>2</sup>, Giada Lettieri<sup>1</sup>, Emiliano Ricciardi<sup>1</sup>, Luca Cecchetti<sup>1</sup>, Pietro Pietrini<sup>1</sup>, Giulio Bernardi<sup>1</sup>

<sup>1</sup> *Molecular Mind Laboratory, IMT School for Advanced Studies, Lucca, Italy*

<sup>2</sup> *University of Pisa, Pisa, Italy*

**Introduction:** Emotional self-regulation consists in modulating the subjective experience of a given emotion and/or its prompted behavioral expression. Sleep restriction or deprivation is associated with an impairment in the regulation of emotional responses thought to depend on an altered prefrontal “control”. Interestingly, recent studies demonstrated that extended wakefulness leads to the appearance of spatially circumscribed, sleep-like episodes (1-8Hz) that determine behavioral errors when occurring in task-related brain areas. Such episodes likely reflect functional fatigue and sleep need. Given these premises, we hypothesized that local sleep-like episodes occurring within prefrontal cortical areas may represent the physiological link between insufficient sleep and emotion regulation failures.

**Methods:** In two distinct experimental visits, nineteen healthy subjects (26±3yrs, 10F) were presented with amusing video-clips and asked either to suppress their facial reactions (emotion suppression, ES) or to freely express emotional responses (free expression, FE). An actigraph was worn for 7-days and used to determine sleep-time before each experiment. Facial-view video and high-density(hd) EEG (64-electrodes) were continuously recorded during the tasks. Changes in facial expression were identified and manually marked on the video recordings. Continuous hd-EEG recordings were preprocessed using standard approaches to reduce artifactual activity and source-modeled using sLORETA. The signal power in delta (1-4Hz) and theta (4-8Hz) frequency-bands was computed for four-second-long data epochs immediately preceding the onset of changes in facial expression. Paired t-tests were used to compare ES and FE conditions.

**Results:** Twelve subjects had at least one emotion suppression failure in the ES condition. Relative to FE, changes in facial expression during ES were preceded by local increases in delta (1-4Hz) activity in prefrontal, anterior cingulate and left-parietal regions ( $p < 0.05$ , cluster-based correction). Moreover, shorter sleep duration the night prior to the ES experiment correlated with the number of emotion suppression failures ( $p = 0.01$ ) and tended to be associated with higher frontal delta activity during emotion suppression failures ( $p = 0.05$ ).

**Conclusions:** The present results demonstrate that the occurrence of local, sleep-like episodes affecting brain areas related to emotional regulation may represent the direct cause of emotion suppression failures. Our results offer a neurophysiological explanation for previous reports linking sleep loss and alterations of emotional self-regulation.