Functional Networks Observed with Scale-Free and Oscillatory Cortical Activity

Haiguang Wen, Zhongming Liu (zmliu@purdue.edu)

Weldon School of Biomedical Engineering

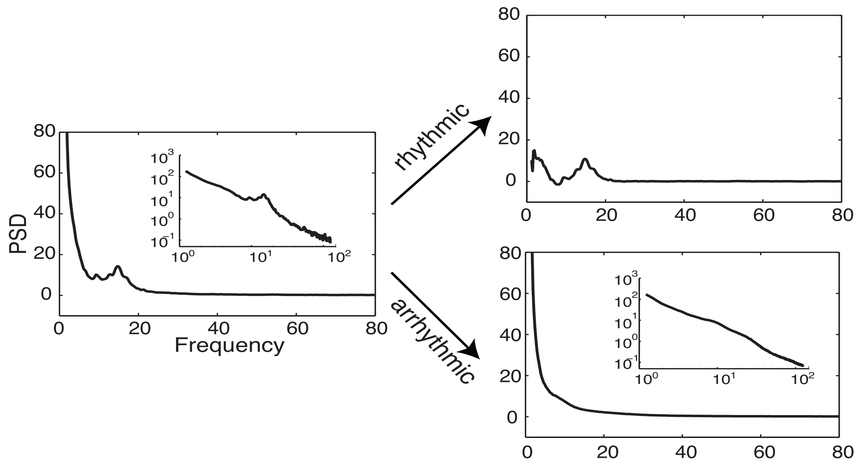
School of Electrical and Computer Engineering

PURDUE UNIVERSITY

Introduction

Brain electrical signals often exhibit a varying mixture of broadband arrhythmic and narrowband rhythmic patterns, known as **scale-free** and **oscillatory** activities respectively. These distinct electrophysiological signals are thought to originate from distinct mechanisms and indicate distinct features of underlying structural networks (He et al. 2010; Buzsaki et al., 2004; Liu et al. 2013). Here we separately characterized the contributions of scale-free and oscillatory electrophysiological fluctuations to brain network patterns observed with electrocorticography (ECoG), magnetoencephalography (MEG) and functional magnetic resonance imaging (fMRI) across various behavioral states.

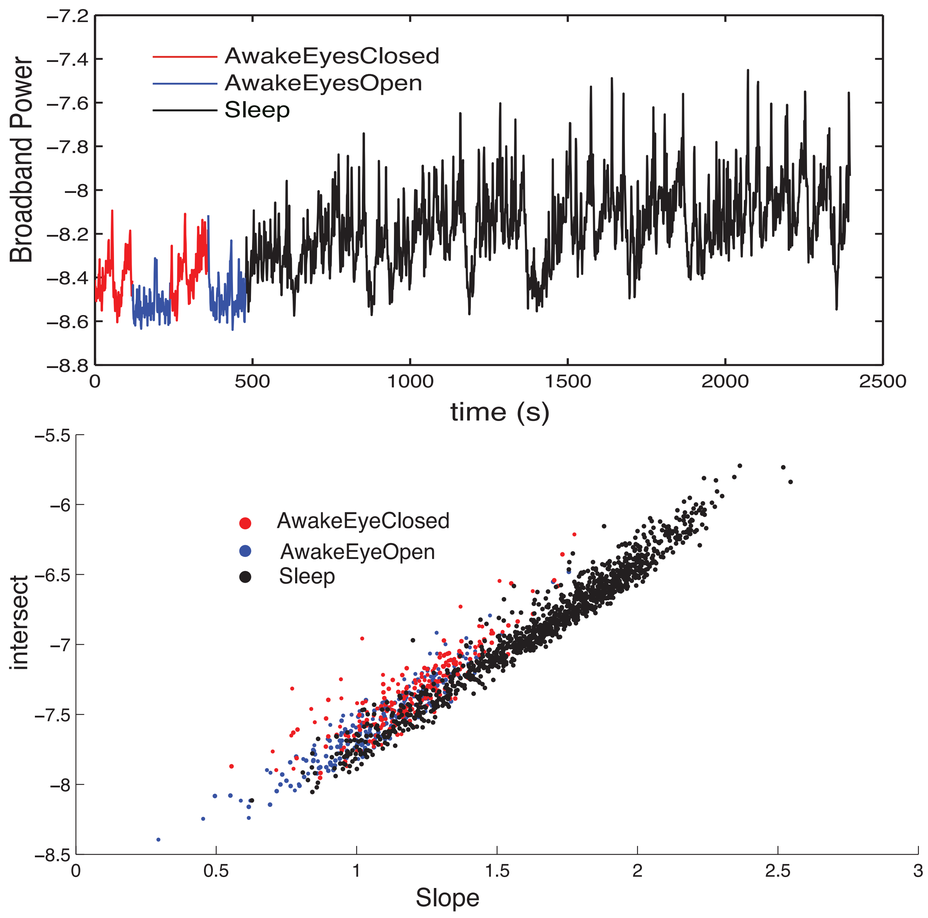
Irregular Resampling Autospectral Analysis



The temporally resolved power spectrum was separated into two components that were attributed to the underlying scale-free and oscillatory electrical activities using a newly developed signal processing method (Wen and Liu, under review).

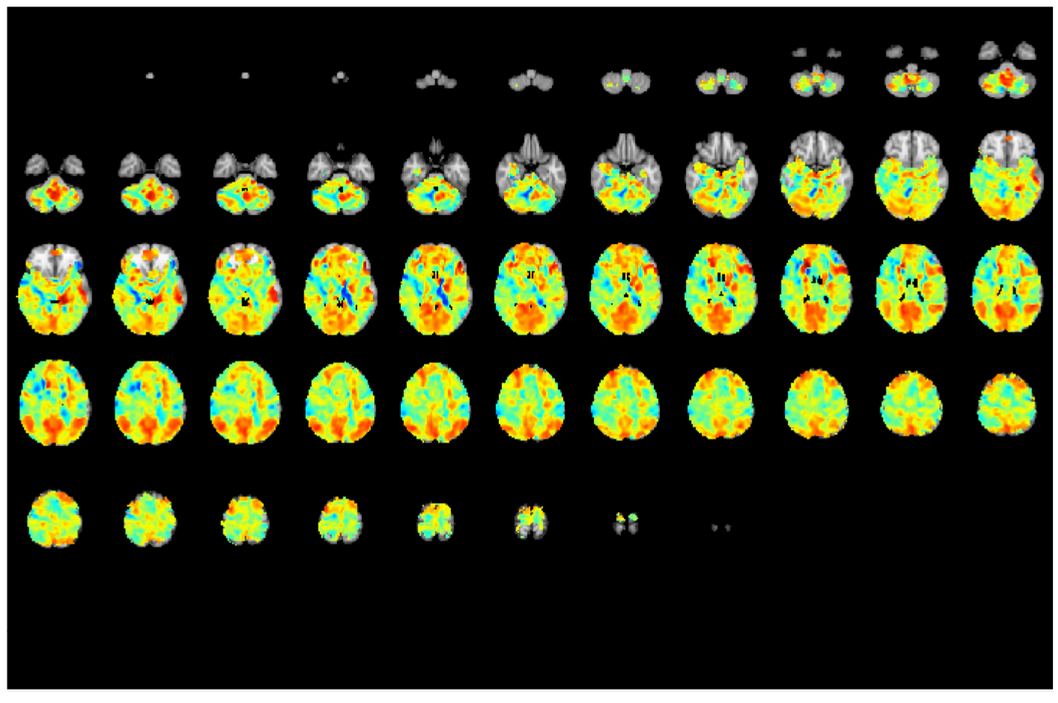
MEG (human)

Different scaling properties were also observed with human MEG signals for distinct behavioral states (eyes-open/eyes-closed wakefulness vs. sleep)



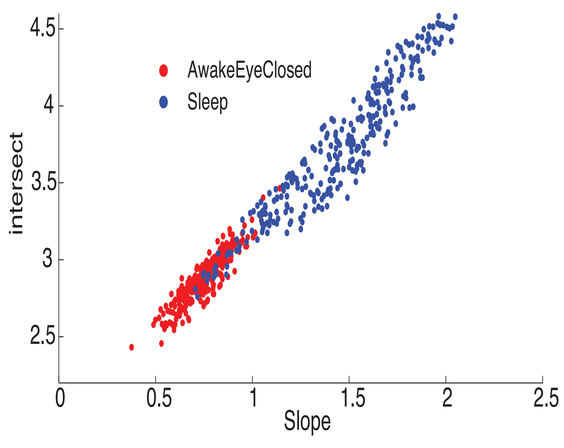
EEG-fMRI (human)

The temporal fluctuation of scale free activity was correlated to large-scale brain networks (e.g. default-mode network) observed with resting state fMRI.

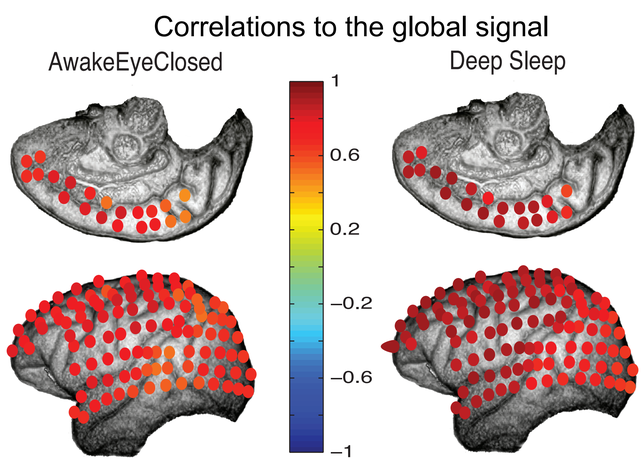


ECoG (monkey)

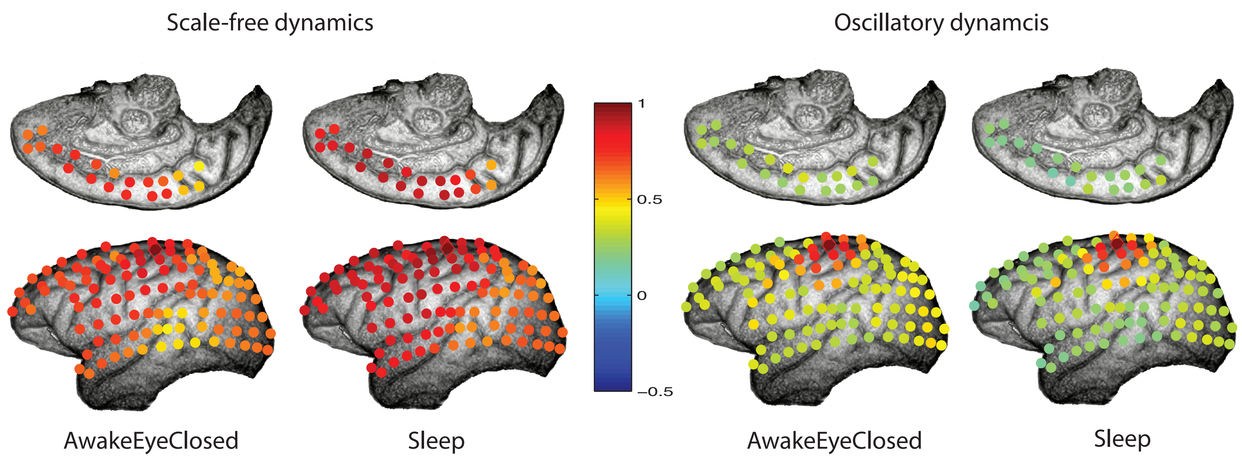
The scale-free activity exhibits different scaling properties between the wakefulness and sleep.



The fluctuations of scale-free activity are correlated globally in both wakefulness and sleep.



The seed-based correlation patterns are global for the scale-free activity and local for the oscillatory alpha (10 Hz) activity.



(The ECoG data were downloaded from the public website of the Richen Brain Science Institute)

Reference

He, Zempel, Snyder, Raichle (2010). The temporal structures and functional significance of scale-free brain activity. Neuron, 66(3), 353-369.

Buzsaki and Draguhn (2004). Neuronal oscillations in cortical networks. Science, 304(5679), 1926-1929.

Liu, de Zwart, Chang, Duan, van Gelderen, Duyn (2013). Neuroelectrical decomposition of spontaneous brain activity measured with functional magnetic resonance imaging. Cereb. Cortex, Epub ahead of print.

Wen and Liu. Separating fractal and oscillatory components in the power spectrum of neurophysiological signal, under review.

Acknowledgment

The research was supported in part by NIH R01MH104402