Title: Behavioral and arousal states control neurovascular-coupling

Authors: Kevin L. Turner1,2, Ravi Teja Kedarasetti2,3, Kyle Gheres2,4, Patrick J. Drew\*1,2,4,5

Affiliations:

Department of Biomedical Engineering, The Pennsylvania State University, University Park, PA

Center for Neural Engineering, The Pennsylvania State University, University Park, PA

Department of Engineering Science and Mechanics, The Pennsylvania State University, University Park, PA

Graduate Program in Molecular, Cellular, and Integrative Biosciences, The Pennsylvania State University, University Park, PA

Department of Neurosurgery Engineering, The Pennsylvania State University, University Park, PA

\*Corresponding author, [pjd17@psu.edu](mailto:pjd17@psu.edu)

Abstract:

Hemodynamic signals in the brain are used to infer neural activity, and bilateral correlations in

hemodynamic signals have been observed in the absence of any overt stimulus or task.

However, recent studies have suggested that the nature and strength hemodynamic signals

depend on arousal state. Here, we monitored neural activity and hemodynamic signals in

un-anesthetized, headfixed mice to understand how sleep and wake states impact cerebral

hemodynamics. In parallel with electrophysiological recordings, we used intrinsic optical

signal imaging to measure bilateral changes in cerebral blood volume (CBV). We concurrently

monitored body motion, whisker movement, muscle EMG, and cortical LFP to classify the

arousal state of the mouse into awake, NREM sleep, or REM sleep. We found that mice

regularly fell asleep for a few minutes at time during imaging. During both NREM and REM

sleep, mice showed large increases in CBV relative to the awake state. During NREM sleep,

the amplitude of bilateral low-frequency oscillations in CBV increased markedly. Bilateral

correlations in neural activity and CBV were highest during NREM sleep, and lowest in the

awake state. Our results show that hemodynamic signals in the cortex are strongly modulated

by arousal state and emphasize the importance of behavioral monitoring during studies of

spontaneous activity.

Acknowledgements: This work was supported by NIH grants RO1NS078168 and R01NS079737

Introduction