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PII: S1053-8119(16)00213-5
DOI: doi: 10.1016/j.neuroimage.2016.02.080
Reference: YNIMG 13020

To appear in: *NeuroImage*

Received date: 29 June 2015
Accepted date: 1 February 2016

Please cite this article as: Coon, W.G., Gunduz, A., Brunner, P., Ritaccio, A.L., Pesaran, B., Schalk, G., Oscillatory Phase Modulates the Timing of Neuronal Activations and Resulting Behavior, *NeuroImage* (2016), doi: 10.1016/j.neuroimage.2016.02.080

Oscillatory Phase Modulates the Timing of Neuronal Activations and Resulting Behavior

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Abstract

Human behavioral response timing is highly variable from trial to trial. While it is generally understood that behavioral variability must be due to trial-by-trial variations in brain function, it is still largely unknown which physiological mechanisms govern the timing of neural activity as it travels through networks of neuronal populations, and how variations in the timing of neural activity relate to variations in the timing of behavior. In our study, we submitted recordings from the cortical surface to novel analytic techniques to chart the trajectory of neuronal population activity across the human cortex in single trials, and found joint modulation of the timing of this activity and of consequent behavior by neuronal oscillations in the alpha band (8–12 Hz). Specifically, we established that the onset of population activity tends to occur during the trough of oscillatory activity, and that deviations from this preferred relationship are related to changes in the timing of population activity and the speed of the resulting behavioral response. These results indicate that neuronal activity incurs variable delays as it propagates across neuronal populations, and that the duration of each delay is a function of the instantaneous phase of oscillatory activity. We conclude that the results presented in this paper are strongly supportive of a general model for variability in the effective speed of information transmission in the human brain and for variability in the timing of human behavior.

Keywords: electrocorticography (ECoG), oscillations, reaction time, broadband gamma