Quantifying oscillatory frequency and its role in visual perception and top-down control

Jason Samaha[1,2], Andreas Wutz[3], David Melcher[4], Bradley R. Postle[1]

[1]University of Wisconsin-Madison
[2]University of California, Santa Cruz
[3]Massachusetts institute of technology
[4]University of Trento

Neural oscillations are a pervasive feature of mesoscopic brain recordings and are thought to play an important role in perception and cognition. Oscillatory activity in the brain is most frequently characterized in terms of its amplitude and phase. Although this has led to many important findings regarding the role of these parameters in perception and top-down control, the dominant frequency of narrow-band oscillations may also index important physiological and computational processes. We describe recently introduced techniques for quantifying peak oscillatory frequency in a time-varying manner and apply these methods to better understand the role of alpha-band (8-13 Hz) frequency in shaping temporal integration windows in visual perception. Occipital alpha frequency shows substantial variation across individuals and relative stability within an individual. These individual differences are predictive of the temporal resolution of visual perception, as assessed via two-flash fusion thresholds, revealing that higher alpha frequencies correspond to greater temporal resolution. Time-resolved measurement of alpha frequencies across trials revealed substantial variability, which was also predictive of perceptual performance, indicating that spontaneous, trial-to-trial variability in alpha frequency impacts perception. To understand if variation in alpha frequency is stochastic or if it can be guided by top-down factors such as task demands, we developed two tasks: one that encouraged temporal integration across stimuli, and another that encouraged temporal segregation. Using MEG recordings, we found that occipital alpha frequency decreased when visual task demands required temporal integration compared with segregation. Together, these results provide evidence for a link between the alpha rhythm and temporal windows of perceptual processing, and, for the first time, suggest that alpha frequencies can be modulated by task demands so as to strategically regulate the temporal resolution of visual perception.