Oscillatory bursts in numerous bands ranging from low (theta) to high frequencies (e.g., gamma) undoubtedly play an important role in cortical dynamics. Largely because of the inadequacy of existing analytic techniques, however, oscillatory bursts and their role in cortical processing remains poorly understood. To study oscillatory bursts effectively one must be able to isolate them and characterize them in the single trial. We describe a series of straightforward analysis techniques that produce useful indices of burst characteristics. First, stimulus-evoked responses are estimated using Differentially Variable Component Analysis (dVCA), and are subtracted from the single-trial. The single-trial characteristics of the evoked responses are stored to identify possible oscillations with burst activity. Time-frequency (T-F), or wavelet, analyses are then applied to the single trial residuals. While T-F plots have been used in recent studies to identify and isolate bursts, we go further by fitting each burst in the T-F plot with a two-dimensional Gaussian. This provides a set of burst characteristics, such as, center time, burst duration, center frequency, frequency dispersion, and amplitude, all of which contribute to the accurate characterization of the individual burst. The burst phase can also be estimated. Burst characteristics can be quantified with several standard techniques (e.g., histogramming and clustering), as well as Bayesian techniques (e.g., blocking) to allow a more parametric analysis of the characteristics of oscillatory bursts, and the relationships of specific parameters to cortical excitability and stimulus integration.

Identifying Bursts

Identifying oscillatory bursts in raw data is extremely difficult. The trace below derived from an intracortical visual-evoked field potential trace has a gamma band burst at 50 ms. (This trace is actually a current source density (CSD) derivation from a multielectrode array, hence the units are μA/m²).

Time-frequency methods are clearly superior to standard Fourier techniques in enabling us to isolate oscillatory bursts. We now take this a step further.

Mathematically, we model an oscillatory burst as a Sine Wave with a Gaussian envelope. This is the Gaussian wavepacket model.

This enables us to describe each burst with a set of burst parameters.

Distribution across Cortical Layers

Using a diffuse red light flash, intracortical field potentials were recorded from a linear multielectrode array spanning the cortical layers in macaque V1 (Miura et al, 2000). After estimating and removing the evoked responses using dVCA, the CSD profile of the residuals was derived and the bursts were analyzed. Bursts occurring in distinct cortical layers can easily be characterized.

Acknowledgements

We thank Dr. Ivetten Libbert, Dr. Ashesh Mehta, Tammy McGinnis, Noelle O’Connell, Alinee Mills, Dr. Mingzhou Deng, Dr. Steven Brasser, and Dr. Leonard Trieu. The work was supported by the NASA ESTIUSCT Program, NASA Aeronautic Technology Enterprise, NIH R4205/89 and MH40135; and Medical Scientist Training Program (T32GM07238).

Please visit our talk 711.7 and our poster 752.7 for more on our work with oscillations and oscillatory bursts.