James Roberts
QIMR Berghofer Medical Research Institute, Herston
Australia

Crackling noise in neonatal cortex

One of the most common complications at birth is asphyxia, which deprives the cortex of oxygenated blood. During the brain's recovery, cortical activity exhibits a period of highly-irregular electrical fluctuations known as burst suppression. Here I will present recent analysis showing that these bursts have fractal properties, with power-law scaling of burst sizes across a remarkable five orders of magnitude and a scale-free relationship between burst sizes and durations. These scaling relationships appear to be clinically meaningful, correlating with later outcome measures. Drawing on techniques used in analyzing crackling noise in magnets, burst waveforms are shown to exhibit scaling collapse in their average shapes, converging to a simple form that is asymmetric at long time scales. Analysis of a simple model suggests that this asymmetry reflects activity-dependent changes in cortical excitatory-inhibitory balance. Bursts become more symmetric following the resumption of normal activity, with a corresponding change in burst scaling relationships, suggesting that noise metrics are sensitive to changes in neurophysiology. These findings place burst suppression in the broad class of scale-free physical processes termed crackling noise, and demonstrate the utility of analyzing noise properties in unraveling underlying mechanisms.