Neuronal population activity responsible for rhythmic movements: Lognormality, spiking regimes and connectivity

Motor patterns such as chewing, breathing, walking and scratching are primarily produced by neuronal circuits within the brainstem or spinal cord. These activities are produced by concerted neuronal activity, but little is known about the degree of participation of the individual neurons. Here, we use multi-channel recording (256 channels) in motor regions of the spinal cord to investigate the distribution of spike rates across neurons during generation of rhythmic movement. We found that the shape of the distribution is skewed and can be described as "log-normal"-like, i.e. normally shaped on logarithmic frequency-axis. Such distributions have been observed in other parts of the nervous system and been suggested to implicate a fluctuation driven regime (Roxin et al J. Neurosci. 2011). This is due to an expansive nonlinearity of the neuronal input-output function when the membrane potential is lurking in sub-threshold region. We further test this hypothesis by quantifying the irregularity of spiking across time and across the population as well as via intra-cellular recordings. We find that the population moves between supra- and sub-threshold regimes, but the largest fraction of neurons spent most time in the sub-threshold, i.e. fluctuation driven regime.