Understanding neuronal responses to transient inputs: a dynamical systems approach | Justyna Signerska-Rynkowska

Experimental studies of neuronal dynamics involve recording of both spontaneous activity patterns and the responses to sustained and short-term inputs. Although spontaneous activity of neurons has received much theoretical attention, the dynamic processes that influence neuronal responses to transient inputs are less understood. We describe underlying dynamical mechanisms shaping these responses in a widely accepted class of nonlinear adaptive hybrid models and discuss related phenomena: post-inhibitory facilitation (PIF) and slope-detection. In PIF an otherwise subthreshold excitatory input can induce a spike if it is applied with proper timing after an inhibitory pulse, while neurons displaying slope-detection property spike to a transient input only when the input's rate of change is in a specific, bounded range.

Concerning PIF, we provide a geometric characterization of associated dynamical structures. For slope-detection, we give a complete analytical description for tent inputs. Moreover, although these phenomena have been previously associated with Type III neurons in Hodgkin's classification, we show that PIF and slope-detection extend beyond Type III regime.
This is a joint work with Jonathan Rubin (University of Pittsburgh) and Jonathan Touboul (Brandeis University).