BURSTS AS A UNIT OF NEURAL INFORMATION: SELECTIVE COMMUNICATION VIA RRESONANCE

Eugene M. Izhikevich
The Neurosciences Institute
10640 John Jay Hopkins Drive, San Diego, CA, 92121, U.S.A.
Eugene.Izhikevich@nsi.edu, www.izhikevich.com

ABSTRACT

Many neurons fire bursts, which are intrinsically-generated stereotypical patterns of closely-spaced action potentials. *What is the functional importance of generating such bursts instead of single spikes?* One prevailing answer to this question, influenced by half a century of treating neurons as spatio-temporal integrators, is that bursts increase reliability of communication between neurons. Indeed, sending a short burst of spikes instead of a single spike increases the chances that at least on e of the spikes avoids synaptic transmission failure. The timing of spikes within the burst does not play any role here. Moreover, it is often assumed that the shorter the interspike interval within the burst, the better: If two spikes within a burst trig ger synaptic transmission, the combined postsynaptic potential (PSP) is larger when the interval between the spikes is smaller.

This talk is based on our recent TINS paper (Izhikevich et al. 2003), which is complementary to that of Lisman (1997) "Bursts as a unit of neural information: making unreliable synapses reliable". Using theoretical and experimental evidence, we argue th at this classical view is only half of the story. High-frequency stimulation may not be optimal to fire a postsynaptic cell. Indeed, the postsynaptic response may depend on the frequency content of the burst because there is a **frequency preference at the**

- **synaptic level** due to the competing effects of short-term depression and facilitation, and at the
- **neuronal level** due to subthreshold membrane potential oscillations.

In both cases, the transmission of signals from pre- to postsynaptic cell is most effective when the presynaptic cell fires a burst of action potentials with a certain resonant interspike frequency. Since different postsynaptic cells can have different re sonant frequencies, the same burst can be resonant for one cell and not resonant for another, thereby evoking responses selectively in one cell but not the other. By using bursts with different interspike frequencies, the presynaptic cell can selectively affect some postsynaptic targets, but not others. Such selective communication can be achieved on the time scale of tens of milliseconds without involving long-term synaptic modifications.

Keywords: bursting, short-term depression, facilitation, subthreshold oscillations, resonance.

References

[1] Lisman J. (1997) Bursts as a unit of neural information: making unreliable synapses reliable, *Trends in Neuroscience*, **20**:38-43.

[2] Izhikevich E.M., Desai N.S., Walcott E.C., Hoppensteadt F.C. (2003) Bursts as a unit of neural information: selective communication via resonance. *Trends in Neuroscience*, **26**:161-167.