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Neuronal bursting: interactions of the persistent sodium and CAN currents

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The pre-Botzinger complex (pBC) is a heterogeneous neuronal network within the mammalian brainstem and has been experimentally found to generate robust, synchronous bursts [1]. Significant modeling research has been conducted on characterizing the dynamics of individual neurons within the pBC. [2,3] It is well known that the persistent sodium current (I_{NaP}) contributes to square-wave bursting seen in the pBC [4]. Recent experimental work within the pBC identified a signaling cascade that starts with presynaptic glutamate and ends with the release of intracellular calcium that activates a nonspecific cationic current (I_{CAN}) [5]. A subsequent model demonstrated that I_{CAN} may contribute to bursts within the pBC that exhibit depolarization block [6]. With these two mechanisms for generating bursts present within the pBC, an open question is how do they combine to generate the robust bursts seen in the network? The present work seeks to analyze the result of including both I_{NaP} and I_{CAN} within the same model. We consider the effects of heterogeneity in the conductance g_{NaP} of I_{NaP} and the conductance g_{CAN} of I_{CAN}; with this heterogeneity in mind, the model cell may be quiescent, tonically active, have only square-wave bursts, have only depolarization-block exhibiting bursts, or may show both types of bursting. Using the mathematical tools of bifurcation analysis and slow-fast decomposition, we illuminate the mechanisms underlying the transitions of a model cell between the types of dynamics listed above. Our results show that, in cases where g_{CAN} is relatively high, increasing g_{NaP} increases the range of g_{CAN} where the resultant cell has depolarization-block exhibiting bursts. On the other hand, when g_{CAN} is relatively low, increasing g_{NaP} may cause the cell to transition from quiescence, to square wave bursting, to tonic activity, to square wave bursts with high duty cycles, and finally further increase of g_{NaP} causes the cell to again be tonically active. The latter two transitions do not occur if I_{CAN} is absent. The interactions of I_{CAN} and I_{NaP} are relevant to many systems beyond the pBC. Individually, I_{CAN} and I_{NaP} have been focused on as important to rhythmic burst generation in other systems such as the entorhinal cortex [7]; however, it is likely that both currents are present in these systems. Thus, a detailed account for the interaction of I_{CAN} and I_{NaP} may help explain the rhythm generation encountered in other systems beyond the pBC.

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References

1. Smith JC, Ellenberger HH, Ballanyi K, Richter DW, Feldman JL: **Pre-Botzinger complex: a brainstem region that may generate respiratory rhythm in mammals.** *Science* 1991, **254**:726-729.
2. Butera R, Rinzel J, Smith JC: **Models of respiratory rhythm generation in the pre-Botzinger complex. I. Bursting pacemaker neurons.** *Journal of Neurophysiology* 1999, **82**:382-397.
3. Butera R, Rinzel J, Smith JC: **Models of respiratory rhythm generation in the pre-Botzinger complex. II. Populations of coupled pacemaker neurons.** *Journal of Neurophysiology* 1999, **82**:398-415.
4. Del Negro CA, Johnson SM, Butera RJ, Smith JC: **Models of respiratory rhythm generation in the pre-Botzinger complex. III. Experimental tests of model predictions.** *Journal of Neurophysiology* 2001, **86**:59-74.
5. Pace R, Mackay D, Feldman J, Del Negro C: **Inspiratory bursts in the preBotzinger complex depend on a calcium-activated non-specific cation current linked to glutamate receptors in neonatal mice.** *The Journal of Physiology* 2007, **582**:113-125.

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6. Rubin JE, Hayes J, Mendenhall J, Del Negro C: **Calcium-activated nonspecific cation current and synaptic depression promote network-dependent burst oscillations.** *Proc Natl Acad Sci U S A* 2009, **106(8)**:2939-2944.
7. Egorov A, Hamam B, Fransen E, Hasselmo M, Alonso A: **Graded persistent activity in entorhinal cortex neurons.** *Nature* 2002, **420(6912)**:173-178.

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