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Multifunctional central pattern generator controlling walking and paw shaking

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Central pattern generators (CPGs) are oscillatory neuronal networks controlling rhythmic motor tasks such as breathing and walking. A multifunctional CPG can produce multiple patterns, e.g. patterns with different periods [1-5]. Here, we investigate whether a pair of cat behaviors – walking and paw shaking – could be controlled by a single multifunctional CPG exhibiting multistability of oscillatory regimes. In experiments, both behaviors can be elicited in a spinalized cat, and there is evidence that the same circuitry is used for both rhythms [2,3]. We present a parsimonious model of a half-center oscillator composed of two mutually inhibitory neurons. These cells contains two slowly inactivating inward currents, a persistent Na^+ current (I_{NaP}) and a low voltage activated Ca^{++} current (I_{CaLVA}). The dynamics of the multifunctional CPG is based on that the I_{CaLVA} inactivates much slower than I_{NaP} and at the more hyperpolarized membrane potentials. Here, we demonstrate the co-existence of two rhythms (Figure 1). At first, the model demonstrates walking pattern. A switch from a slow, 1-2 Hz walking rhythm to fast, 7-10 Hz paw shake rhythm was elicited by a pulse of conductance of excitatory current delivered to extensor and flexor neurons. Then, a switch back to walking was triggered by a shorter pulse of conductance of inhibitory current delivered to the extensor neuron.

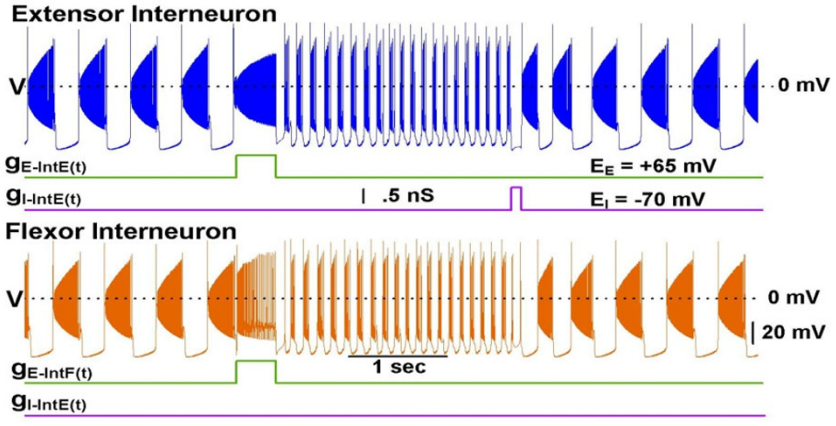

Figure 1 Two mutually inhibitory interneurons, IntE (Extensor Interneuron) and IntF (Flexor Interneuron) produce alternating bursting activity at approximately 1.6 Hz representing walking pattern. A switch to paw shaking is executed by a pulse of excitatory conductance delivered to both cells for 1 second. The paw shake rhythm is represented by a 9 Hz bursting regime. An inhibitory conductance activated for .1 second in IntF causes a large rebound burst and a fast transition back to the walking rhythm.

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The CPG model was also incorporated into a neuromechanical model of a cat hindlimb in the AnimatLab environment [6]. The model provides a cellular mechanism of multifunctional CPG operation.

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