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Integration and coincidence detection represent antithetical strategies used by neurons to encode information. Integrators generate spikes by summing temporally dispersed inputs whereas coincidence detectors respond exclusively to temporally coincident inputs. This difference in encoding in turn affects what information about the stimulus is carried in the output spike train. In this study we sought to identify biophysical determinants of the operational mode. Using a phase plane model, we reproduced the response properties of tonic- and single-spiking neurons in spinal lamina I. These cell types represent quintessential integrators and coincidence detectors, respectively. At a dynamical level, the operational mode was explained by a difference in spike generating mechanism: integrators generated spikes through a saddle-node bifurcation whereas coincidence detectors generated spikes through a separatrix-crossing. In fact, Hodgkin's type 1, 2, and 3 excitability were reproduced in the model by varying a single parameter, where each type of excitability was associated with a unique spike generating mechanism. At a biophysical level, the difference in spike generating mechanism was explained by the direction of subthreshold currents: inward current encouraged spike generation through a saddle-node bifurcation whereas outward current encouraged spike generation through a separatrix-crossing. Single-spiking neurons are shown to express a low-threshold potassium current whereas tonic-spiking neurons express a low-threshold calcium current. Thus, direction of voltage-dependent currents active at subthreshold potentials determines operational mode via control of the spike generating mechanism.

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