Supplemental Materials

Gain control of synaptic response function in cerebellar nuclear neurons by a calcium activated potassium conductance

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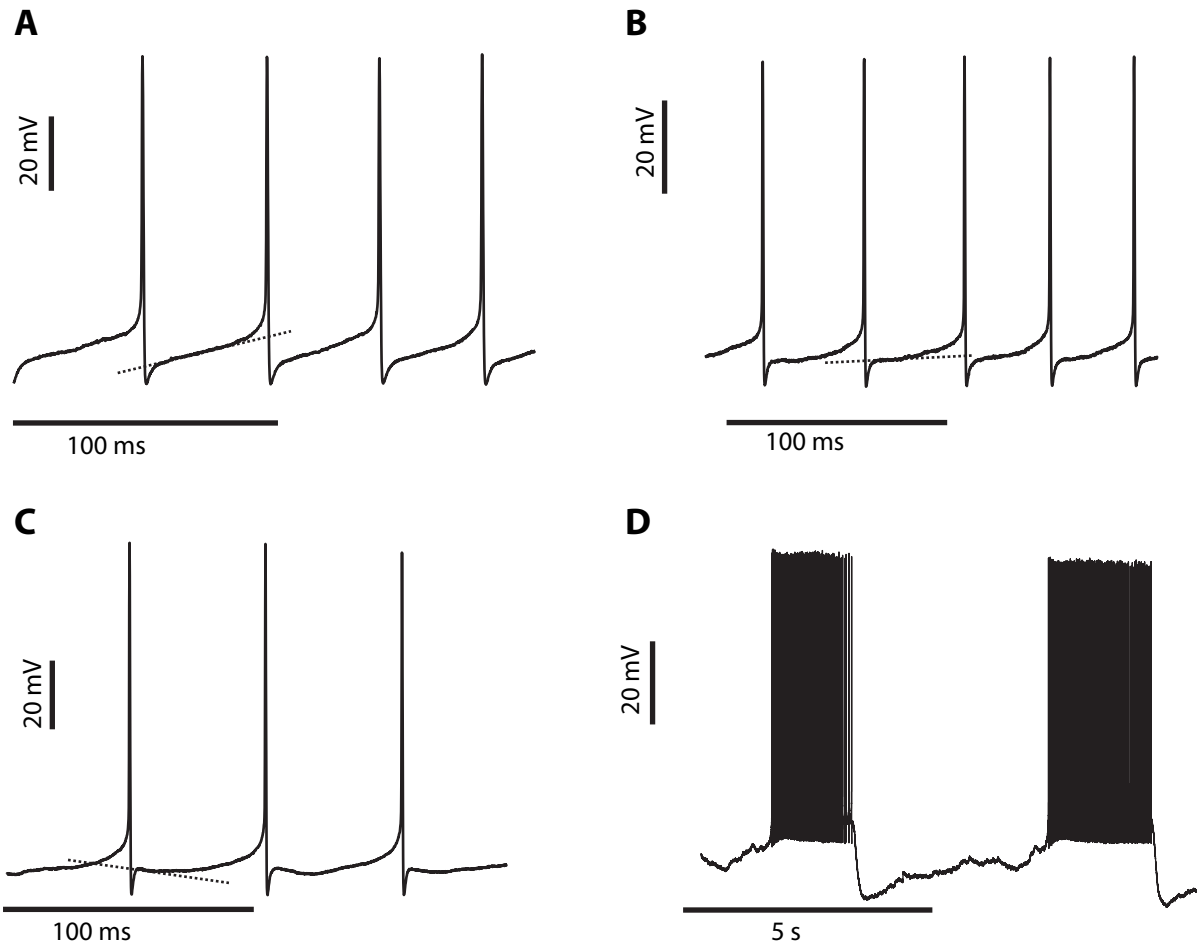
Supplemental Data

Supplemental Figure 1 (next page).

Brain slice recordings were obtained from 4 month old C57BL/6 mice. Animal procedures were approved by the Emory IACUC and in accordance with NIH and USDA guidelines. The extracellular ACSF and intracellular whole cell solutions used during recording were identical to the rat slice studies described in detail in the manuscript. Mice were anesthetized with ketamine/xylazine and perfused transcardially with ice-cold sucrose replaced - ACSF (sucrose replacing NaCl) before decapitation, however. Recordings were obtained from 11 CN cells and evaluated for the mAHP properties. All recordings showed pronounced fast AHPs and a spike width between 0.3 and 0.6 ms. Overall the observed mAHPs were more shallow and more variable than observed in juvenile rat slices. **A-C:** Example traces from 3 CN cells showing a range of mAHP profiles, ranging form no detectable mAHP (A), to a small mAHP that impedes the upslope of the next spike cycle but does not cause a true hyperpolarization (B), to a true hyperpolarization following the initial fast AHP (C). Cases were distinguished by the slope of the initial repolarization following the fast AHP. Of 11 recorded CN cells, 4 showed a negative slope (as case C), 4 showed an initial slope close to zero (as case B), and 3 showed a positive slope continuing as a straight line to the next spike initiation (as case A). **D:** Apamin was applied to the cell shown in (C), and strong bursting ensued, demonstrating the presence of SK current.


A
20 mV
100 ms
B
20 mV
100 ms
C
20 mV
100 ms
D
20 mV
5 s

Supplemental Experimental Procedures

Dynamic clamp equations used to create artificial SK current:

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Injected SK current $$I_{inj}(t) = \bar{g}_{SK} * n(t) * (E_K - V(t)) \quad (1)$$

Time dependence of SK conductance: $$\frac{\partial n(t)}{\partial t} = \frac{n(t) - n_\infty(t)}{\tau_n(t)} \quad (2)$$

Calcium dependence of SK conductance: $$n_\infty(t) = \frac{[Ca^{2+}](t)^4}{[Ca^{2+}](t)^4 + (0.0003)^4} \quad (3)$$

Time constant of SK conductance: $$\tau_n = \begin{matrix} 0.06 - 11.2[Ca^{2+}](t) & [Ca^{2+}](t) > 0.005 \\ 0.004 & otherwise \end{matrix} \quad (4)$$

Calcium concentration: $$[Ca^{2+}](t) = C(t) + [Ca^{2+}]_{base} \quad (5)$$

Calcium inflow and outflow: $$\frac{\partial C(t)}{\partial t} = B * I_{HVA}(t) - \frac{C(t)}{\tau_{Ca}} \quad (6)$$

L-type calcium current: $$I_{HVA}(t) = \bar{g}_{HVA} * m(t)^3 * (E_{Ca} - V(t)) \quad (7)$$

Activation gate of HVA current: $$\frac{\partial m(t)}{\partial t} = \frac{m(t) - m_\infty(t)}{\tau_m(t)} \quad (8)$$

$$m_\infty(t) = \frac{1}{1 + \exp\left(\frac{V(t) + 0.0345}{-0.009}\right)} \quad (9)$$

$$\tau_m(t) = Q_{\Delta T} \frac{0.1512}{a(t) + b(t)} \quad (10)$$

$$a(t) = \frac{1600}{1 + \exp\left(-72(V(t) - 0.005)\right)} \quad (11)$$

$$b(t) = \frac{20(V(t) + 0.0089)}{\exp\left(\frac{V(t) + 0.0089}{0.005}\right) - 1} \quad (12)$$