Supporting Information

Song and Santos-Sacchi 10.1073/pnas.1218341110

Equations

Capacitance data were fit to the first derivative of a two-state Boltzmann function

$$C_m = Q_{\max} \frac{ze}{kT} \frac{b}{(1+b)^2} + C_{lin},\ b = \exp\left(\frac{-ze(V_m - V_h)}{kT}\right),$$

where $Q_{\max}$ is the maximum nonlinear charge moved, V_h is voltage at peak capacitance or equivalently, at half maximum charge transfer, V_m is membrane potential, z is valence, C_{lin} is linear membrane capacitance, e is electron charge, k is Boltzmann's constant, and T is absolute temperature.

Model differential equations are

$$X_o \underset{k_2}{\overset{k_1}{\rightleftharpoons}} X_c \underset{\beta_0}{\overset{\alpha_0}{\rightleftharpoons}} X \underset{\beta}{\overset{\alpha}{\rightleftharpoons}} C$$

$$\frac{dX_o}{dt} = X_c \cdot k_2 - X_o \cdot k_1$$

$$\frac{dX_c}{dt} = X_o \cdot k_1 + X \cdot \beta_0 - X_c \cdot \alpha_0 - X_c \cdot k_2$$

$$\frac{dX}{dt} = X_c \cdot \alpha_0 + C \cdot \beta - X \cdot \alpha - X \cdot \beta_0$$

$$\frac{dC}{dt} = X \cdot \alpha - C \cdot \beta.$$

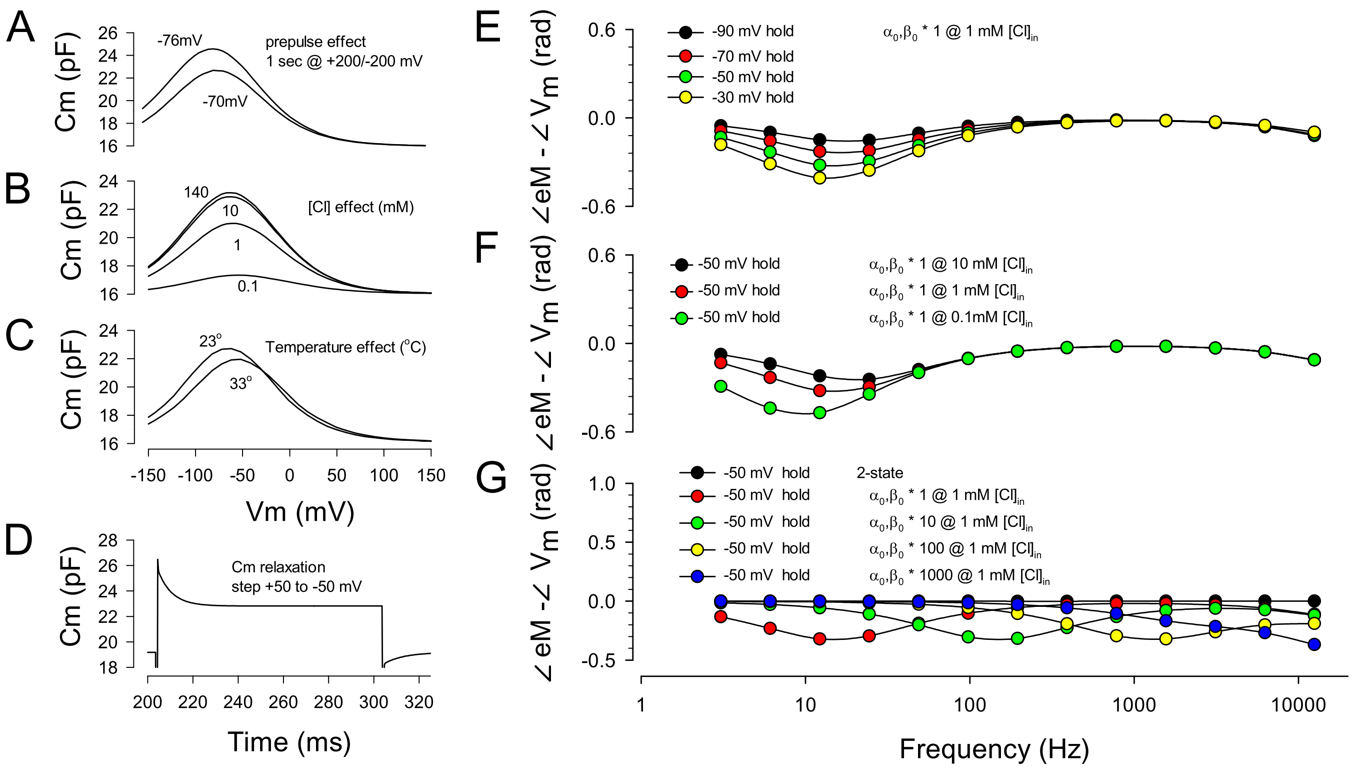

Fig. S1. Kinetic model shows similar NLC behavior to that observed in OHCs. (*A*) V_h shift results from prepulse. (*B*) Depolarizing shifts and decrease in NLC result from reduction in intracellular chloride. (*C*) Heating shifts V_h to depolarizing levels. (*D*) Step voltage commands induce an immediate jump in C_m followed by a relaxation. See text for details. (*E*) Kinetic model produces a phase lag between V_m and eM. The lag observed with 10 mV AC stimulation is voltage and chloride dependent (*F*). It is also dependent on intermediate gateway transition rate (*G*), illustrating that the actual biophysical stretched exponential rate will provide wide-ranging frequency-dependent phase lags.

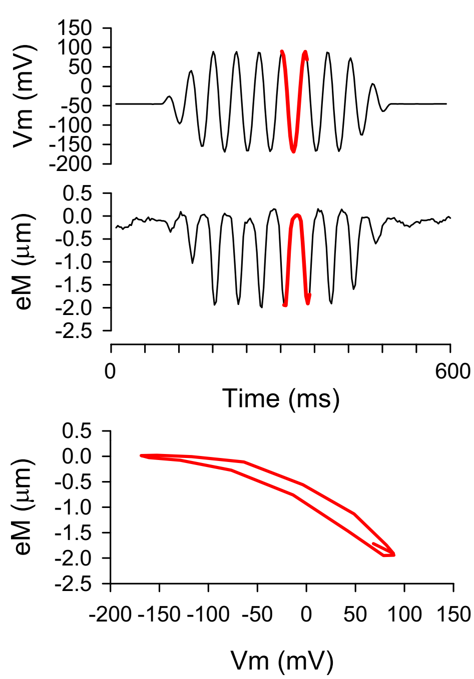

Fig. S2. Phase lag in eM. OHC with 1 mM chloride in/out. Sinusoidal voltage (*Top*) stimulation elicits a rectified mechanical response (*Middle*). *Bottom* shows Lissajous of eM vs. Vm, indicating a phase lag of about 0.1 rad. An absence of phase lag would produce an overlapping line. Similar results were obtained for 2 OHCs at 24 and 48 Hz.