

Bennett et al., Vol. 55, No. 4, April 1989

Due to a production error, Figs. 1, 3, 4, 5, 6, 7, and 8 appeared in incorrect order, and were placed with the wrong legends. The figures appear below in correct order and with their correct legends.

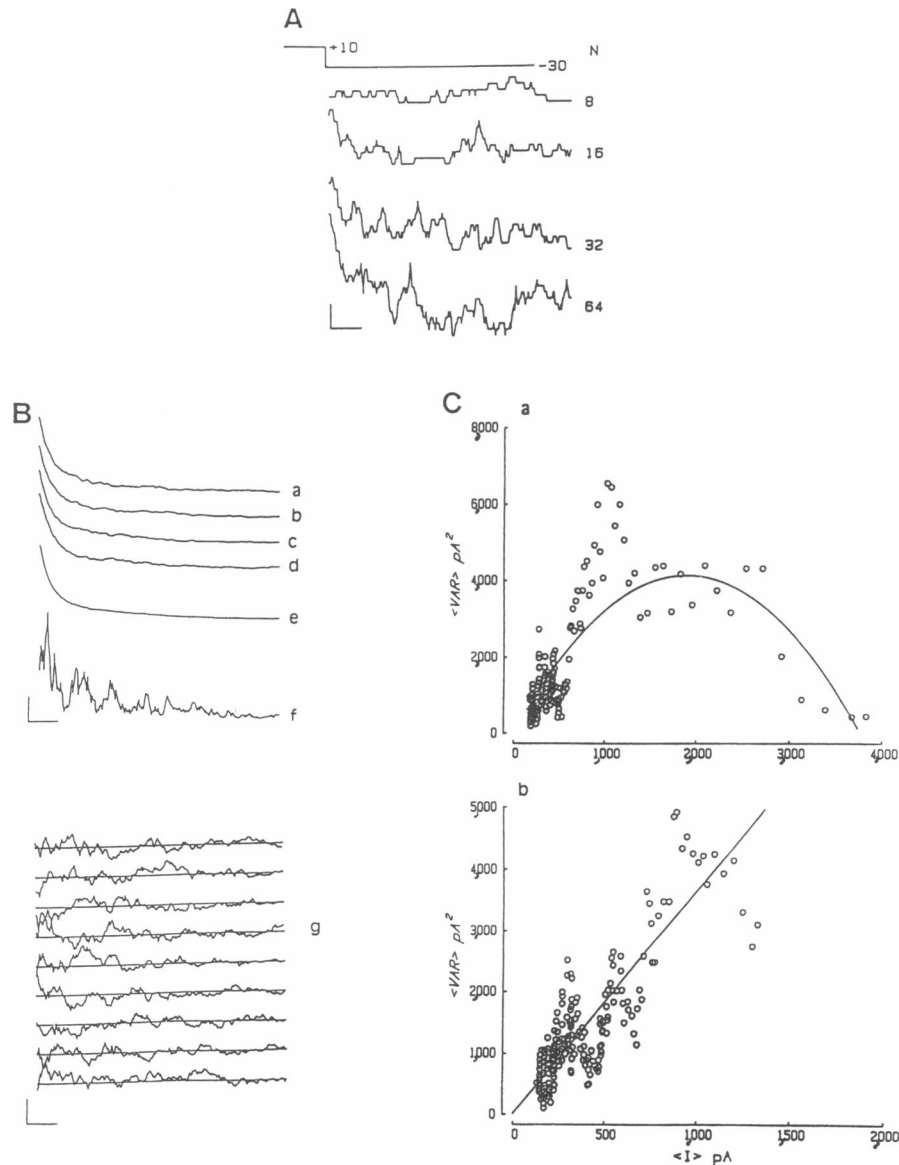


FIGURE 1 Computed behavior of K channel current fluctuations and a test for the fidelity of extracting the single-channel current from macroscopic fluctuations. (A) Summation of 8, 16, 32, and 64 K channels whose kinetic behavior was calculated from the rate constants derived by Bennett et. al (1985). Channels were allowed to reach steady state appropriate for a membrane potential of +10 mV and then the rate constants were changed to those appropriate for -30 mV (see Methods). The process was repeated N times to simulate N channels. (B) Simulated deactivating K-tail currents (a-d) calculated from 1,000 channels, the ensemble average of ten such records (e), the ensemble variance calculated from ten records (f), and difference records (g) obtained by subtracting the ensemble average current tail from the individual records. (C) The relationship between the ensemble current and variance when P_{open} was >0.5 a and b when P_{open} was small (<0.5). The fitted curves (see Eq. 2) give estimates of the single-channel current and the number of channels. In part b the P_{open} was too small to allow a reliable estimate of the number of channels, but the single-channel current could still be estimated.

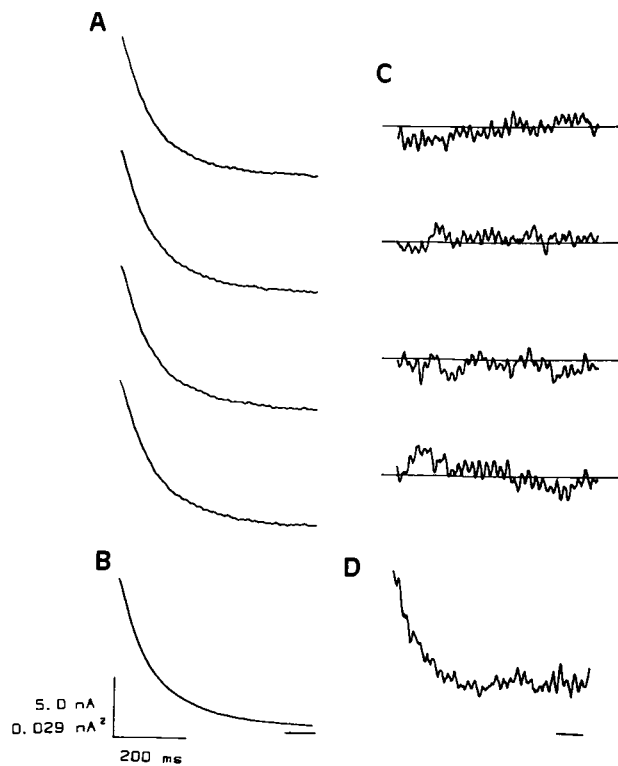


FIGURE 3 Time course of ensemble current and ensemble variance. (A) Time Course of individual I_K tails at -30 mV after an activation step to $+15$ mV. (B) Ensemble average of 30 individual I_K tails. (C) Difference records obtained by subtracting local averages of 3–10 sweeps from the individual sweeps that were used to compute the averages. (D) Ensemble variance as a function of time. Calibration bars: 5 nA for A and B and 0.029 nA² for D, 200 ms. The small horizontal bars in the lower right of B and D are the respective zero levels.

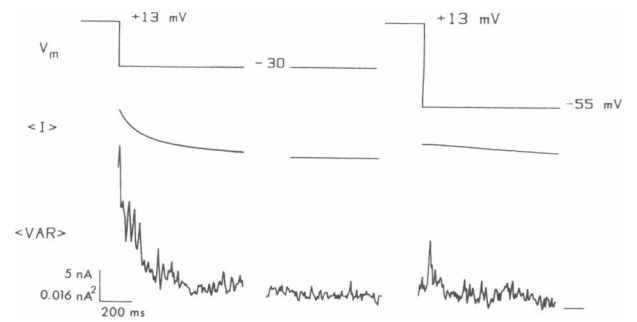


FIGURE 4 Time course of ensemble current and variance at two different membrane potentials. The top row shows the voltage protocol used. The middle row illustrates the ensemble average currents at the potentials indicated in the top panel. On the left, I_K deactivates at -30 mV after activating steps to $+13$ mV. Beneath the ensemble average current is the ensemble variance during deactivation which has a time course similar to the deactivating current. The middle column of traces show the voltage, ensemble current, and ensemble variance at -30 mV when there is no activating step. The records in third panel are similar to those of the left panel but with a holding potential of -55 mV near the channel current reversal potential of -57 mV. The preparation was bathed in an $[K]_o$ of 12 mM. The small horizontal bar in the lower right corner is the zero variance level.

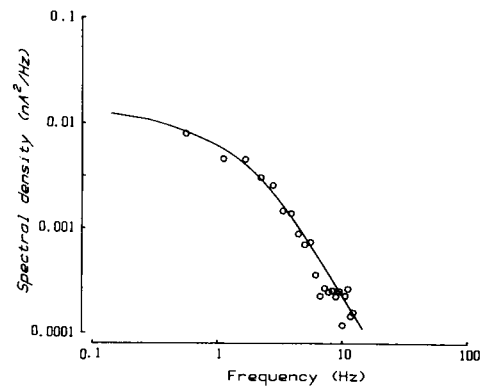


FIGURE 5 Spectral density of current fluctuations. Local averages of three to ten records were computed as described in Methods and the averages were subtracted from the individual records. The resulting difference records of current fluctuations about a mean of zero were used to calculate the spectral density as a function of frequency. The circles are the average of spectra calculated from 13 difference records. The ensemble averaged current tail was fit by a 2-exponential function with time constants of 89 and 418 ms (f_c : 1.78 and 0.38 Hz). The solid curve through the data represents the sum of two Lorentzians with corner frequencies of 1.78 and 0.38 Hz. Data were filtered at 20 Hz by an 8-pole Bessel filter and digitized at 143 Hz.

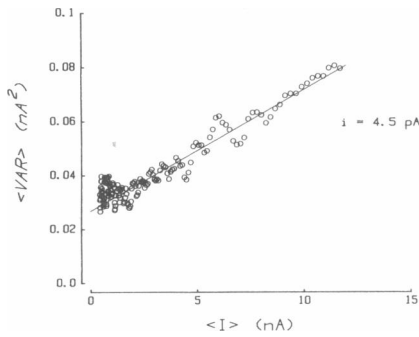


FIGURE 6 Potassium channel current variance as a function of mean K channel current, obtained from the same fiber of Fig. 3. The K channel current was measured at the holding potential of -30 mV after a voltage pulse of $+15$ mV. The solid line is the best fit linear relationship and the slope is the single-channel current value of 4.5 pA.

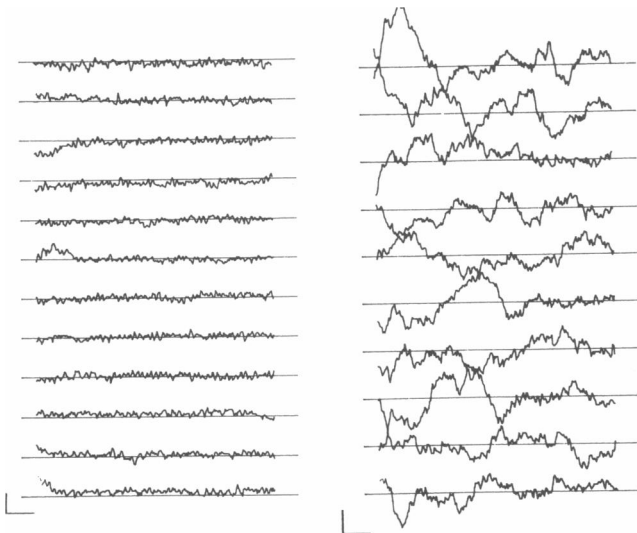


FIGURE 7 Difference records obtained by subtracting local averages from individual currents tails. Individual difference records are plotted as a function of time. Local averages were subtracted from each record so the fluctuations are around a mean of zero (reference line drawn). The left panel shows fluctuations under control conditions. In the right panel fluctuations in $2 \mu\text{M}$ norepinephrine are shown. The external potassium concentration, $[\text{K}]_o$, was 12 mM. The calibration bars at the lower left of each panel represent 0.5 nA (vertical) and 200 ms (horizontal).

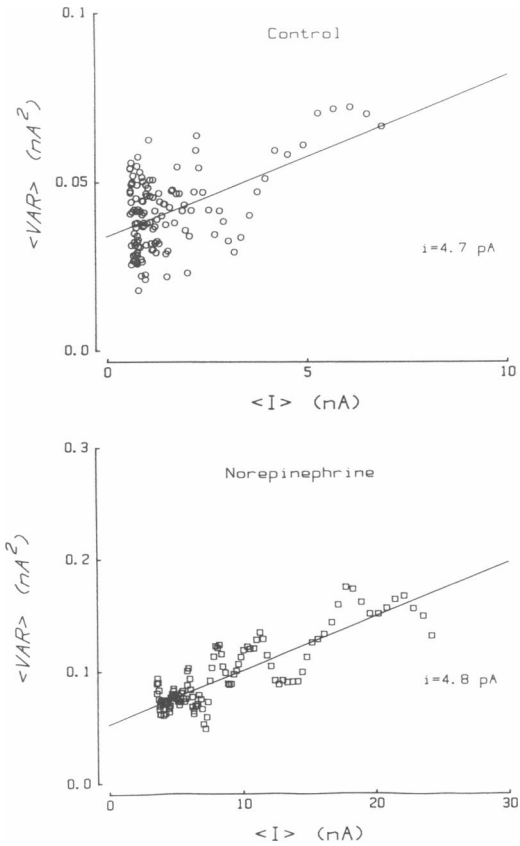


FIGURE 8 Ensemble variance as a function of ensemble current in the absence (upper panel) and presence (lower panel) of norepinephrine. Ensemble average variance, $\langle \text{VAR} \rangle$, and current, $\langle I \rangle$, were calculated as described in Fig. 3 and in Methods. The slope of the relationship between $\langle I \rangle$ and $\langle \text{VAR} \rangle$ was the same in control and in the presence of $2 \mu\text{M}$ norepinephrine indicating that the single-channel current did not change even though the macroscopic current was increased in this experiment by a factor of 3.3