Anesthetics Affect the Frequency-Current Curves of Individual Neurons

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Background

Anesthetics cause:

Loss of consciousness | Loss of motor control | Amnesia

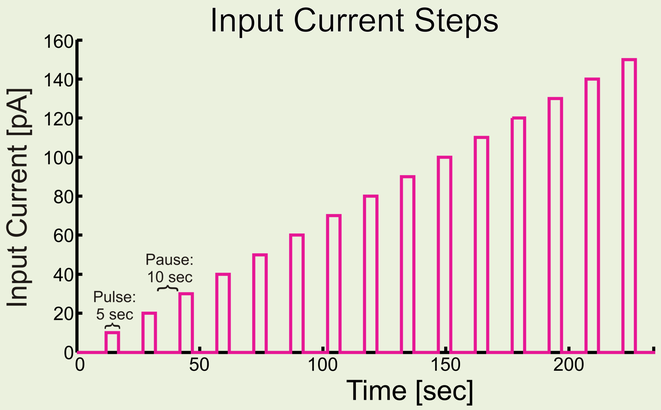
Physiological correlates:

Cell Response	Network Effects
Increased inhibitory post-synaptic current (IPSC) amplitude Increased IPSC decay time constant	Decreased incidence of gamma (40+ Hz) oscillations Decreased frequency of gamma

In order to begin to understand the causal relationship between the cellular effects and the network effects, we characterized anesthetic-induced changes in the frequency-current (f-I) curves.

Methods

We used the whole-cell patch-clamp method to record intracellular voltage and apply current steps.



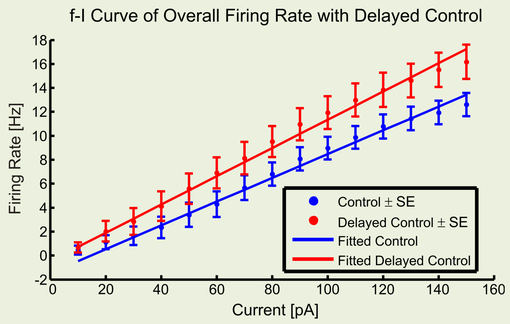
Hippocampal CA1 pyramidal cells (*n*=9) from rat brain slices were patched and then given input current to bring the membrane potential to approximately -60 mV. The range of current steps were then run six times, the first three without propofol and second three with 100 μM propofol. Ten minutes were given after application of the drug to allow for perfusion.

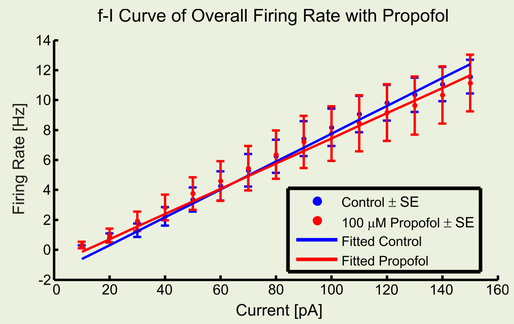
To control for the effects of time, other cells (*n*=10) were patched and given the current protocol at similar times without the application of propofol.

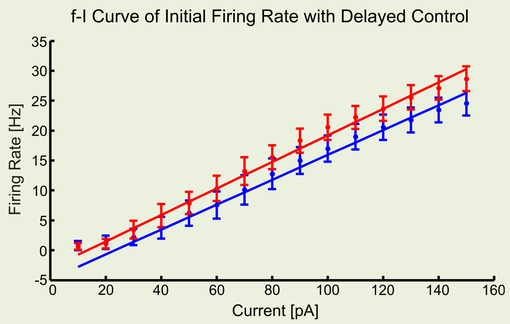
Results

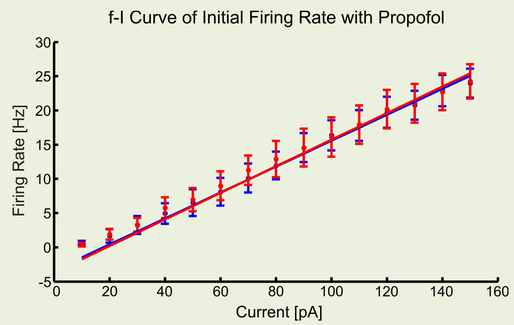
Each cell's overall firing rate, initial firing rate (first 0.3 sec of current pulses), and steady-state firing rate (last third of pulse times) at each current step were averaged. The slopes (gains) of the f-I curves were computed by a least-squares linear fit for each cell, and then every cell's gain was averaged.

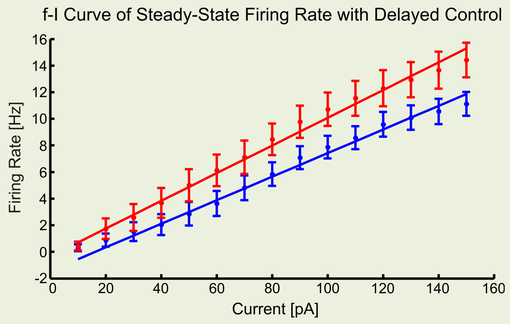
Significant changes were seen in the experiments that control for the time delay of propofol (below, left column). The delayed overall and steady-state gains were significantly higher than the controls (p=0.001 and 0.002, respectively).

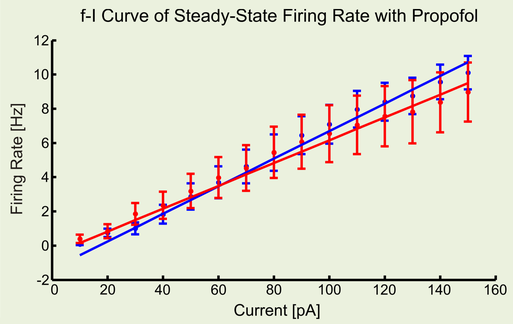






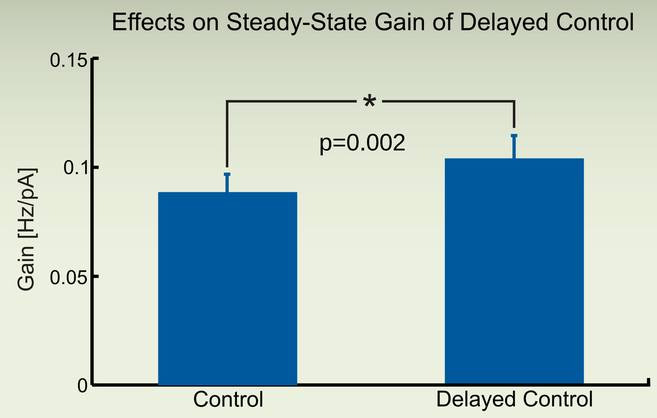


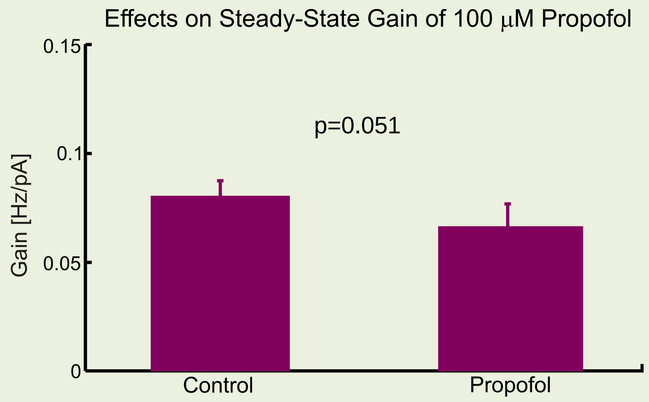


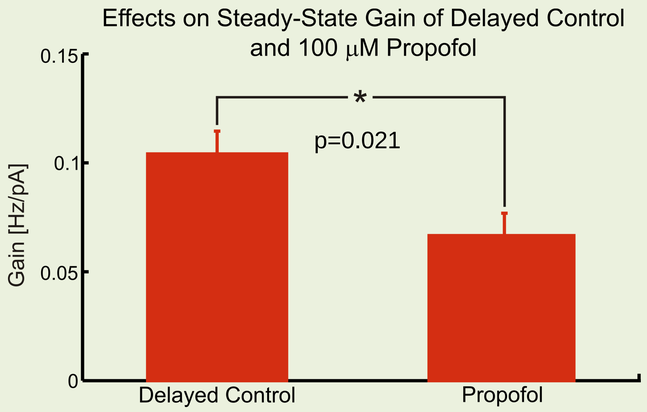


Near significant changes were seen in the steady-state gain of propofol experiments (p=0.051; above, right column).

Additionally, there were significant differences between the overall and steady-state firing rates of the delayed control experiments and the propofol conditions (p=0.043 and 0.021, respectively).







Conclusion

Propofol significantly decreases the gain of the f-I relationship in CA1 pyramidal cells. This may also contribute to changes in network oscillatory behavior in the anesthetized state.

Reference

Whittington MA, Jefferys JGR, Traub RD. Effects of intravenous anaesthetic agents on fast inhibitory oscillations in the rat hippocampus in vitro. Br J Pharmacol. 1996;118(8):1977-1986.

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