

# Interactions of Synaptic Potentials

-How do EPSPs and IPSPs interact to influence excitability

-Emphasis on temporal summation, or the interaction between EPSCs and IPSCs in time

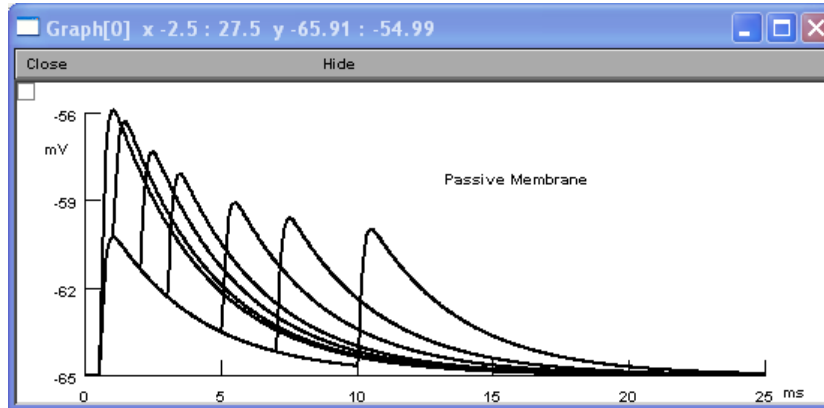
-Synaptic potentials together with active membrane properties can yield complex dynamics of excitability

## Goals of this Tutorial

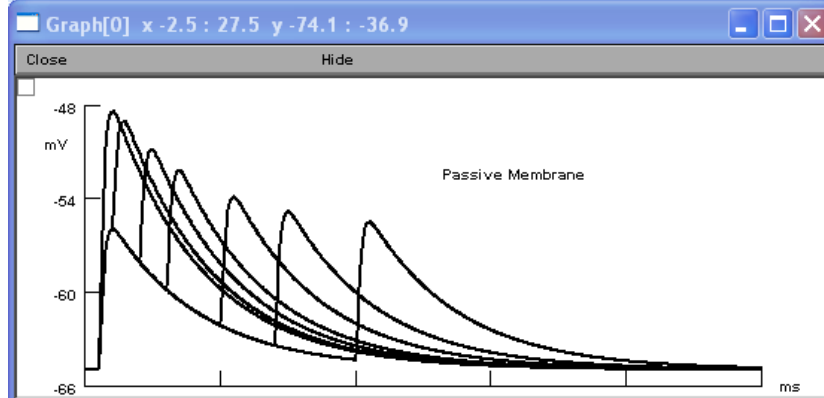
- To observe how EPSPs sum in a passive membrane
- To experiment with summation of EPSPs in an active soma membrane (membrane containing voltage-gated Na and K channels)
- To discover how both EPSPs and IPSPs can affect subsequent membrane excitability
- To realize that EPSPs can be inhibitory and IPSPs can be excitatory, contrary to accepted nomenclature

# Summation of EPSPs in a passive postsynaptic membrane

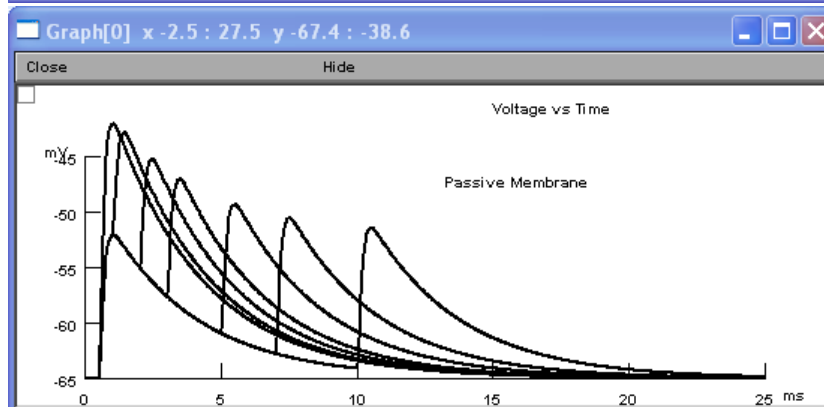
$g_{max} = .5035 \text{ uS}$



$g_{max} = 1 \text{ uS}$



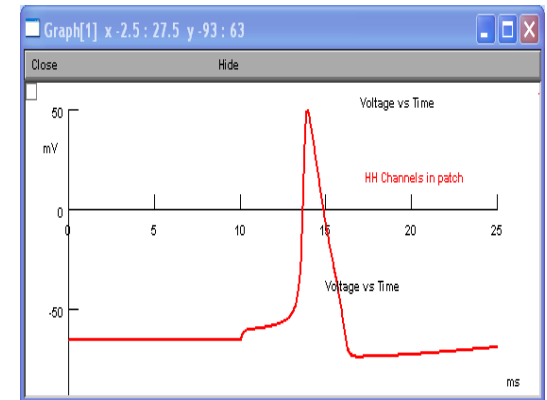
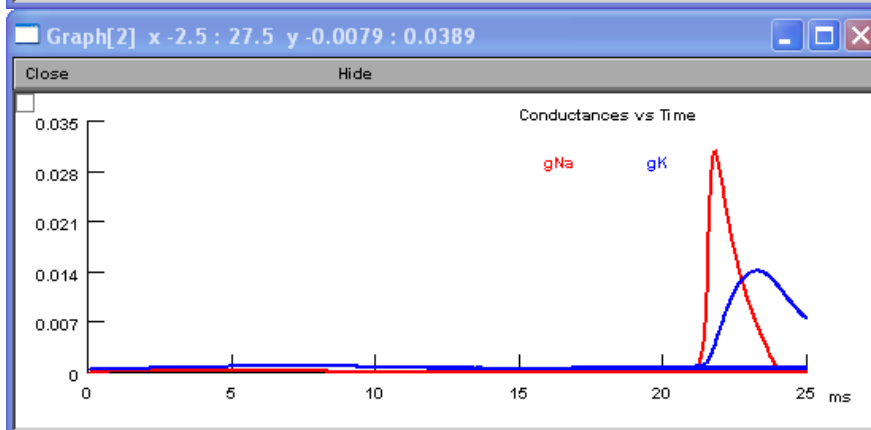
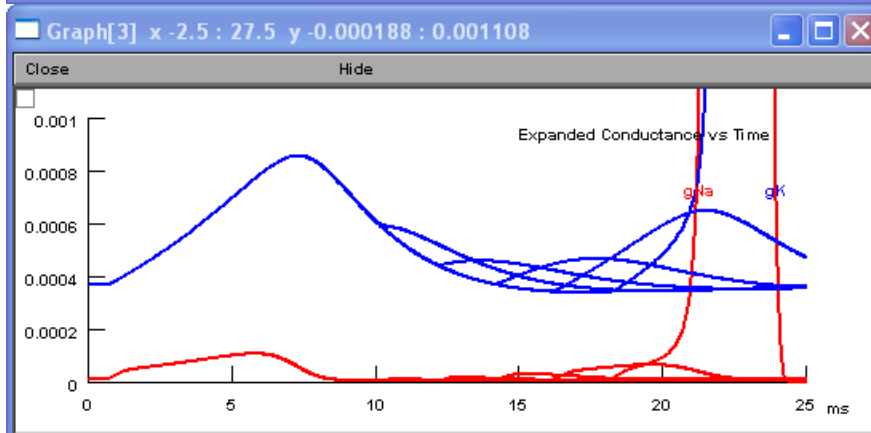
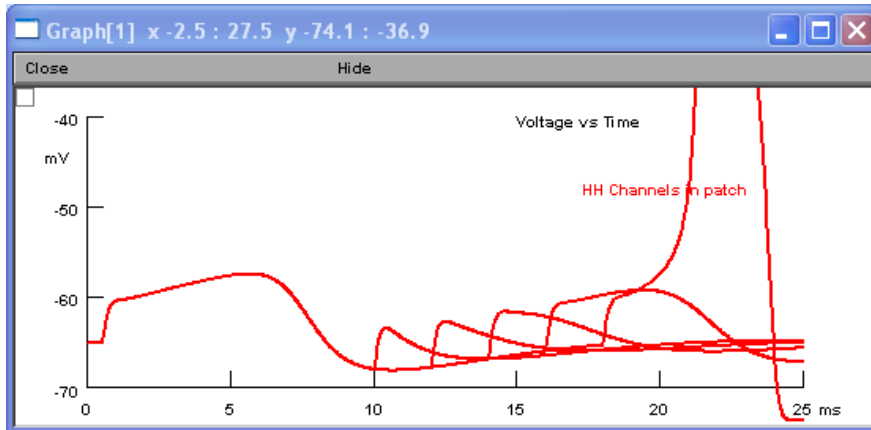
$g_{max} = 1.5 \text{ uS}$



Summation will not always be linear, only when EPSPs are small enough that they do not appreciably change the driving force

By Ohm's law, the synaptic current will be equal to the conductance times the driving force. As the EPP became larger, the driving force (the difference between the voltage at the peak of the EPSP and the reversal potential of the EPP) decreased; this reduced the synaptic current as the EPP edged toward its reversal potential.

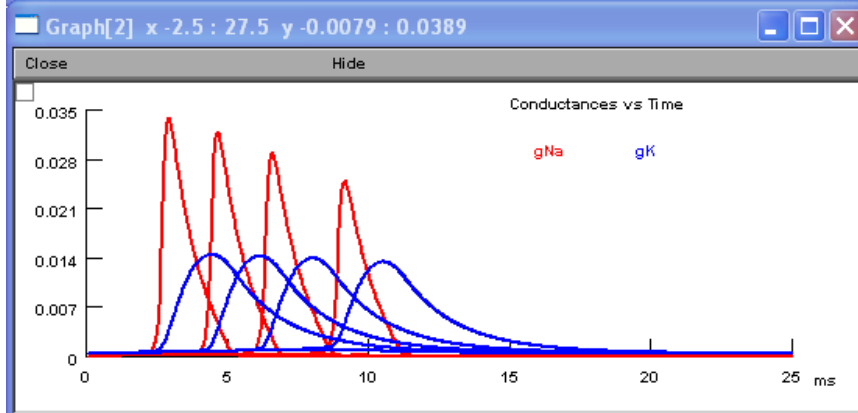
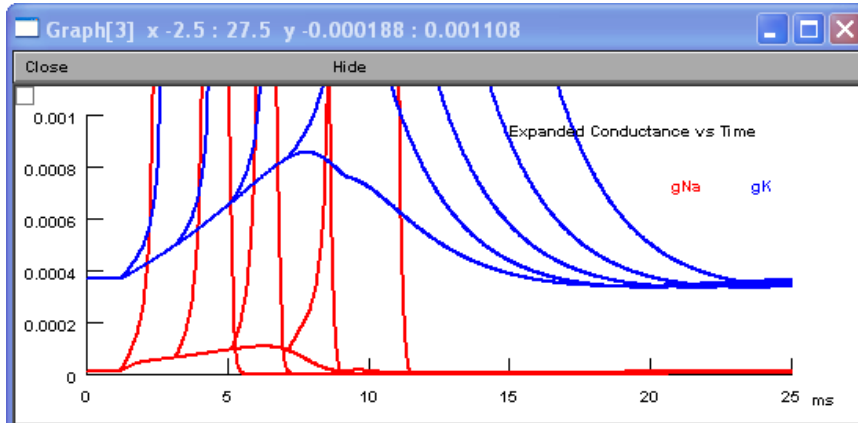
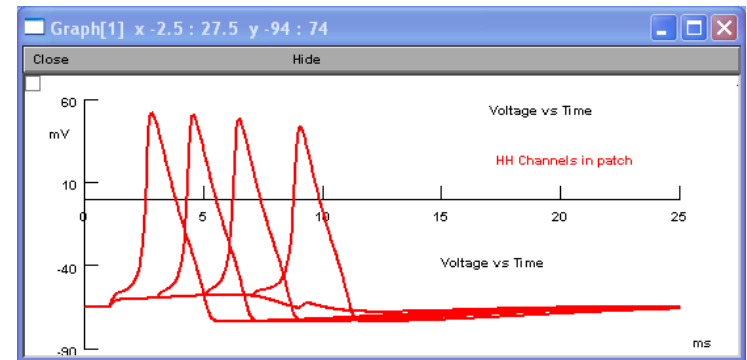
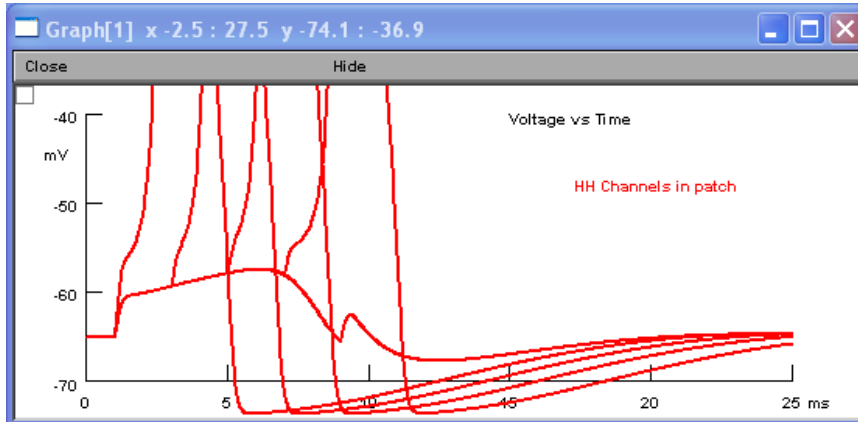
# Summation of EPSPs in a postsynaptic membrane with H&H Channels



2<sup>nd</sup> EPSP alone

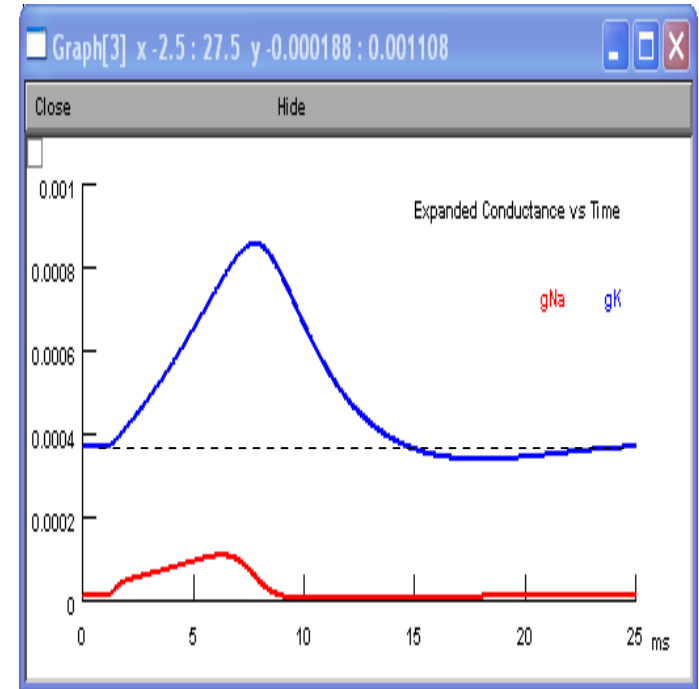
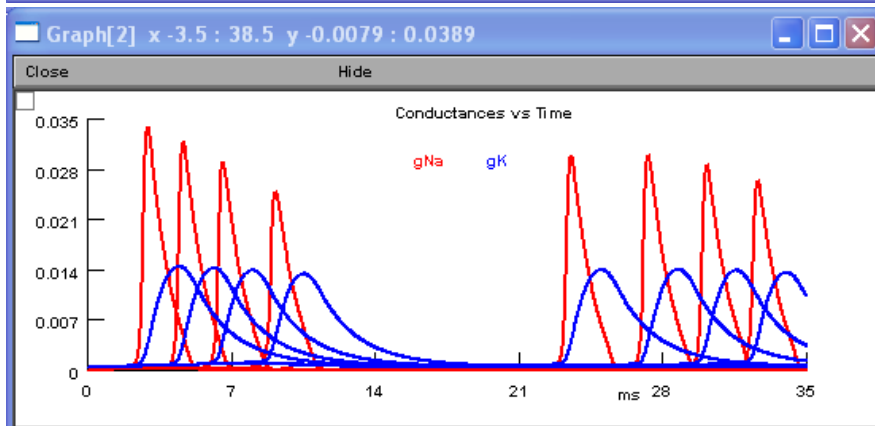
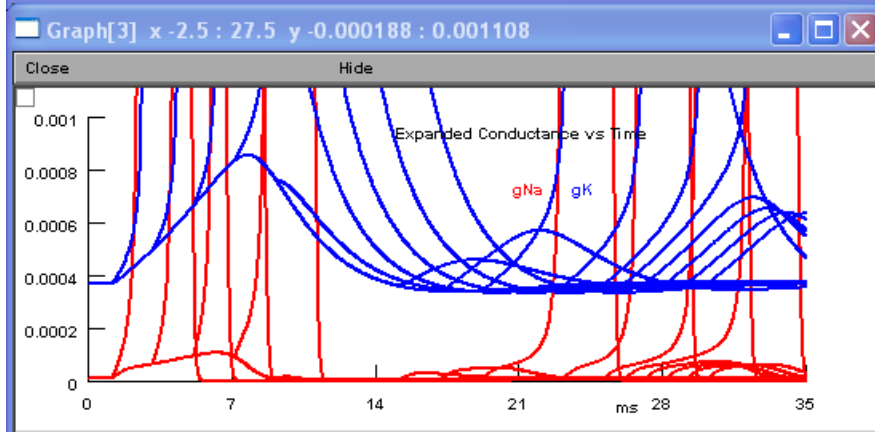
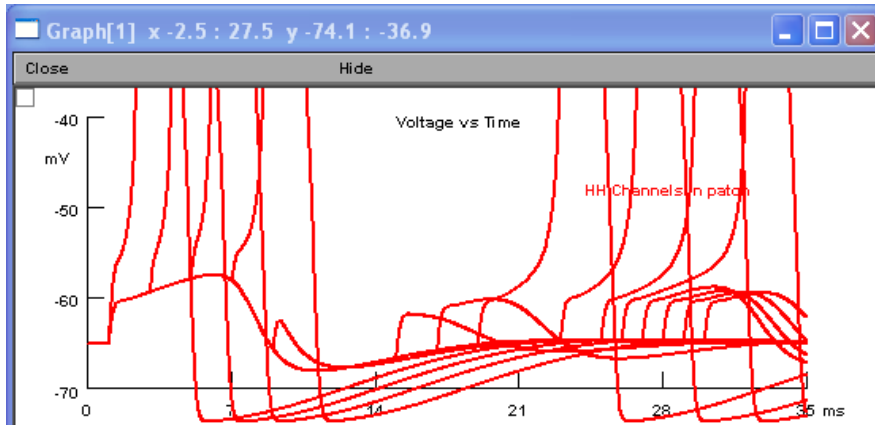
Even though this first EPSP is subthreshold, the membrane potential lingers long enough in a depolarized state to cause a substantial increase in the K conductance, which then takes many milliseconds to return to its resting value. This slow decline of the first EPSP's K conductance renders the second EPSP less effective.

# Combining two Subthreshold EPSPs



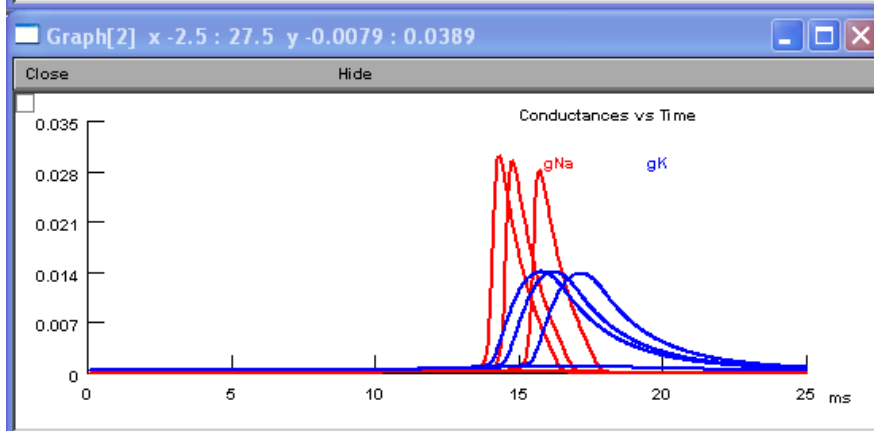
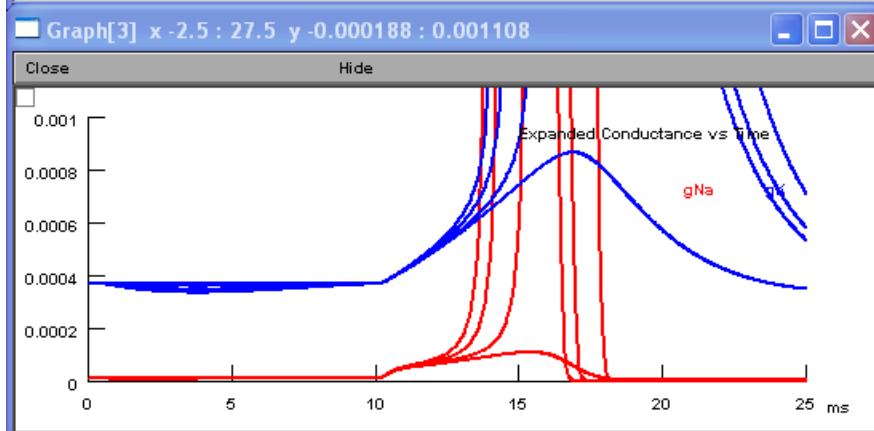
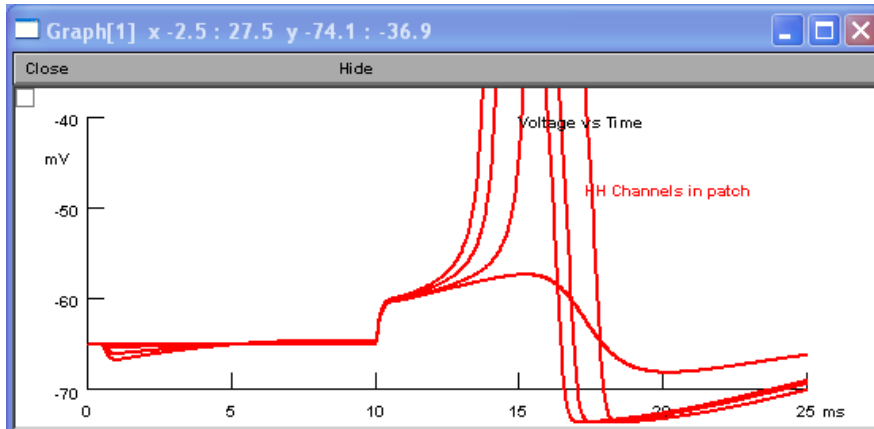
Spike amplitude attenuation is a result of progressively greater Na<sup>+</sup> channel inactivation as the 2 EPSPs are separated...although there is a relatively small decrease in spike amplitude before failure, this decrease can have a significant impact on presynaptic release

# Combining two Subthreshold EPSPs



Between the time window of 17 to 26ms the K conductance drops below its resting value, since the Na conductance has returned to its resting value by this time a spike can be triggered

# The effects of an IPSP on membrane excitability



Membrane hyperpolarization due to the preceding IPSP leads to a decrease in K conductance as well as reducing Na channel inactivation allowing spike generation