Using virtual synapses to study synaptic integration in sympathetic ganglia

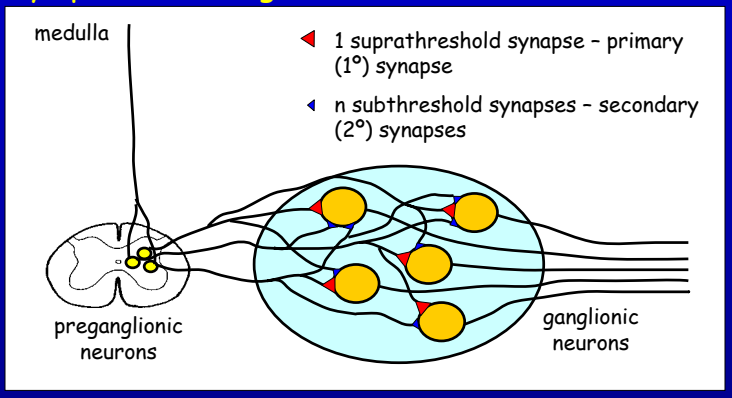
Paul H.M. Kullmann

John P. Horn

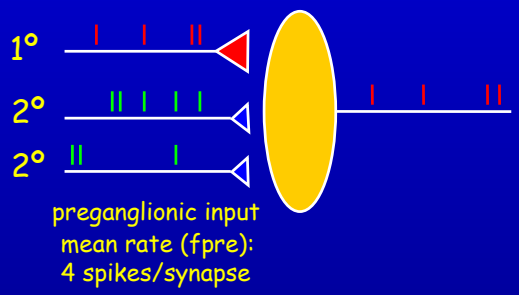
Dept. of Neurobiology

University of Pittsburgh School of Medicine

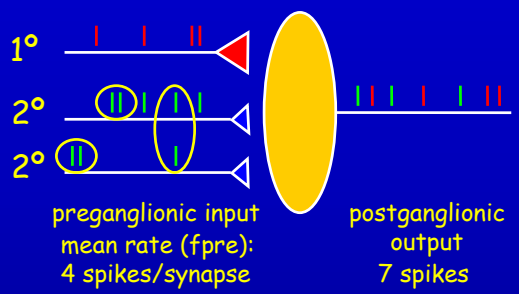
Sympathetic Ganglia:



# of 2° synapses:	bullfrog B neuron:	n = 1 to 4
	rat SCG:	n ~ 9
	human:	n ~ 50



1 : 1 relay



Synaptic Gain
= output/input
= 7 / 4 = 1.75

Predictions:

1. Synaptic gain increases with number of 2° synapses
2. Synaptic gain increases with strength of 2° synapses
3. Muscarinic excitation increases gain by strengthening 2° synapses

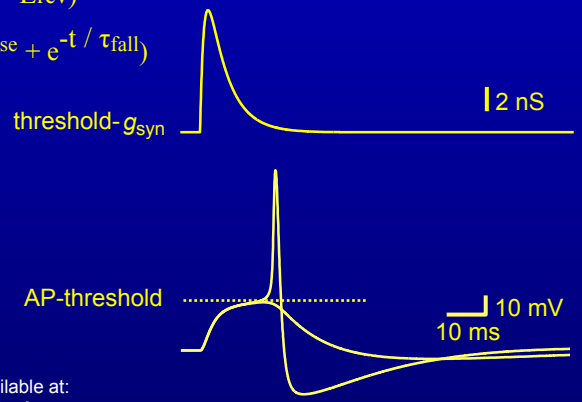
Experimental approach:

- perforated patch clamp recordings from dissociated B-type sympathetic neurons from bullfrog paravertebral ganglia 9 and 10
- virtual nicotinic synapses implemented by a dynamic clamp:

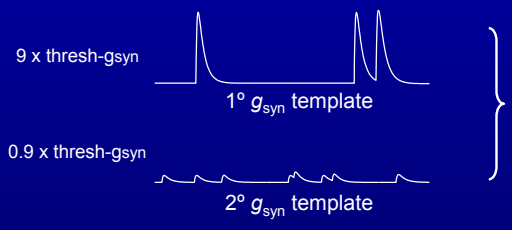
$I_{syn} = g_{syn} * (Vm - Erev)$

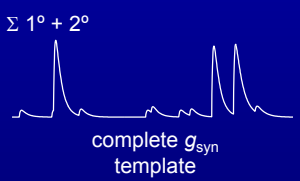
$g_{syn} = A * (-e^{-t / \tau_{rise}} + e^{-t / \tau_{fall}})$

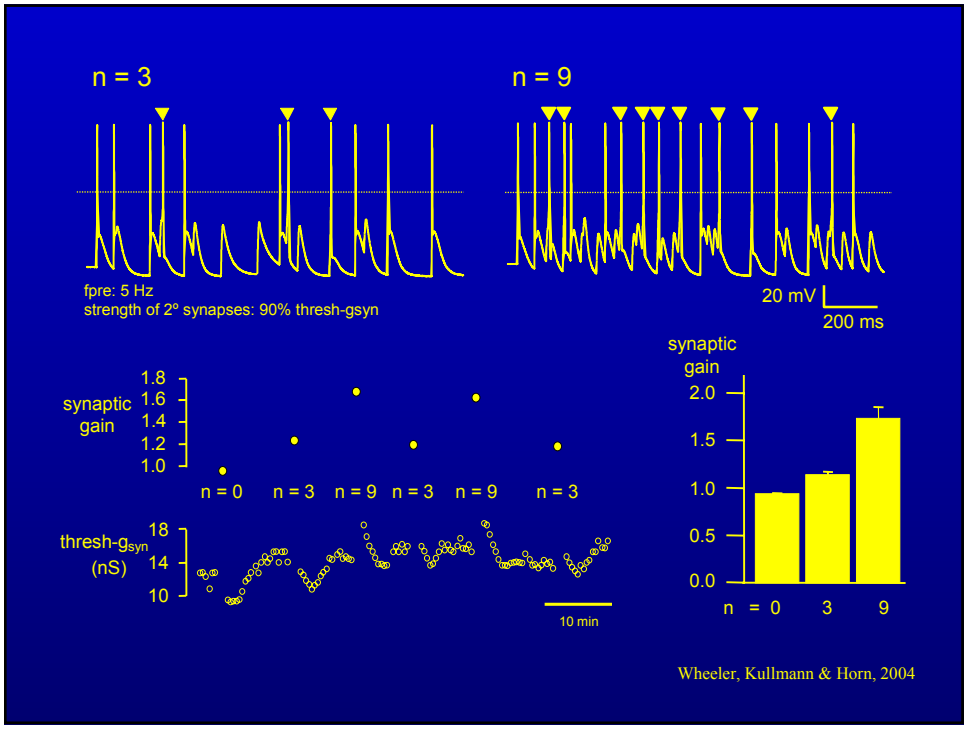
$\tau_{rise} = 1$ ms
$\tau_{fall} = 5$ ms
$Erev = 0$ mV



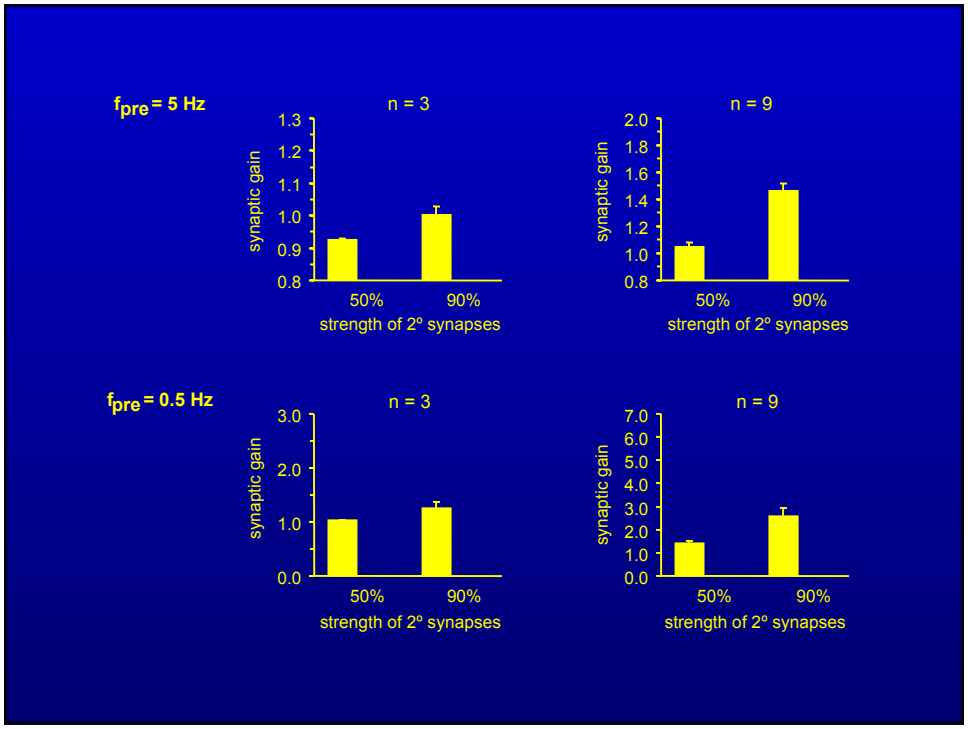
dynamic-clamp software available at:
http://hornlab.neurobio.pitt.edu

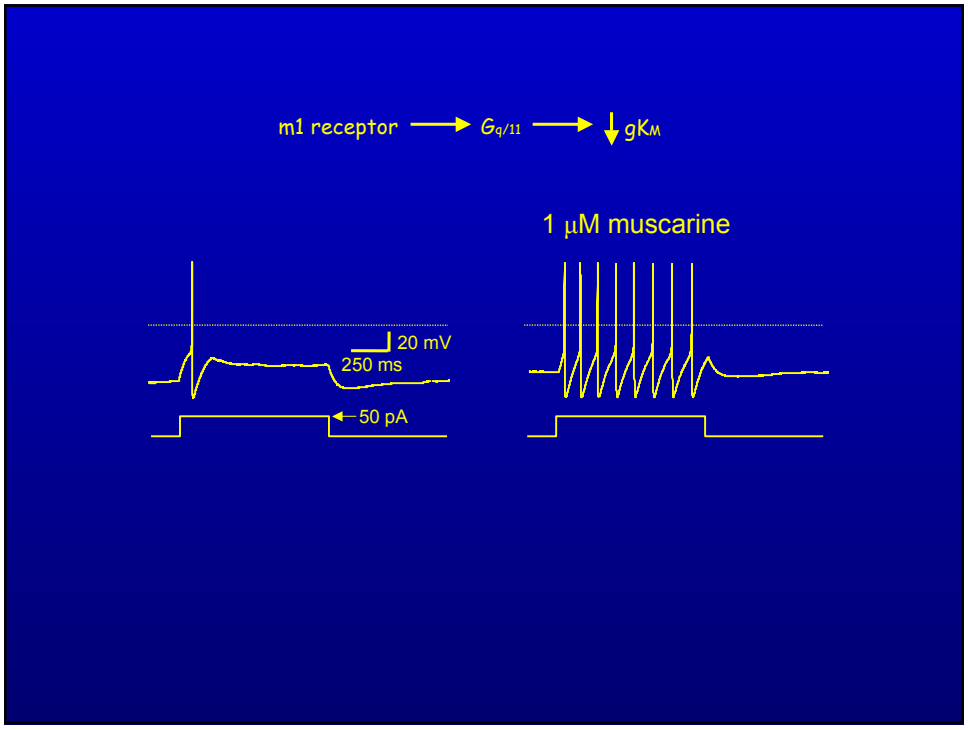


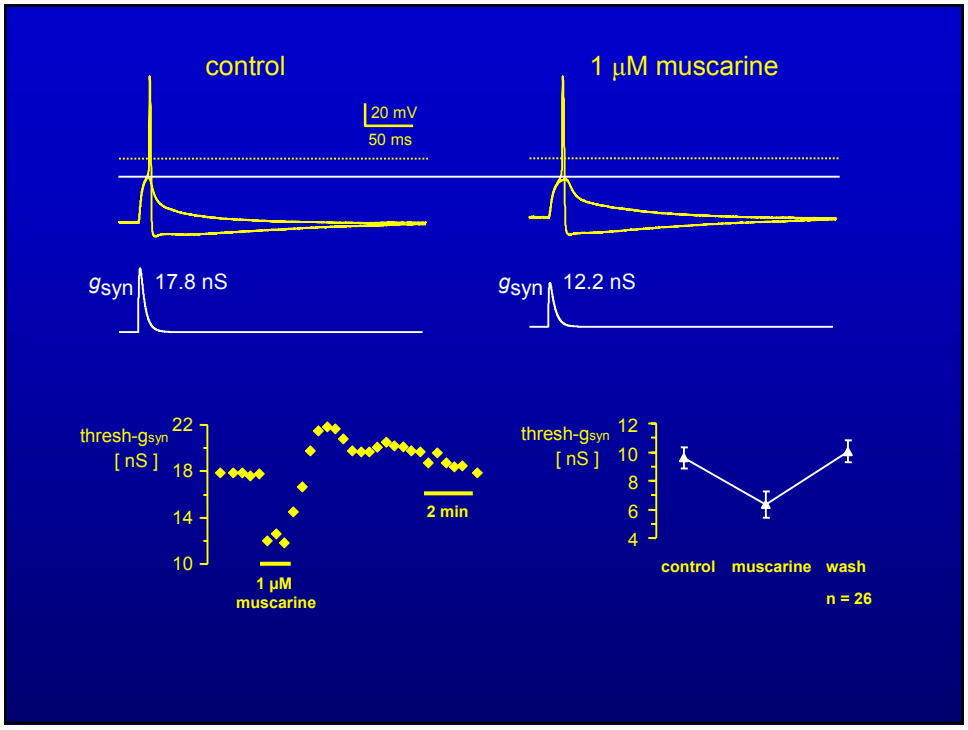




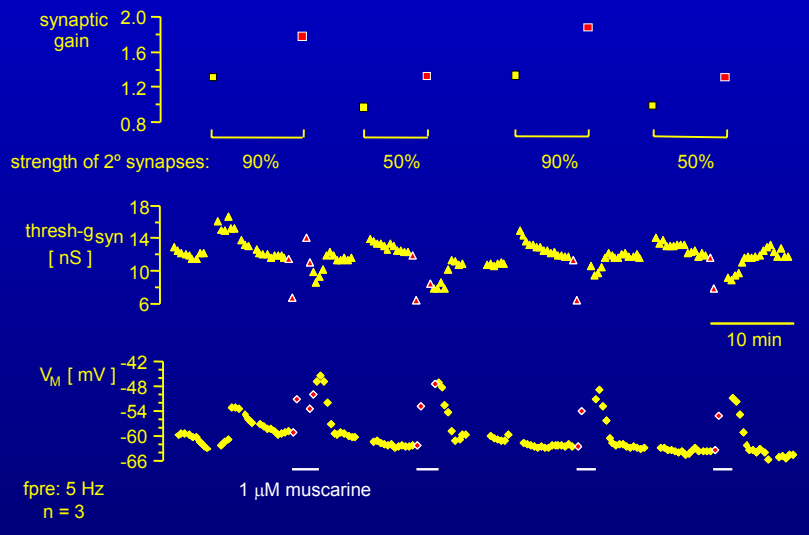
Wheeler, Kullmann & Horn, 2004

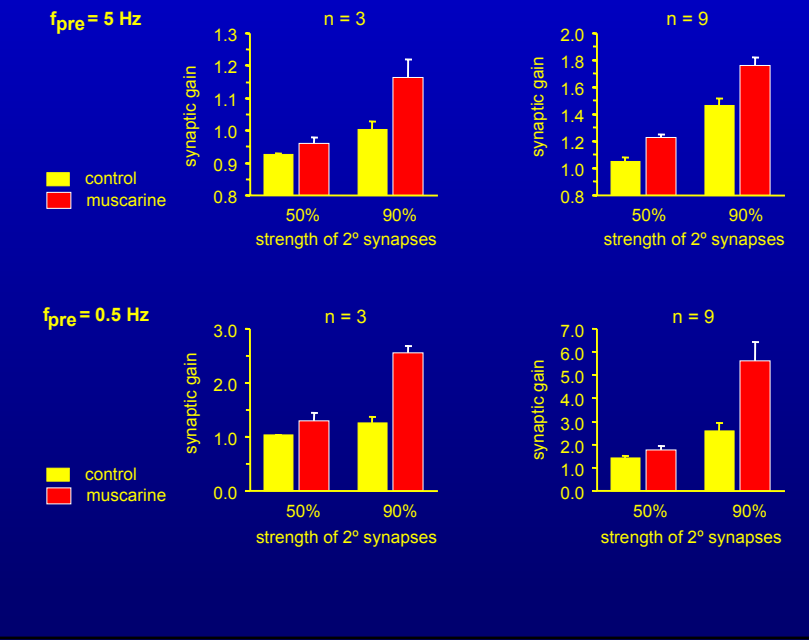


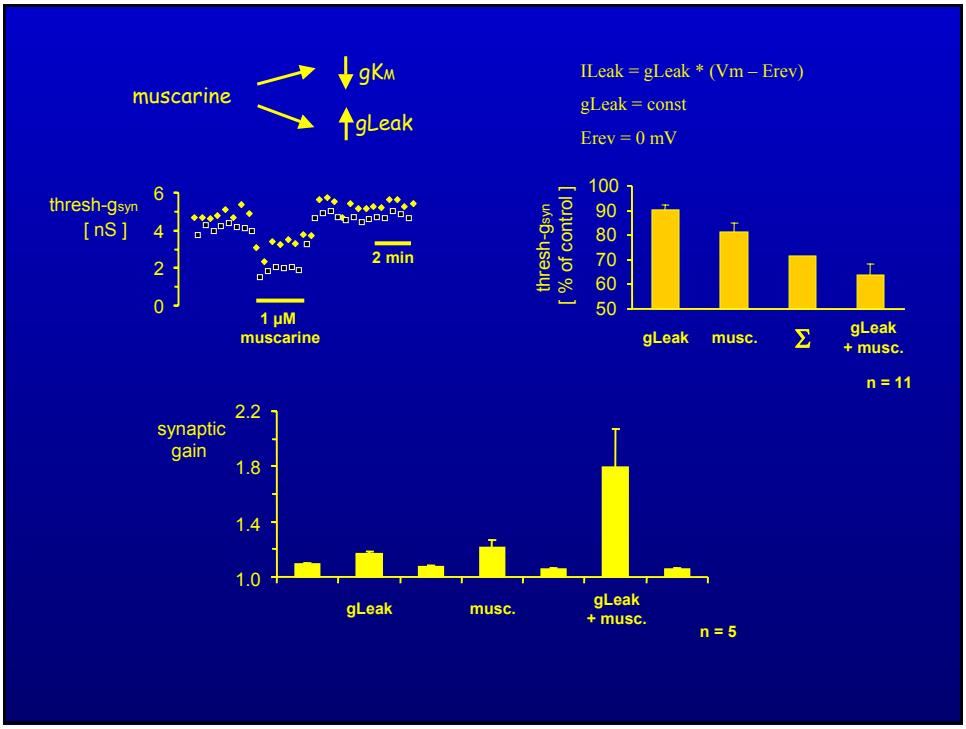

m1 receptor
$G_{q/11}$
gK_M
1 μM muscarine
20 mV
250 ms
50 pA


control
1 μM muscarine
20 mV
50 ms
g_{syn} 17.8 nS
g_{syn} 12.2 nS
thresh-g_{syn} [nS]
22
18
14
10
1 μM muscarine
2 min
thresh-g_{syn} [nS]
12
10
8
6
4
control
muscarine
wash
n = 26

Synaptic strength and muscarinic modulation regulate gain







Conclusions:

- amplification increases with number of weak synapses and strength of weak synapses
- strength of weak synapses is increased by muscarinic inhibition of M-current
- concomitant increase in gleak acts synergistically
- sympathetic ganglia can act as variable amplifiers

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