Study of GABAergic Inhibition in the Dynamics of Olfaction in the Drosophila Antennal Lobe

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BGGN 260

Summary

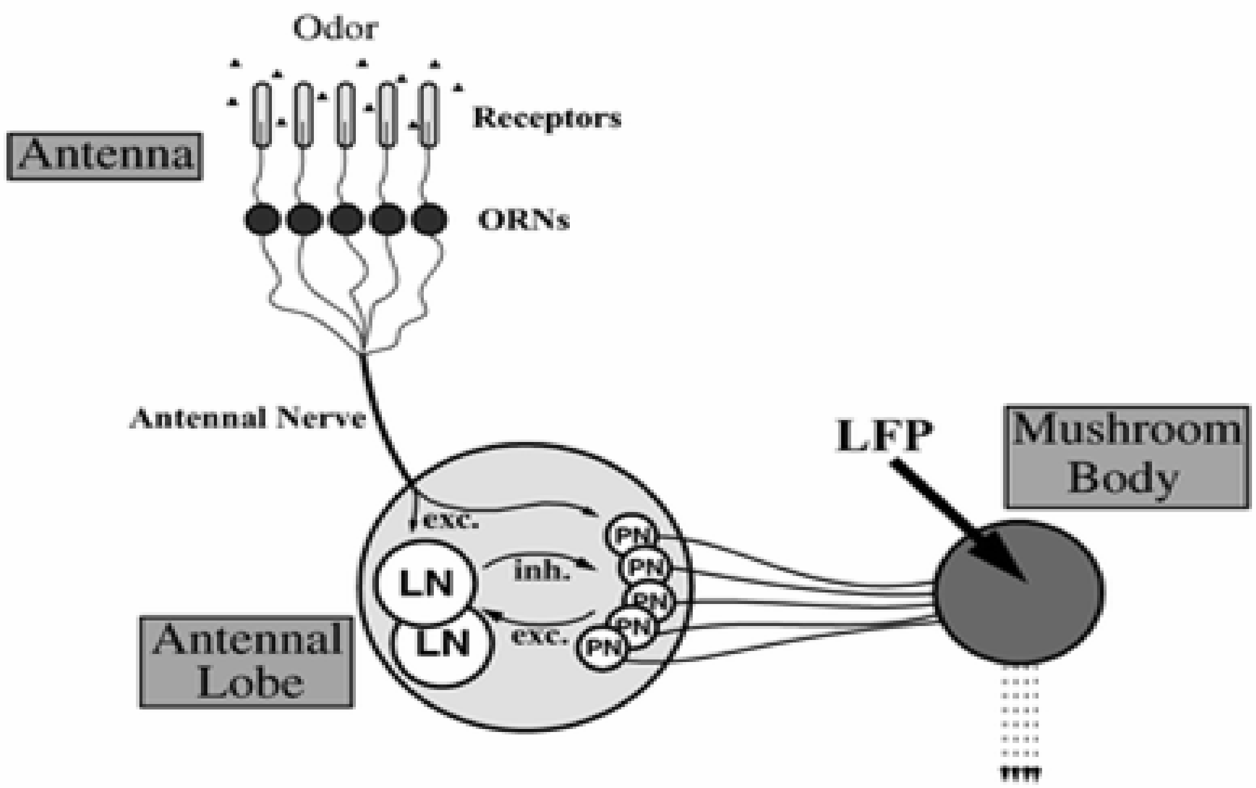
- Role of GABAergic Inhibition in Shaping Odor-Evoked Spatiotemporal Patterns in the Drosophila Antennal Lobe
  - ***R.L. Wilson and G. Laurent,***

    Journal of Neuroscience 25(40): 9059-9079
- I used a Hodgkin-Huxley model implemented in Matlab to study the data shown in Fig 2.

PN and LN Modeling

- Projection Neurons (PN) sense odor but don't co-localize with GABA.
  - Have GABAa receptors and GABAb receptors.
- Local Neurons (LN) co-localize with GABA and use GABA to inhibit PN's.
  - Have GABAa receptors only.
- GABA receptor specificity discovered by results of sensitivity to Picrotoxin and CGP54626 experiments
  - LN sensitive to Picrotoxin alone which inhibits GABAa receptors only.
  - PN peaks only half reduced by Picrotoxin and require CGP54626 for total reduction. CGP54626 inhibits GABAb receptors.

Antenna Lobe Neuronal Model

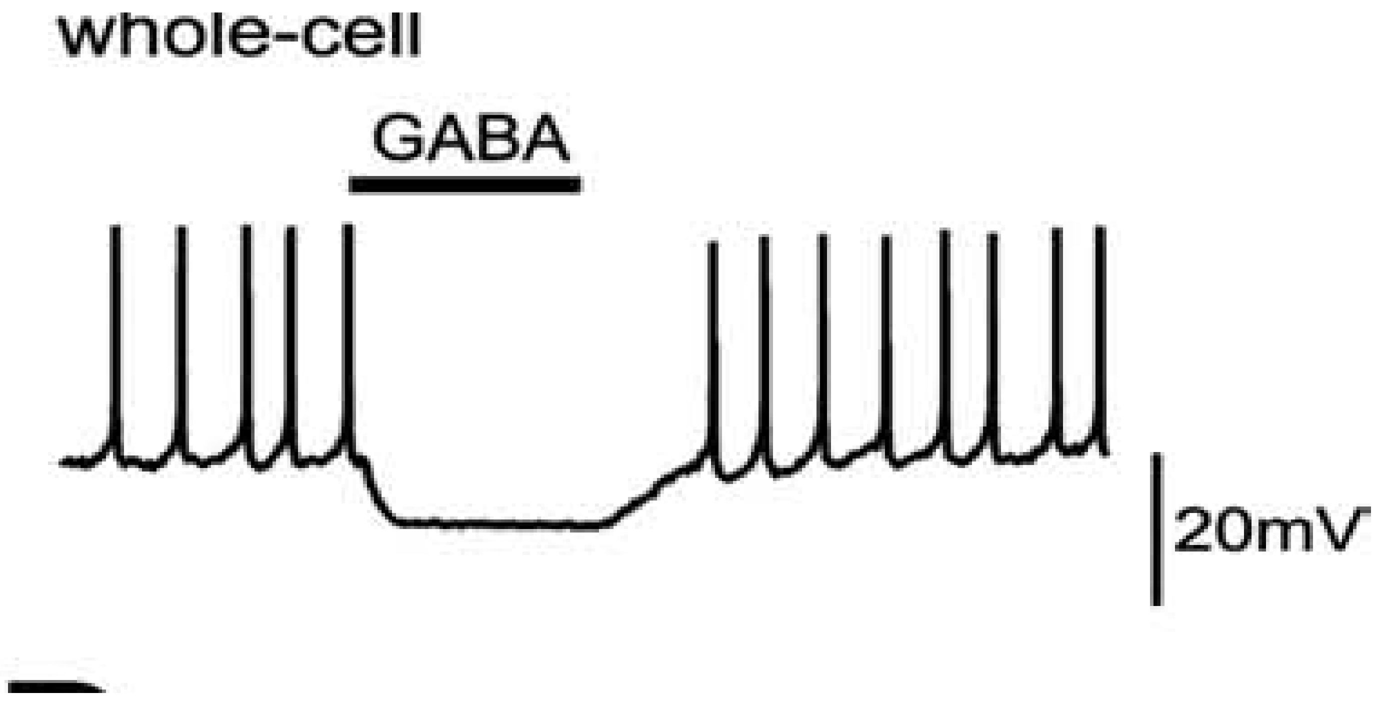


Inh. reflects the release of GABAa by LN to inhibit signaling from PN

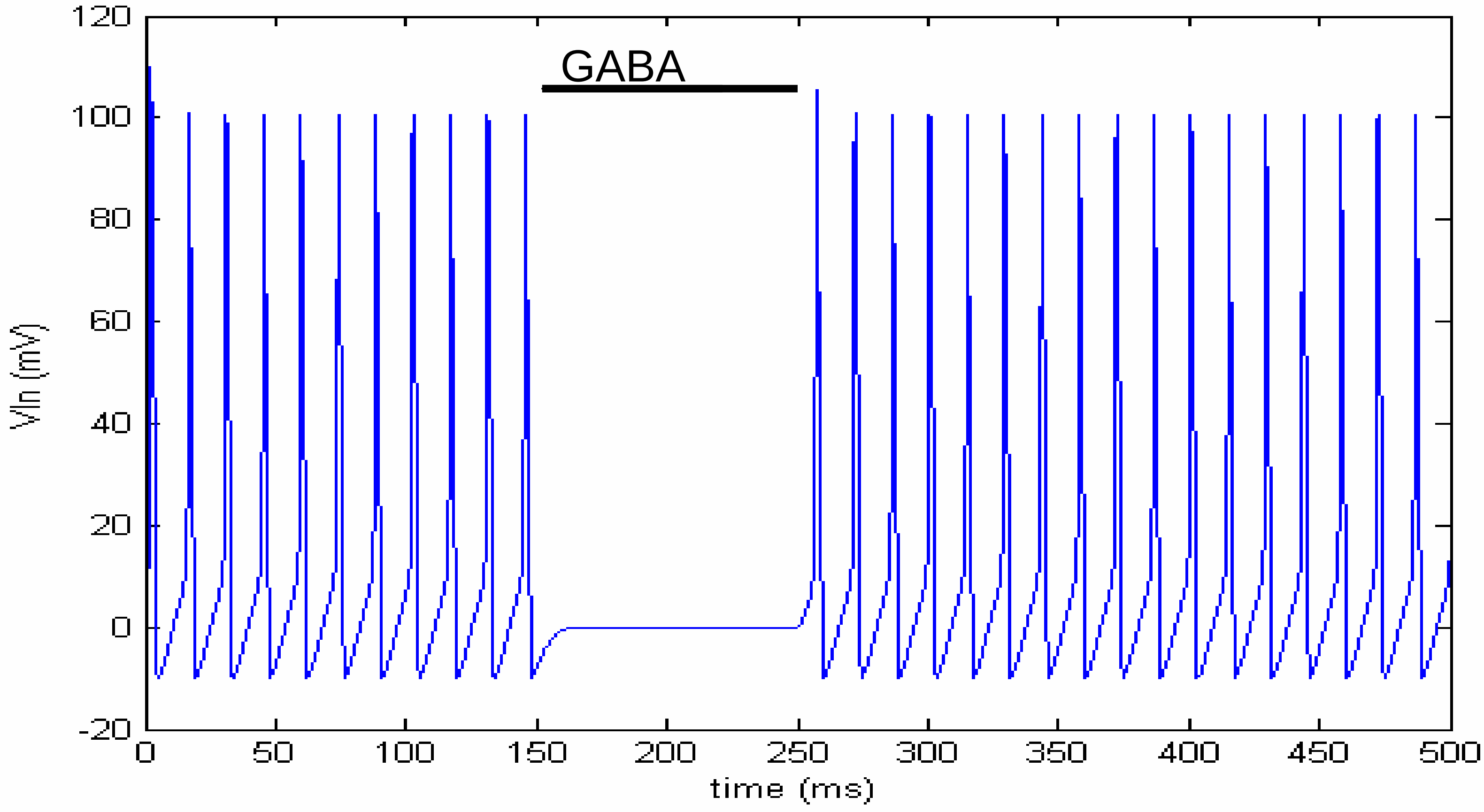
Implemented LN Model

- INaln=gNa*mln^3*hln*(vln-ENa);
- IKln=gK*nln^4*(vln-EK);
- ILln=gL.*(vln-EL);
- Set ENa=120 , EK=-12, EL=10.6, gNa=120, gK=36, gL=0.3, ggabaa=0.5
- rdotln=ggabaaalpha*Tln*(1-rln)-ggabaabeta*rln;
- Igabaaln=ggabaa*rln*(vln-ECl);
- vlndot=(-INaln-IKln-ILln-Igabaaln+Iln)/C;
- Set Iln=10; between 150ms and 250ms [GABA] = 250; before 150ms and after 250ms, [GABA] = 0.

Recorded Data (Wilson and Laurent)



LN output



GABA
120
100
80
60
40
20
0
-20
Vln (mV)
0
50
100
150
200
250
300
350
400
450
500
time (ms)

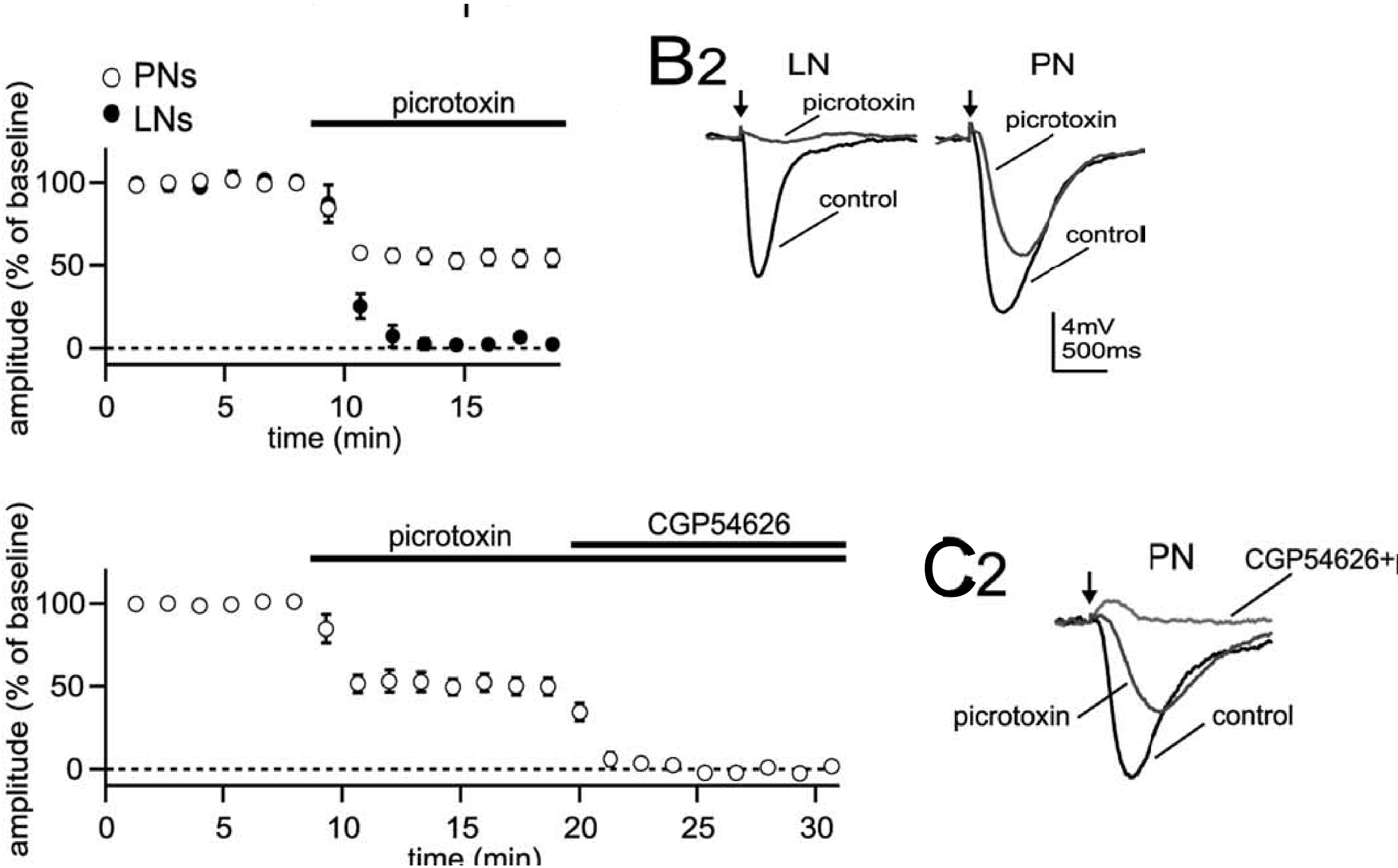
Modeling of Antagonist Effects on Synapses

- For LN curves used same equations, but set Iln = 0, [GABA]=25 for 10ms. Compared the curves for ggabaa = 0.5 (Control) and ggabaa = 0.01 (picrotoxin).
- For PN curves added an Igabab to vpn equation for the response to gabab. rdotpnb=ggababalpha*Tpn*(1-rpnb)-ggababbeta*rpnb;

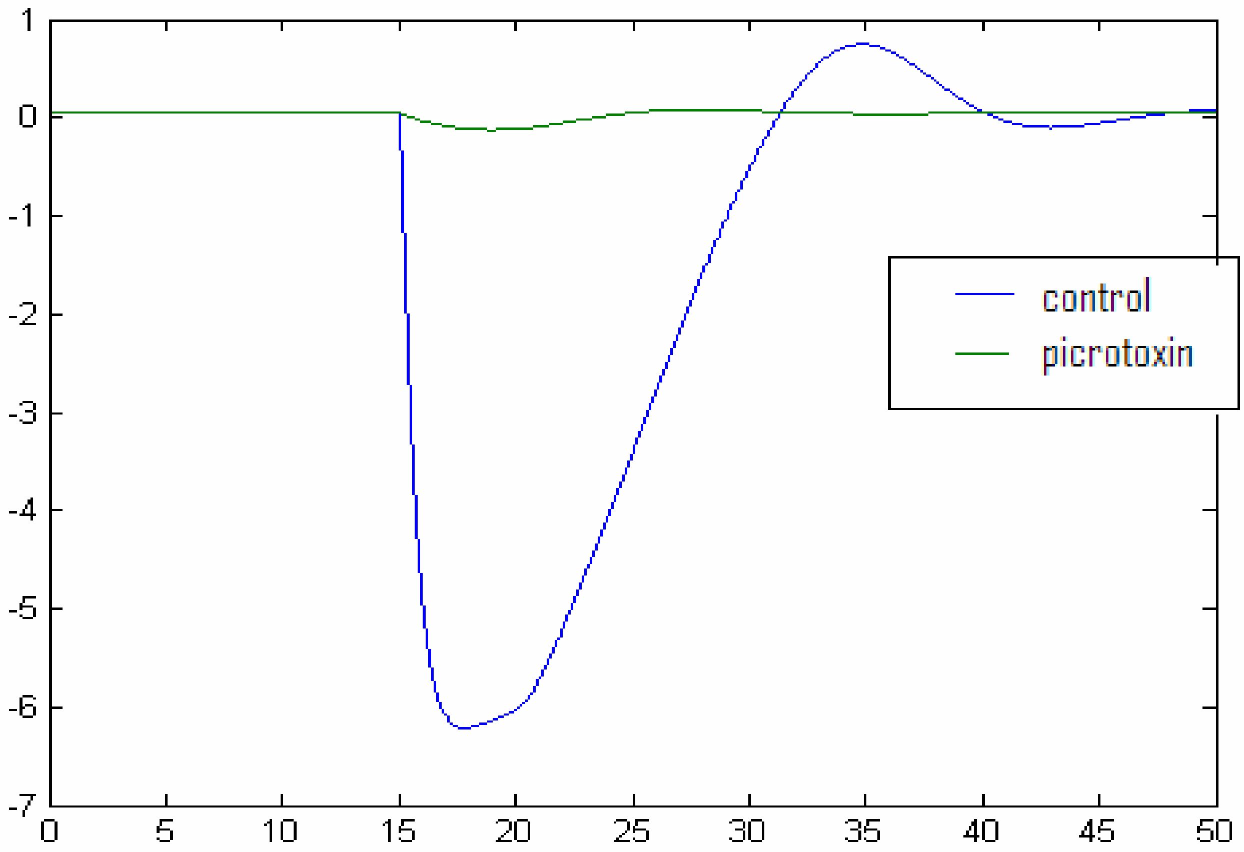
  Igababpn=ggabab*rpnb*(vpn-Egabab);

  – Set Ipn = 0, [GABA]=25 for 10ms. Compared curves for ggabaa=0.5 and ggabab=0.15 (control) and ggabaa=0.01 and ggabab=0.15 (picrotoxin), and ggabaa=0.01 and ggabab=0.01 (picrotoxin & CGP54626).
- Plotted amplitude difference for picrotoxin results as bar graph.

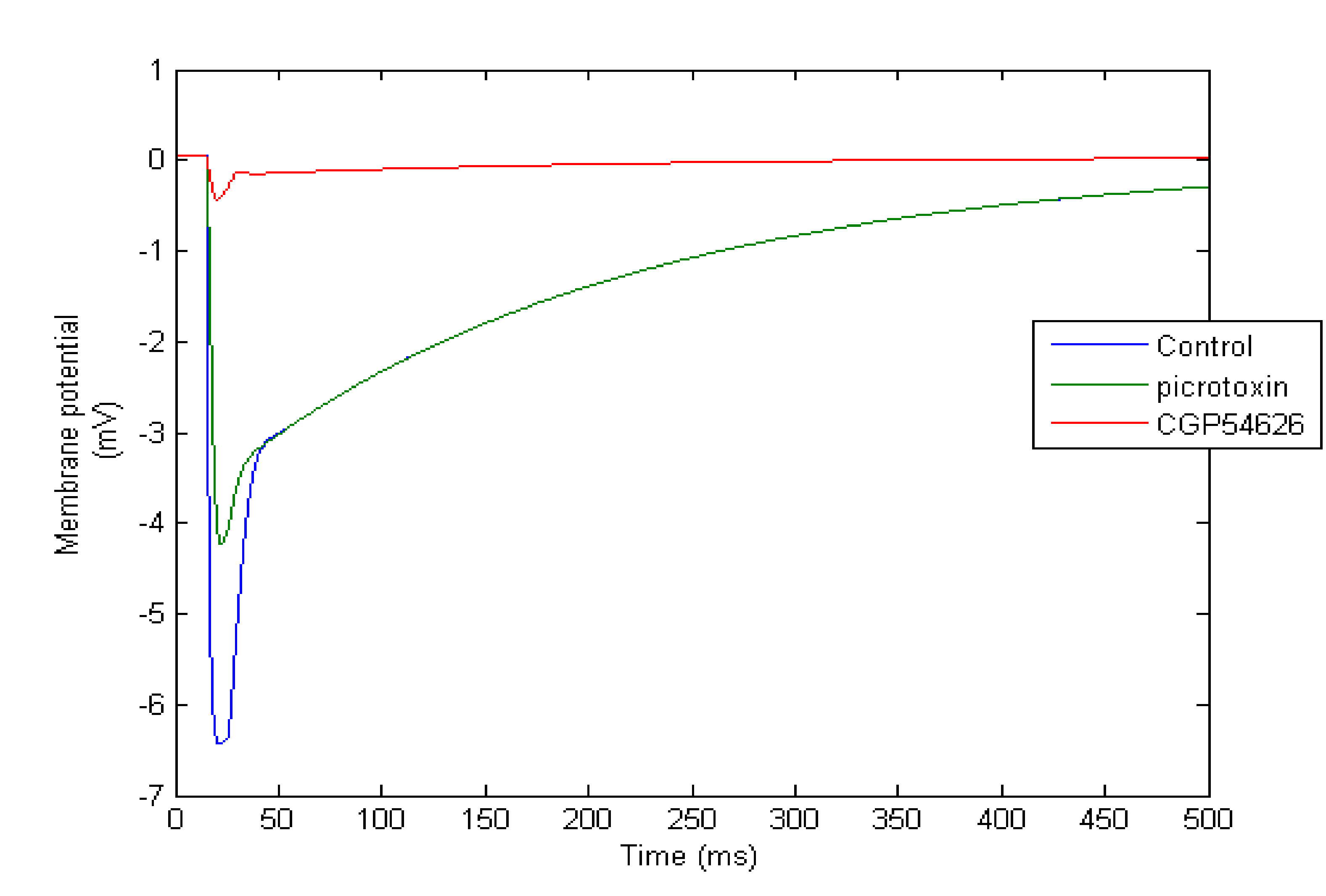
Reference Model (Wilson and Laurent)

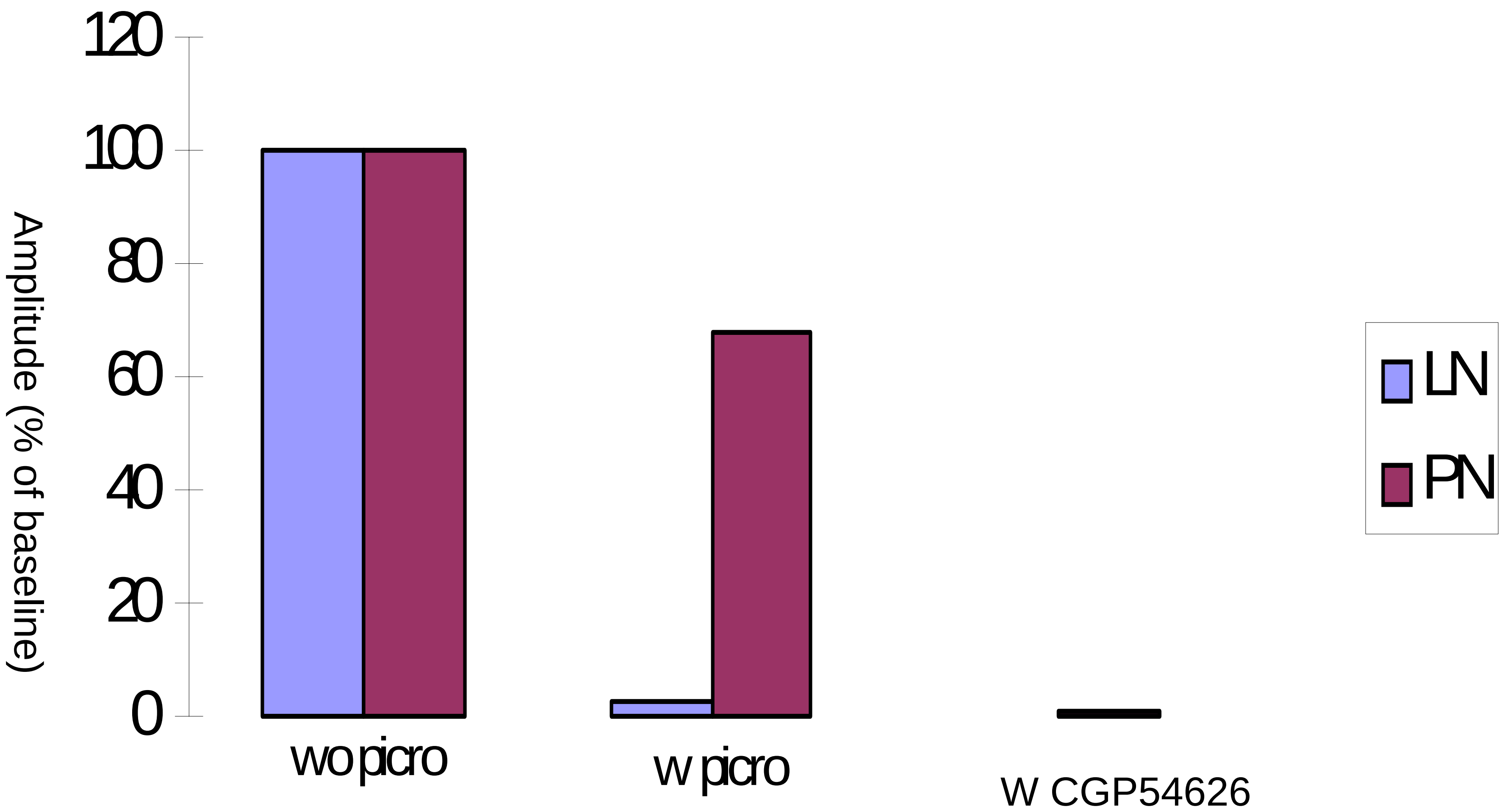


Effect of Picrotoxin on LN



Effect of Picrotoxin and CGP54626 on PN





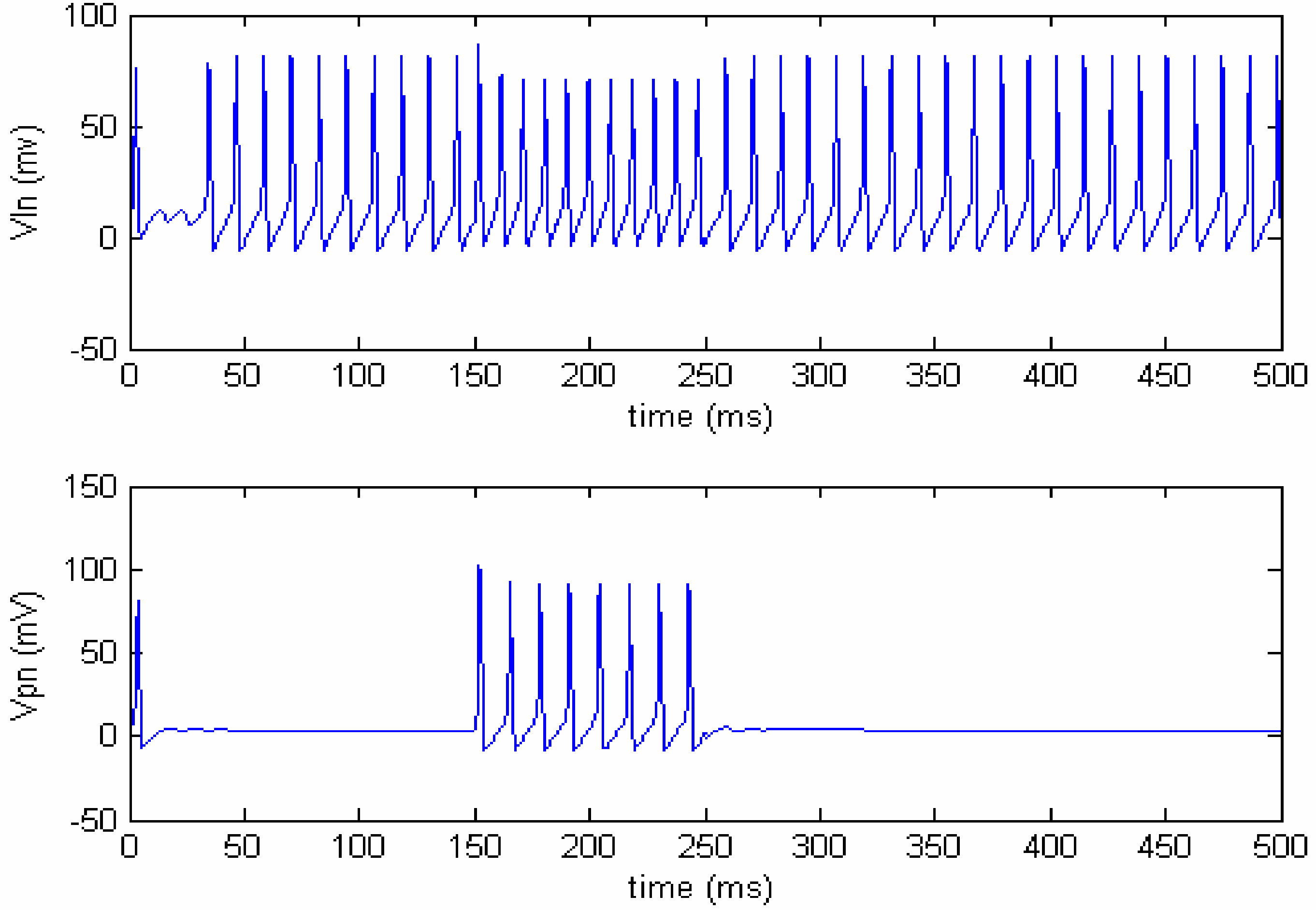
Amplitude (% of baseline)
120
100
80
60
40
20
0
wo picro
w picro
W CGP54626
LN
PN

Excitation of LN and PN with Input from ORN

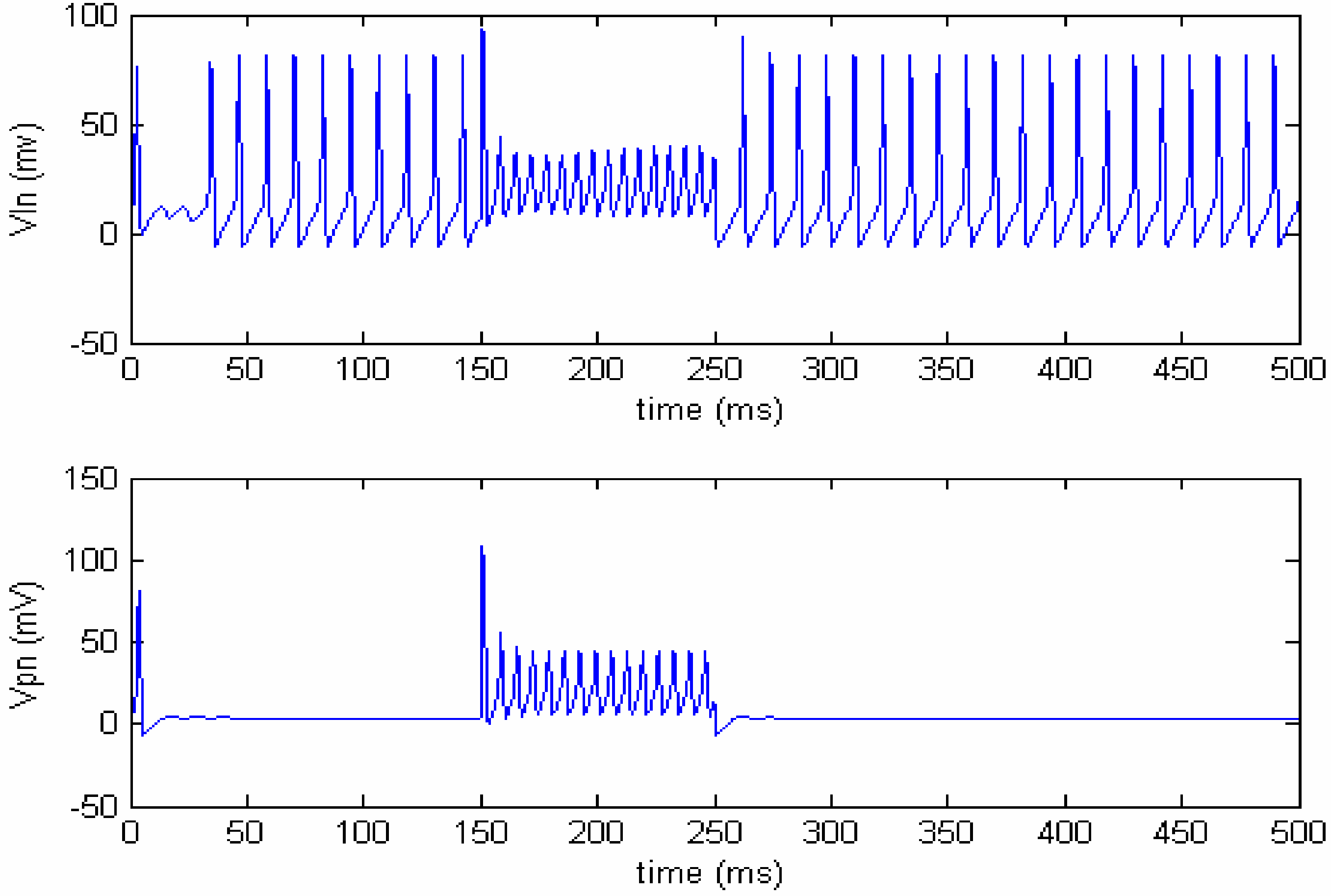
Including Effect of Ampa

- Iampaln=gampa*rln*(vln-Eampa);
- vlndot=(-INaln-IKln-ILln-Igabaaln-Iampaln+Iln+Iln2)/C;
- vpndot=(-INapn-IKpn-ILpn-Igabaapn-Igababpn+Ipn+Ipn2)/C
- Set gampa=0.3, Eampa=70, Iln=10, Ipn=4, ggabaa=0.5, ggabab=0.15
- For times between 150ms and 250ms set Iln2=20 and Ipn2=10. For times less than 150ms and greater than 250ms Iln2=0 & Ipn2=0

Activation of LN by PN



Same, Iln2=100 and Ipn2=100



Conclusions

- The LN neuron is shown to spike in response to the external input, except for when GABA inhibits it.
- Antagonist plot shows that the amplitude of LN IPSP is fully reduced by picrotoxin, but the PN IPSP is reduced only 33% by picrotoxin and totally by picrotoxin with CGP54626.
- The effect of excitation by the ORNs on LN and PN outputs was also studied.
  - Output pulses are lower in amplitude but repeat at a higher frequency when Iln2 and/or Ipn2 are larger.