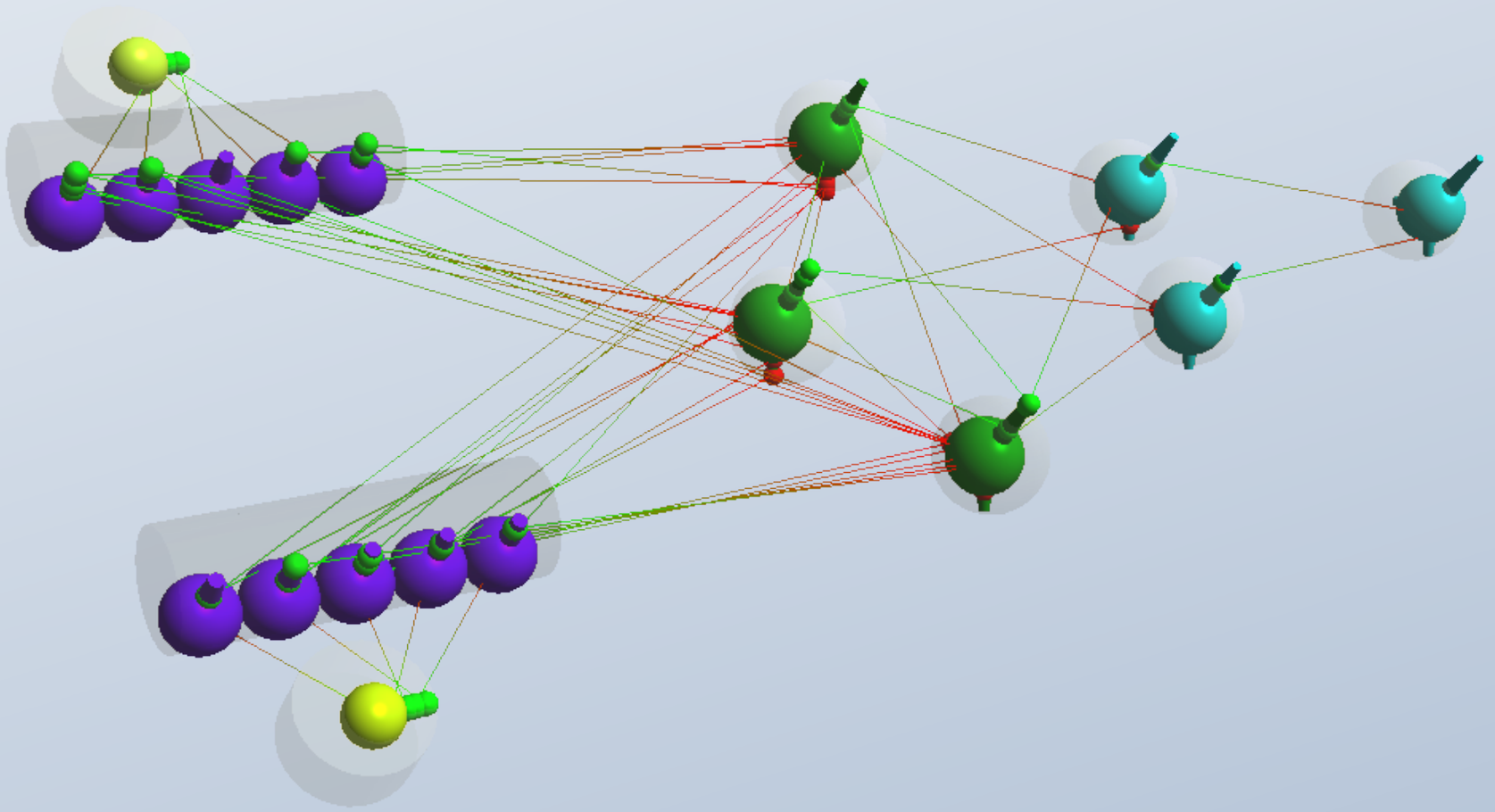
Constructing an in silico model of the pheromone system of the moth

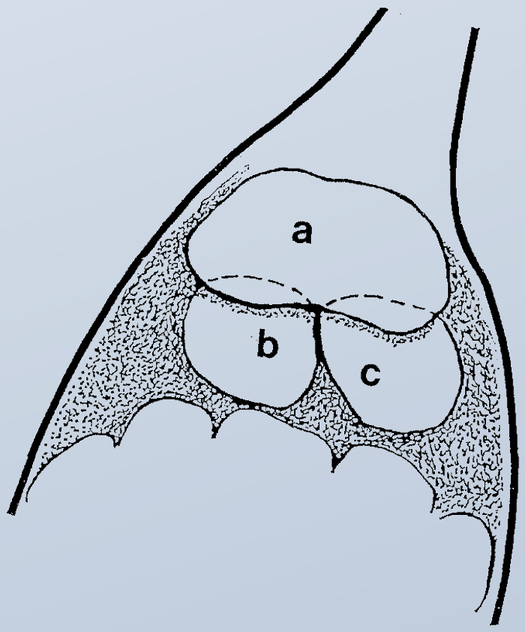
Recognition of the correct ratio of components



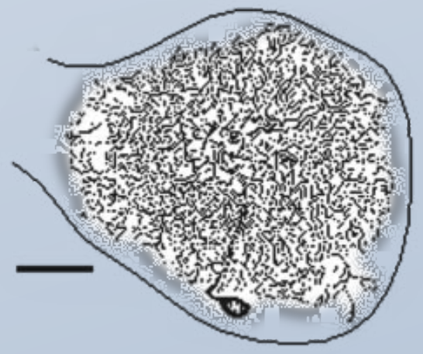
Andrei Zavada, Thomas Nowotny, Sussex University

Relevant facts about (*S. littoralis*) MGC

- Three glomeruli, two ORN types, two pheromone components;
- Profuse arborisations between LNs in glomeruli;
- Connections between LNs are mostly inhibitory, as well as those between LNs and PNs;
- (Synchronised) self-sustained oscillations.

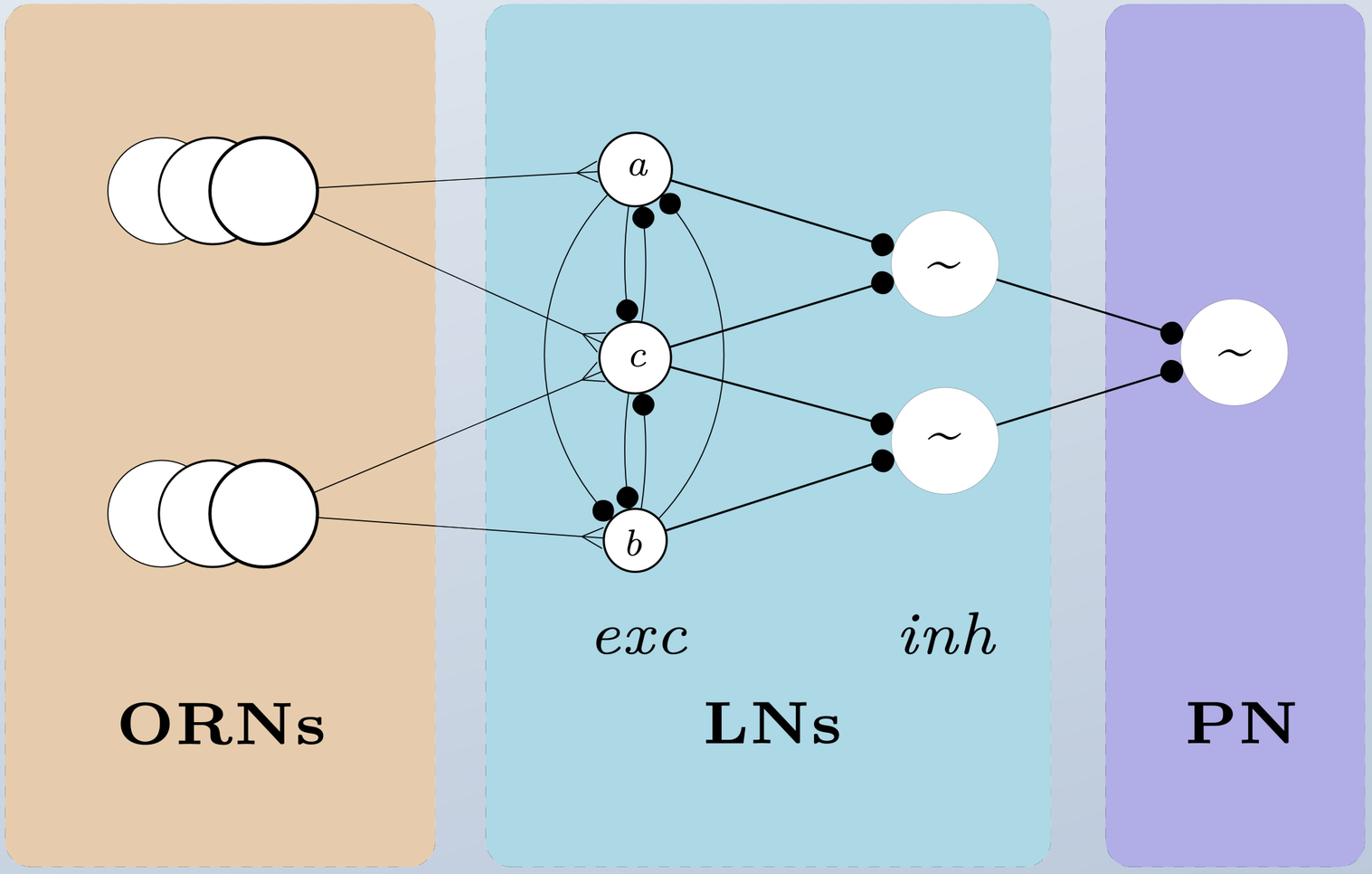


Ochieng SA, Anderson P, Hansson BS. Tissue & Cell, 1995, 27(2):221–32.



Hansson BS & Anton S. Annu. Rev. Entomol., 2000, 45:203–31.
Christensen TA et al. BioSystems, 2001, 61:143–53.

Model structure: Topology & Individual components



Inhibition at PN from LN_{inh} effective only with LNs firing simultaneously

Model implementation: Neurons and Synapses

LNs, PNs

g_{Na}	$=$	7.15
E_{Na}	$=$	50
g_{K}	$=$	1.43
E_{K}	$=$	-95
g_{l}	$=$	0.021
E_{l}	$=$	-55
C_{mem}	$=$	0.143
g_{Kl}	$=$	0.00572
E_{Kl}	$=$	-95

Destexhe A, Mainen ZF, Sejnowski TJ. J Comput Neurosci. 1994 Aug;1(3):195-230.

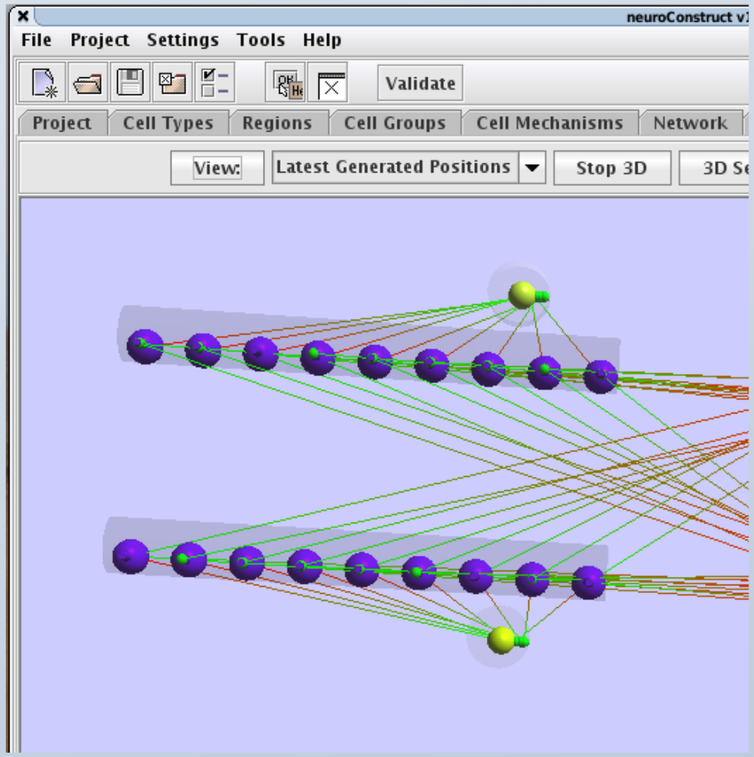
Traub RD, Miles R et al (several sources).

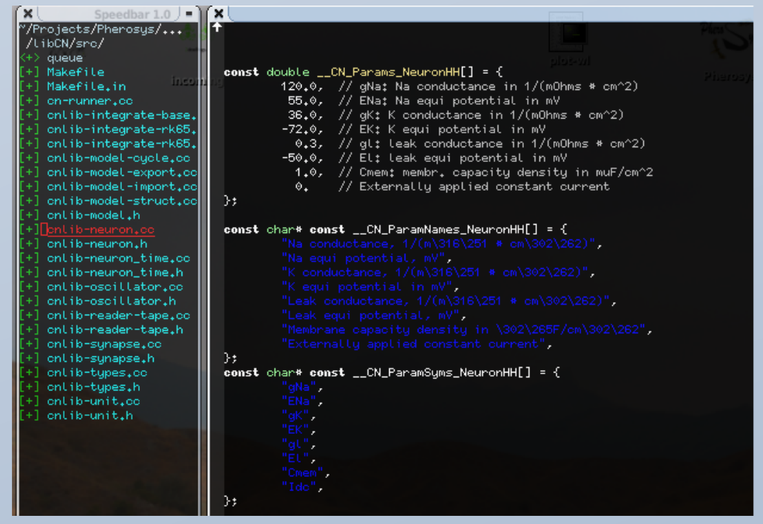
ORNs

- Irregularly spontaneously firing, 2 ms 20 mV rectangular impulses + 10 ms refractory period;
- Rate follows a Poisson distribution with variable λ;
- ORNs formed into battery to produce smoother stimulation.

Model implementation: Technical details

- Using 5-6th order Runge-Kutta integration algorithm;
- Model topology built in neuroConstruct and exported in NeuroML;
- Model runner written in C++;
- ~1:5 model time:execution time (2.4 GHz Core 2 Quad CPU) for the presented model;
- Use of map neurons planned.



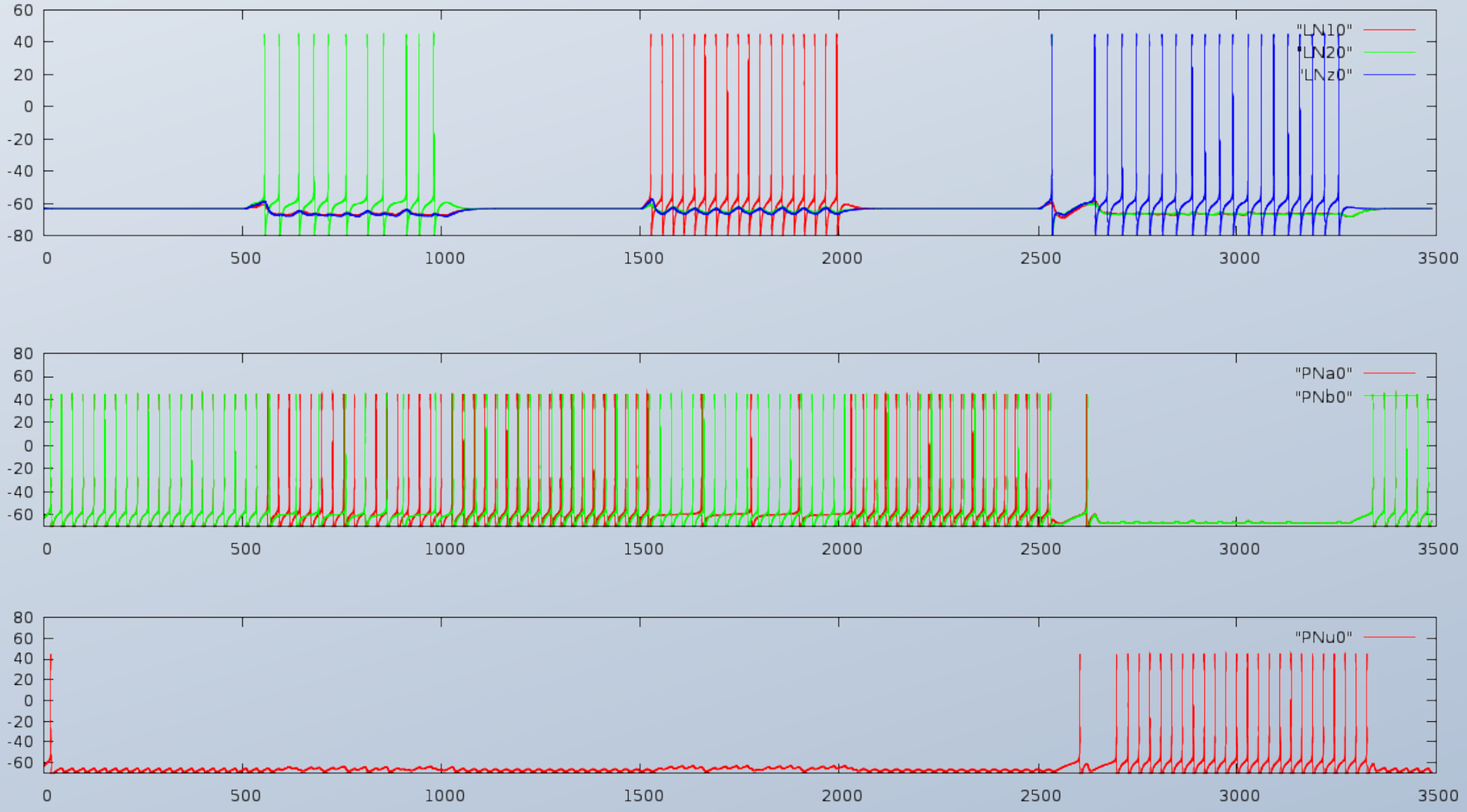


Detection of a 1:1 ratio

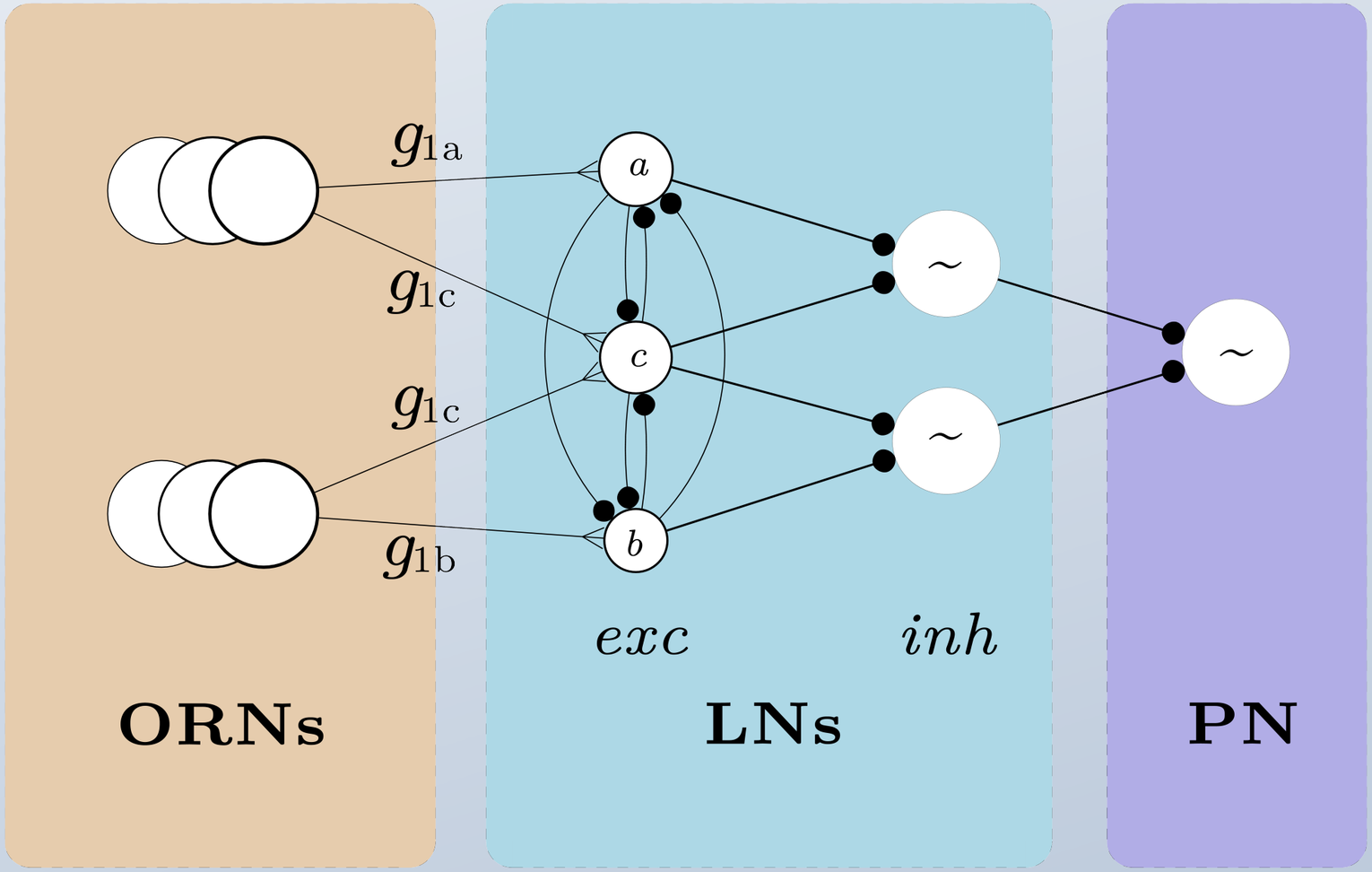
$\lambda_a = 0.02$ $\lambda_b = 0.08$

$\lambda_a = 2.0$ $\lambda_b = 0.08$

$\lambda_a = 0.08$ $\lambda_b = 0.08$



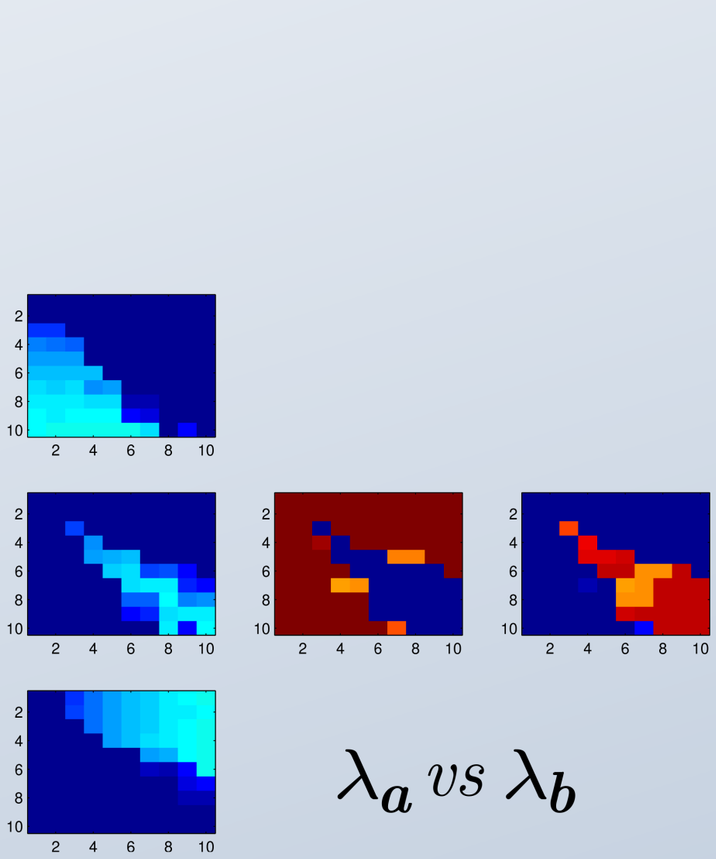
Optimal balance of synaptic strength between ORNs and LNs



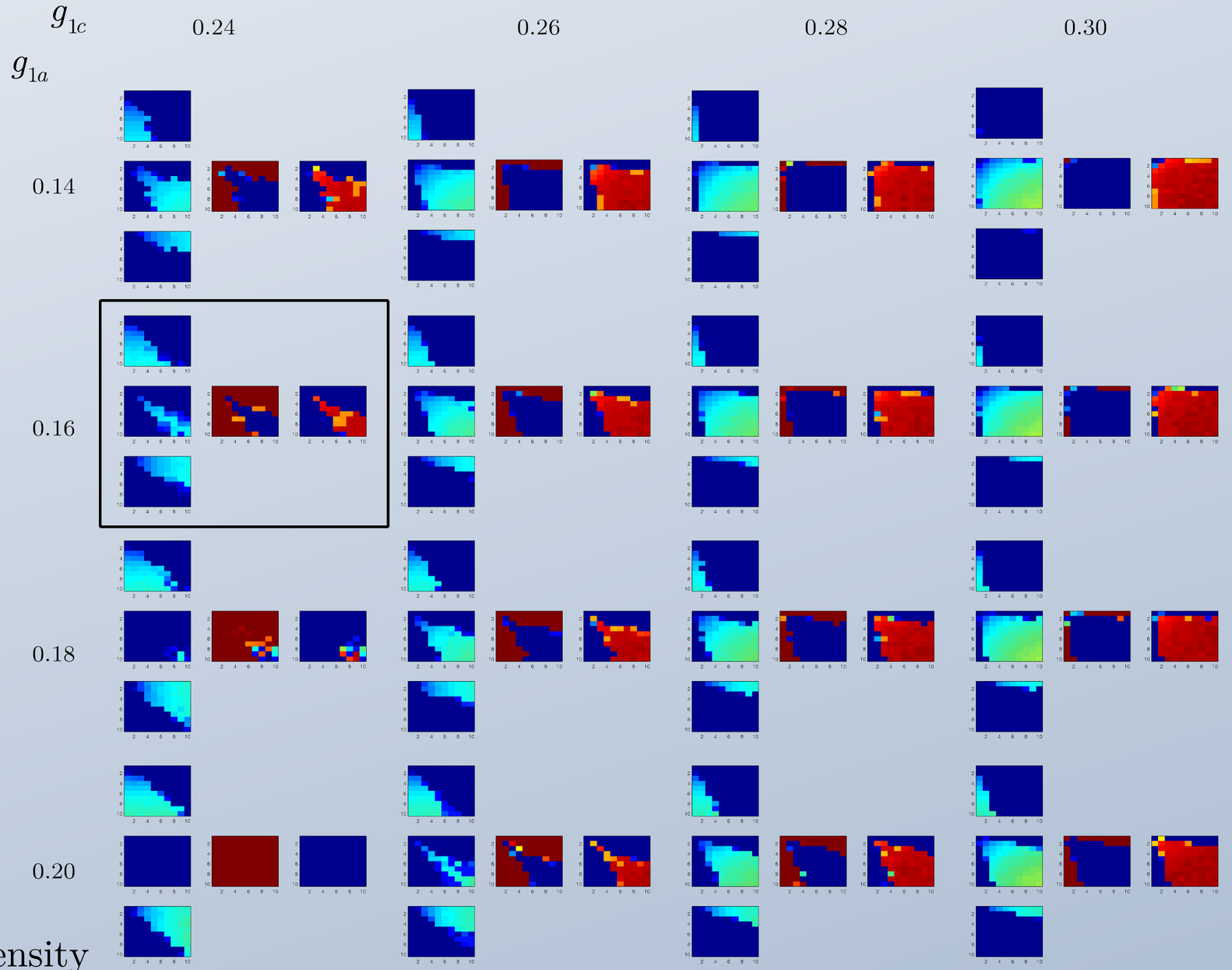
$(g_{1a} + g_{1b}) : g_{1c} = \sim 4{:}3$

$g_{2a} = g_{2b} << g_{2c}$ (can do with a single inhibitory LN)

Running the simulation & Search for optimal parameters (with 200 ORNs)



λ_a *vs* λ_b

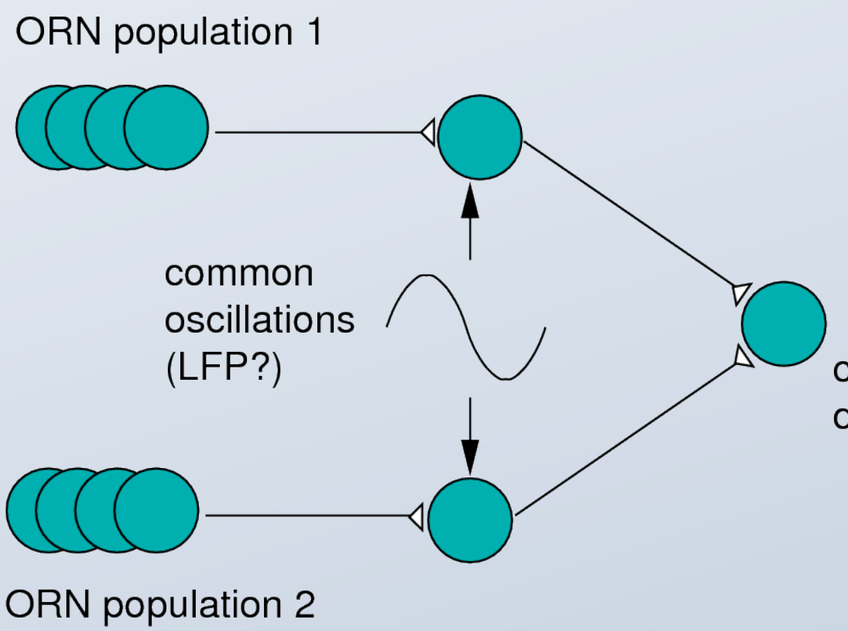


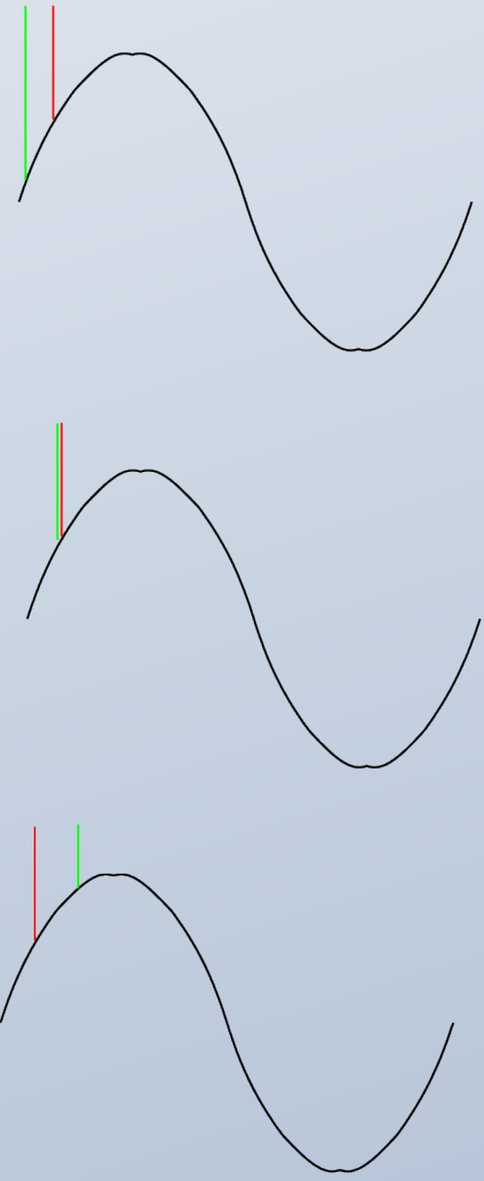
Colour code represents spike density
(blue = no spiking, red = spiking at max rate)

Extending the model

- Adaptable for different ratios: to what extent?
- How to extend it for more than two pheromone components?

An alternative model, based on subthreshold oscillations and coincidence detection



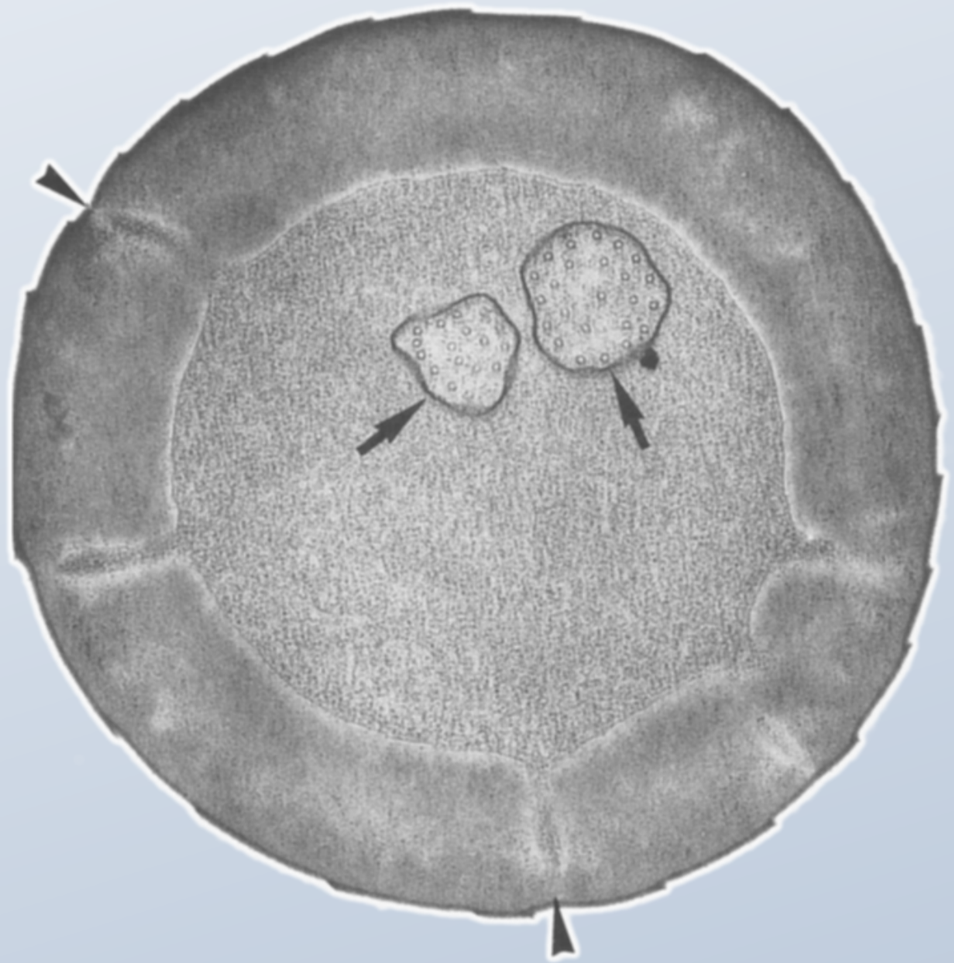


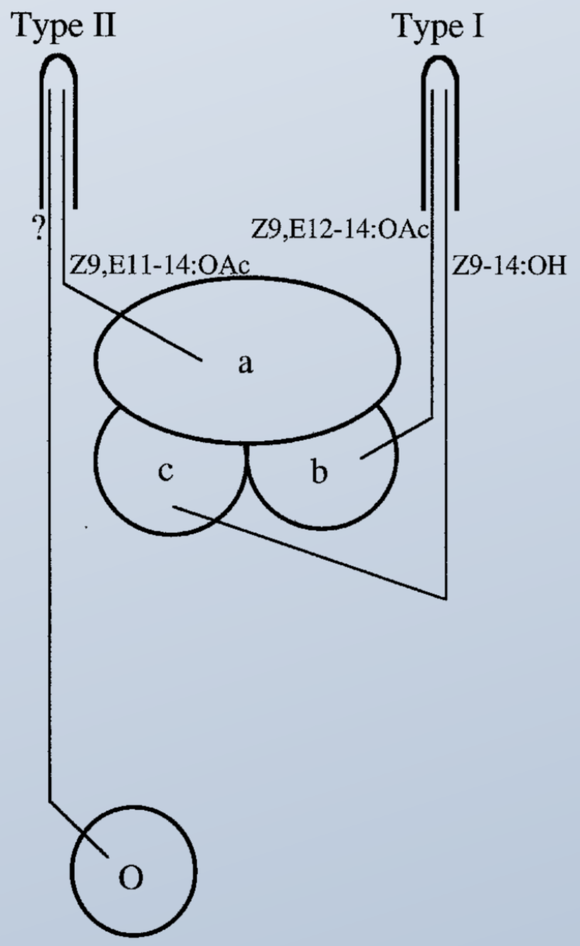
ORN 1 > ORN 2

ORN 1 = ORN 2

ORN 1 < ORN 2

Adaptation for the wide dynamic range of pheromone concentrations





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Thanks!