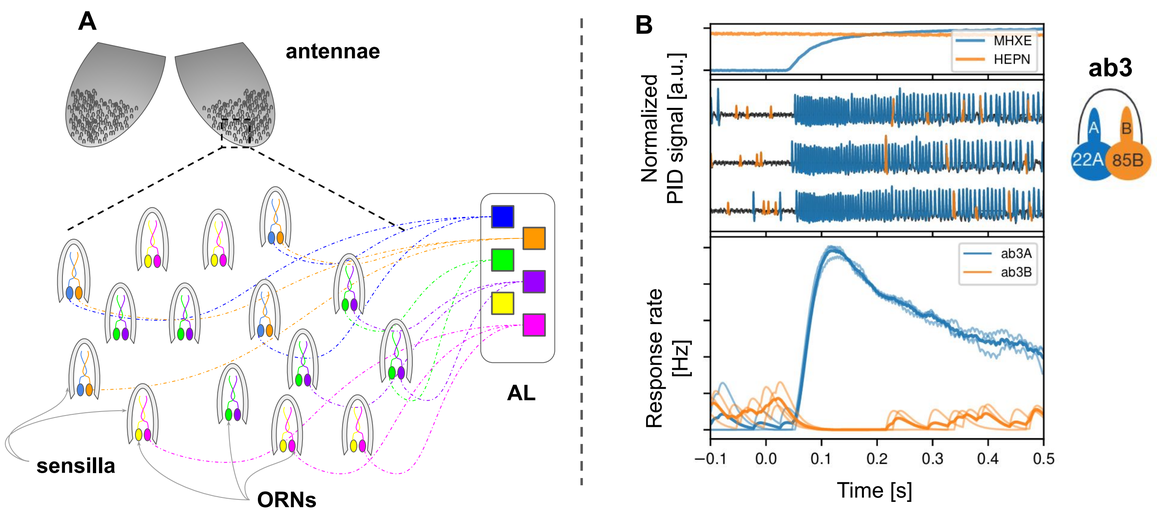
Non-synaptic interactions in the neural encoding of odorants:

A good start is half the battle

Mario Pannunzi*[@]*, Thomas Nowotny
University of Sussex, Brighton, UK
[@] *m.pannunzi@sussex.ac.uk*

Background

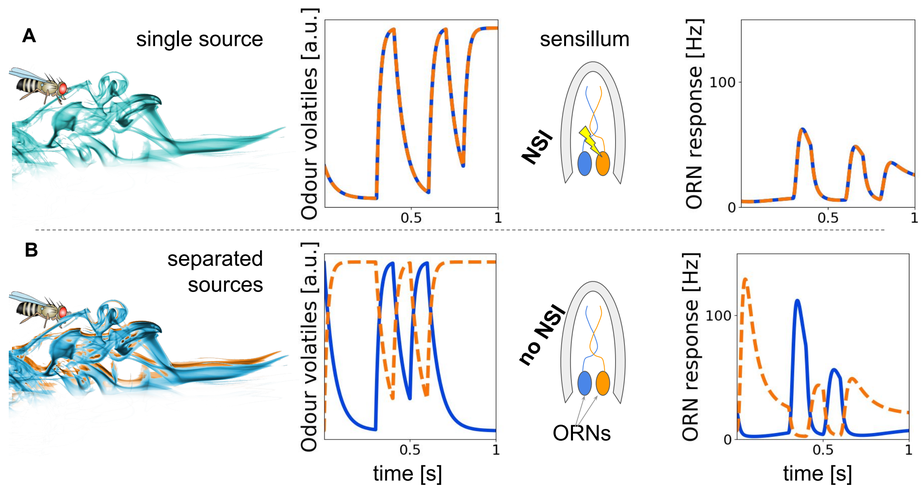
- In many insect species, **olfactory receptor neurons (ORNs)** are housed in hair-like sensilla in a stereotypical manner. Each sensillum contains two or more ORNs of different types[1]
- ORNs in the same sensillum interact without synaptic connection[2]: Non-synaptic interactions
- **Non-synaptic interactions** (NSIs): epiphenomenon or functional?



Background **A)** Pictorial representation of early olfactory areas in insects' brain: receptor neurons and antennal lobe (AL); **B)** Non-synaptic interaction documented for two receptor neurons (ab3A and ab3B) co-housed in the sensillum ab3 in flies[2].

The hypothesis

- Minimal spatio-temporal scales of odor plumes: order of tens of millimetres/milliseconds[4]
- Odourants from the same source travel together in the same filaments, while odourants from separate sources are in separate strands[3].
- Insects recognize whether odours are present in a plume and whether or not they belong to the same filaments[1].
- **NSIs function**: improve spatiotemporal resolution of odour recognition[1]

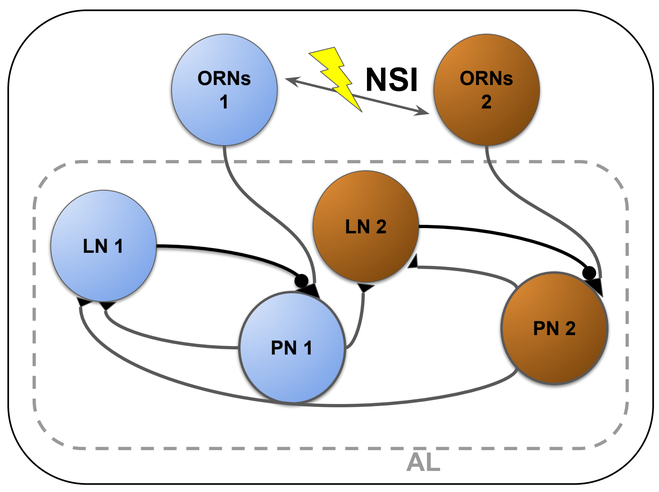


Hypothesis **A)** Strong NSI effect: Single source emits multiple odorants that arrive in close synchronization; **B)** Weak NSI effect: Separate sources, their concentrations are less correlated.

Acknowledgments
Research funded by: European Union under grant agreement 785907(HBP SGA2);
Human Frontiers Science Program, grant RGP0053/2015 (Odor Objects).

Model

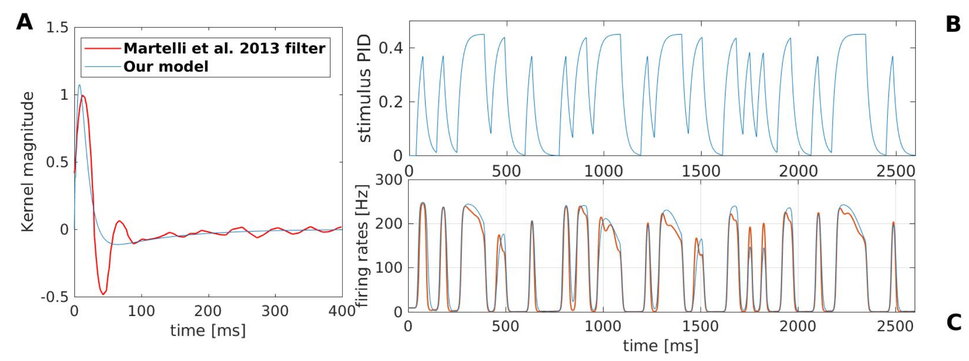
Toy-model of early olfactory area
two ORNs interacting via NSI and their projection neurons (PNs) and local neurons (LNs) in the antennal lobe (AL):



- ORNs: phenomenological model, a first approximation a linear-nonlinear model[5]
- PNs and LNs: Integrate and Fire with adaptation

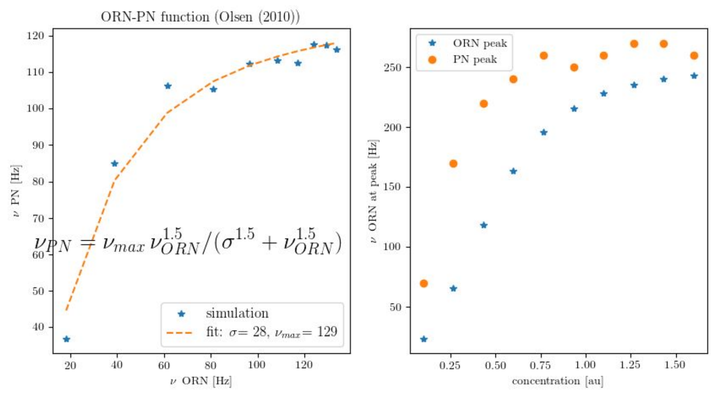
Results (wip)

For several stimulus input waveforms, the model reproduces qualitatively ORN and PN responses observed experimentally

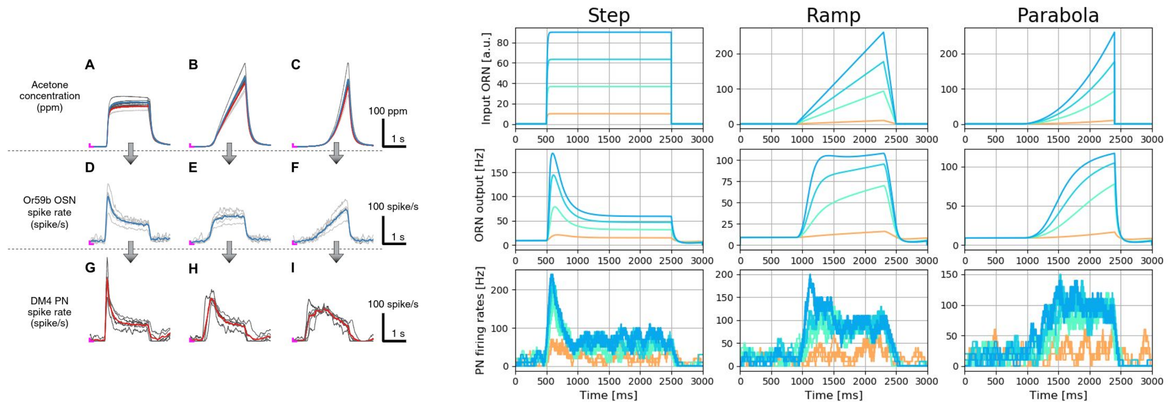


ORN response to a short pulse and a long stimulus

A) ORN response to an infinitely short odorant pulse (Green's function) in comparison to the linear filter in Martelli et *al.*[6]. **B)** Odorant concentration during random odorant pulses. **C)** ORN response to random pulses (B) for the ORN model (in red) proposed in Martelli et al.[6] and for our model (blue).



ORN vs PN responses to a step input. The model reproduces the sigmoidal function shown in Olsen et al.[7].



ORN input and response, PN response

ORN input and response and PN response to three different stimuli - step, ramp, and parabola - as described by Kim et al. (2015)[8].

References

1. Todd J.L., Baker TC. *Insect olfaction*, 1999; 2. Raiser, G. *University of Konstanz, PhD Thesis*, 2018; Su C.Y. et al., *Nature,* 2012; 3. Erskine, A., *Dep. of Neurosci, UCL London,* 2018; 4. Yee, E., et al., *Boundary-Layer Meteorology,* 1995; 5. Kim, A.J., et al., *Journal of computational neuroscience,* 2011; 6. Martelli C., et al., *Journal of Neuroscience*, 2013; 7. Olsen S.R., et al., *Neuron,* 2010; 8. Kim, A. J. et al., *Elife,* 2015.