Characterization of the response of ORNs population to sexual pheromone

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Pherosys summer days, 22-23 rd
June 2009

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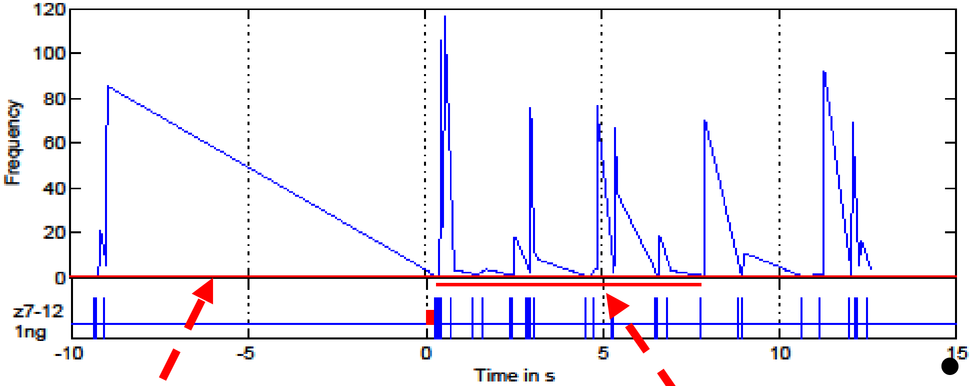
Institut National de la Recherche Agronomique

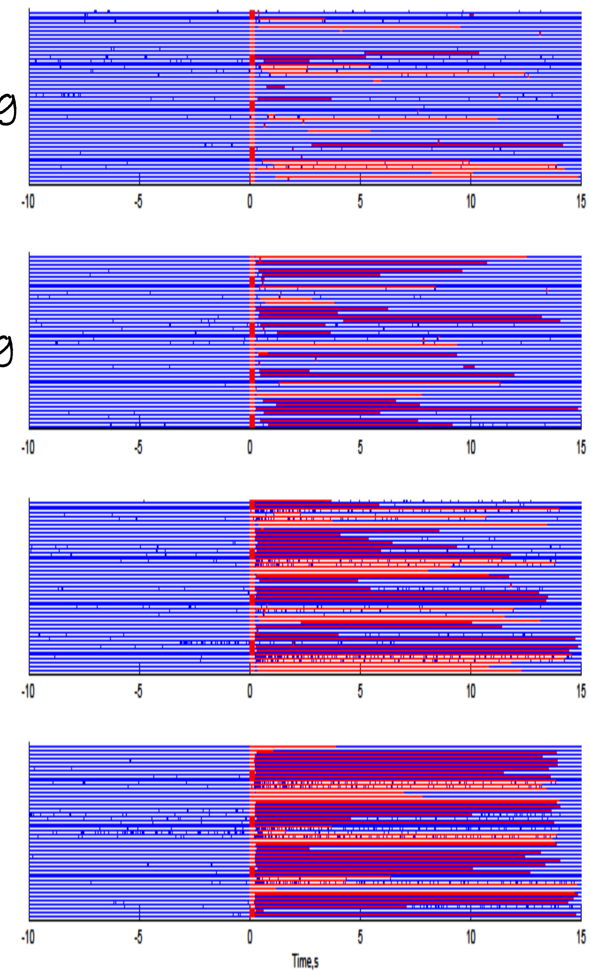
Physiologie de l'Insecte
Signalisation & Communication

Algorithme of responses detection



Threshold frequency= median of spontaneous instataneous frequencies

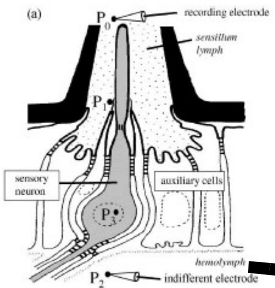
Detected response

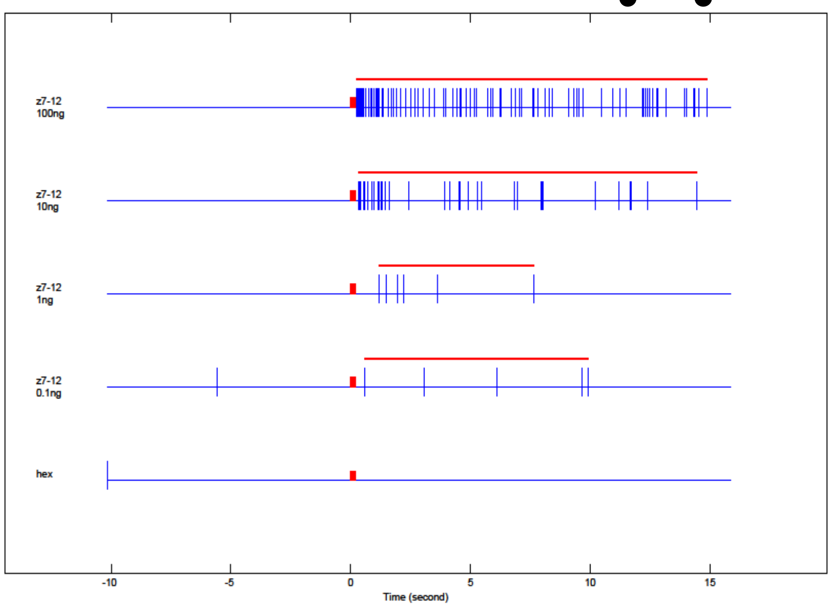


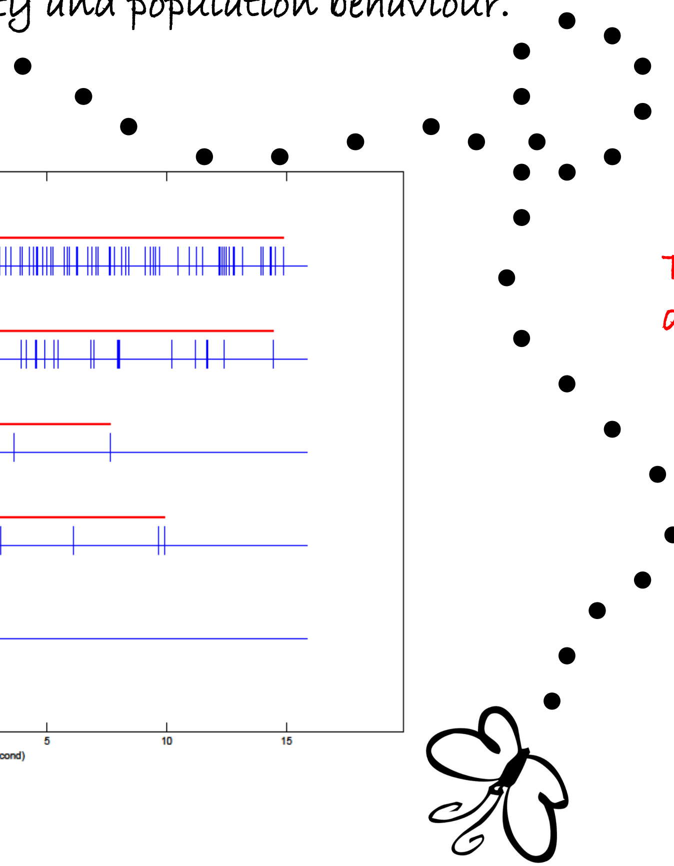
- 45 neurons, 4 doses of Z7-12 + hexane
- 186 detected responses / 223 spike trains

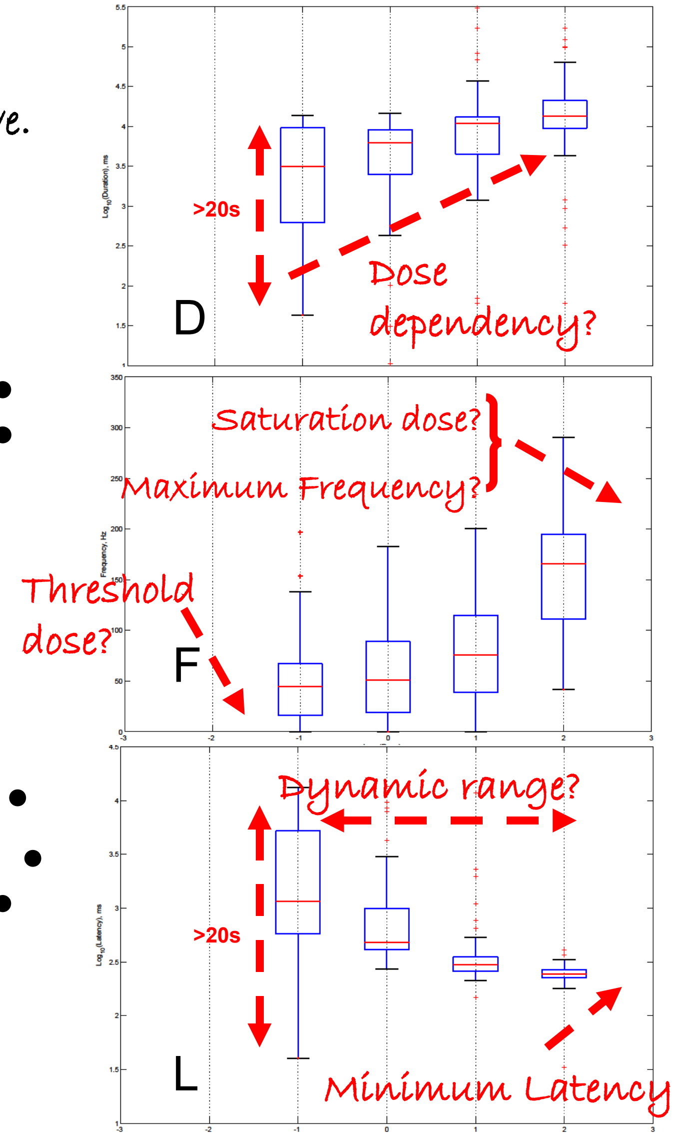
Dose-response curves characteristics

- Quantify single neuron dose-response curve.
- Quantify population dose-response curve.
- Consequences of variability, in term of reliability and population behaviour.



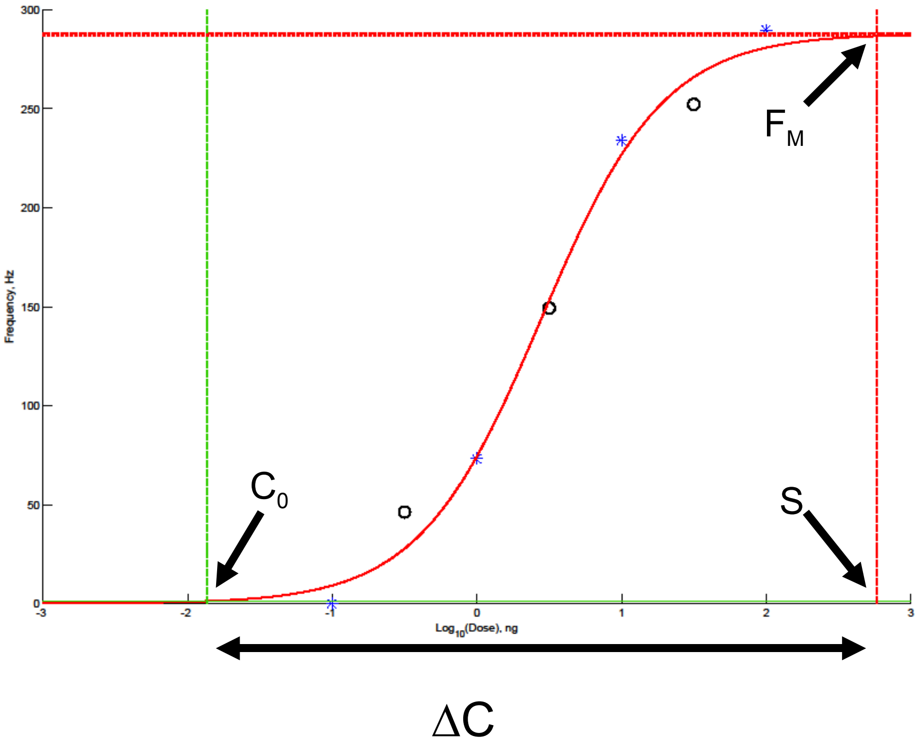


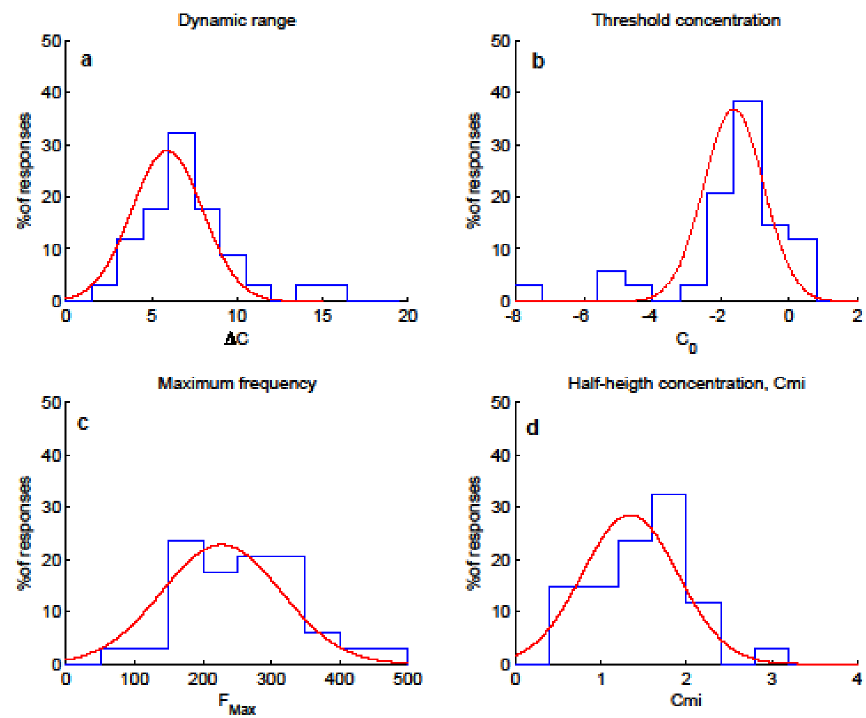




Frequency

- Normal distribution
- Mean C_0=0.015 ng
- Mean ΔC=5.8 decades
- Mean F_M=230 Hz

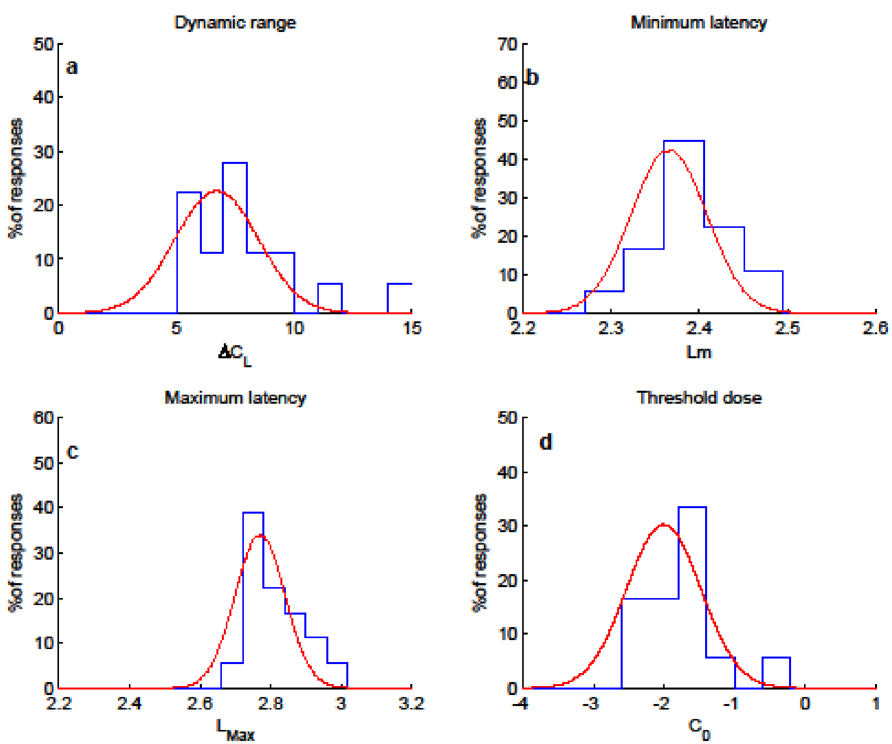


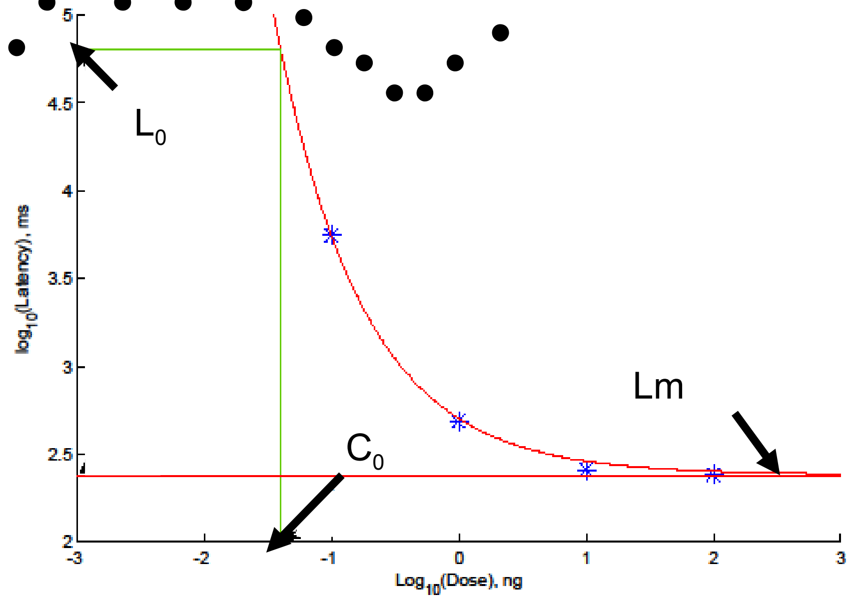


$$F(C) = \frac{F_M}{1 + e^{(-\ln(10).n.(C - C_{mi}))}}$$

Latency

- Normal distribution
- Mean L_m=200 ms
- Mean L_{Max} = 330 ms

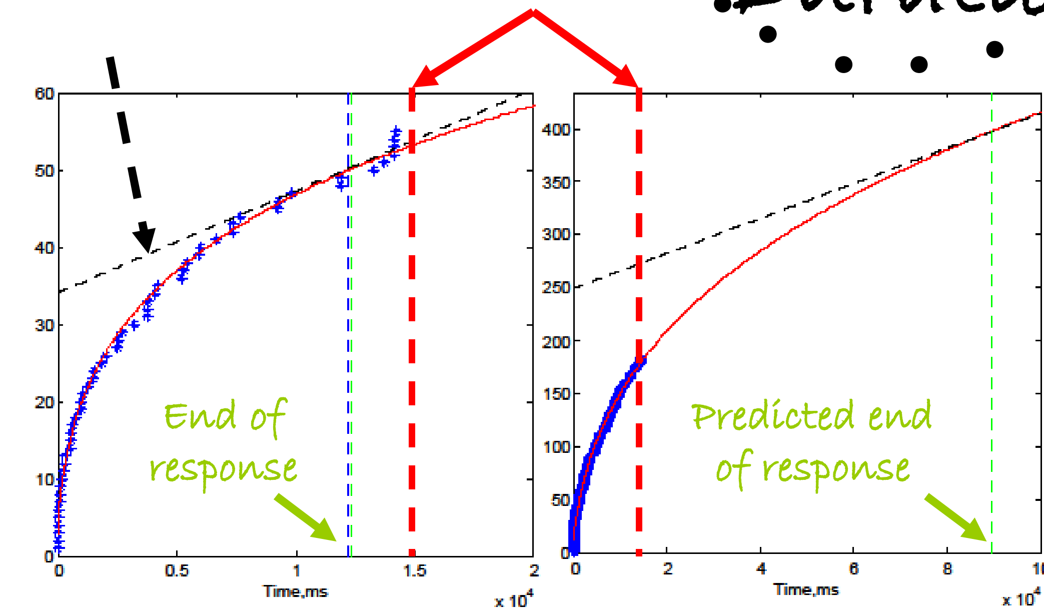




$$L(C) = L_0 . e^{-\lambda (C - C_0)} + L_m$$

$$L_{Max} = L_0 + L_m$$

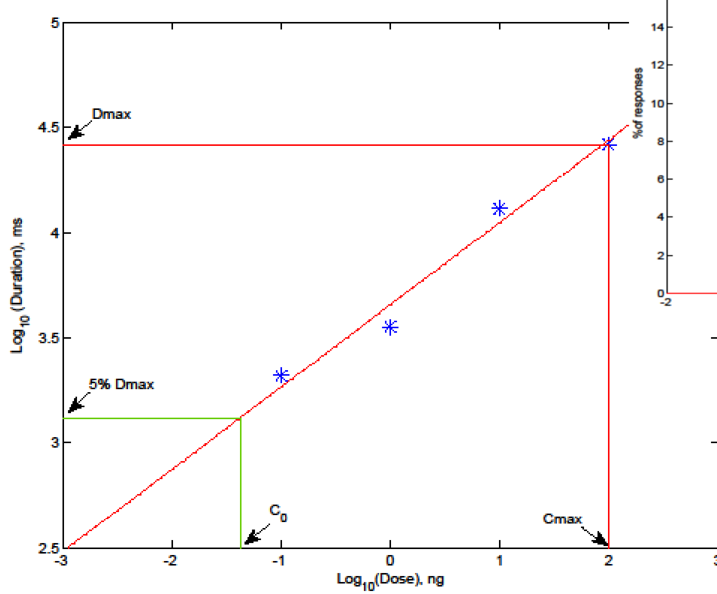
Duration :

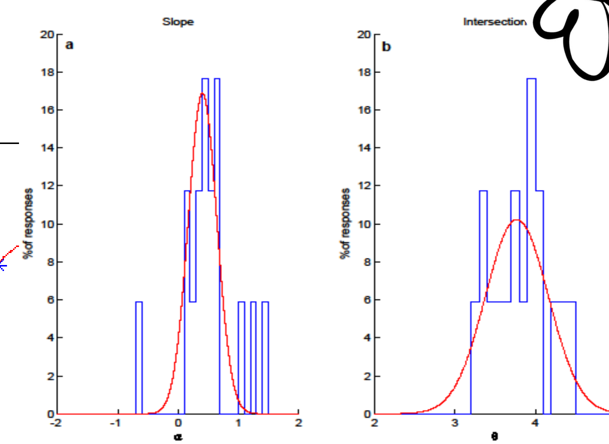


$$N(t) = \begin{cases} N_{10}.[\log_{10}(t - t_0)]^{\beta} & \text{for } t \in \,]t_0, +\infty[\\ \dfrac{F_S}{1000}.t & \text{for } t < t_0 \end{cases}$$

$$\log_{10}(D(C)) = \alpha\, C + \theta$$

- Normal distribution
- Mean Slope=0.3 ms/ng
- Mean D(1ng)=6s

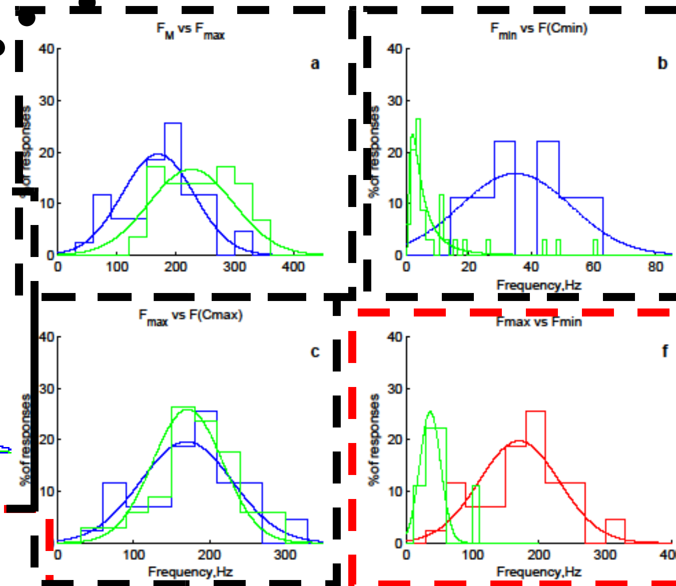


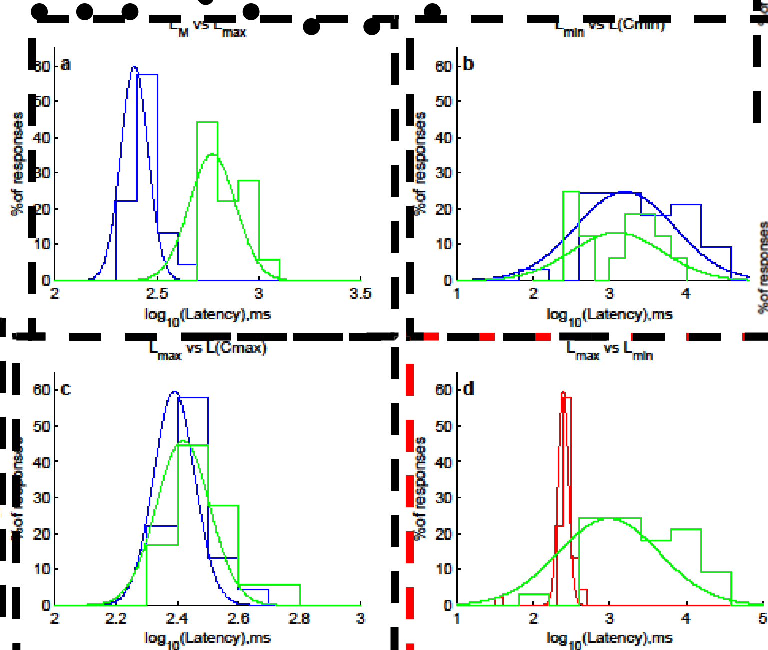


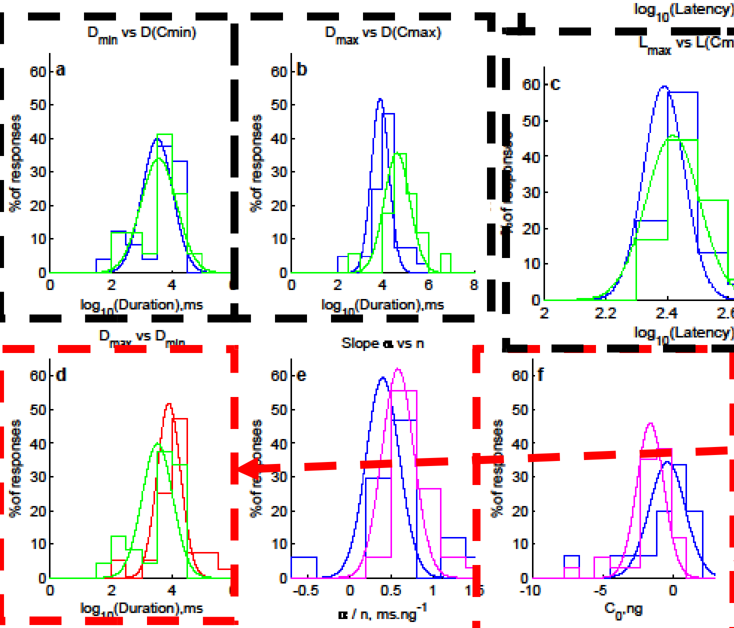
Fitted parameters vs empirical values

$F_{max}, L_{max}, D_{max}$ = F, L, D at 100 ng

$F_{min}, L_{min}, D_{min}$ = F, L, D at 0.1 ng





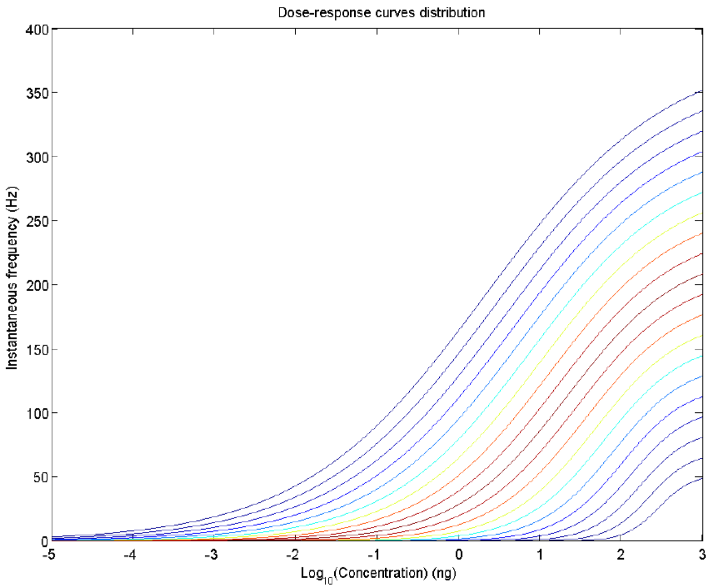


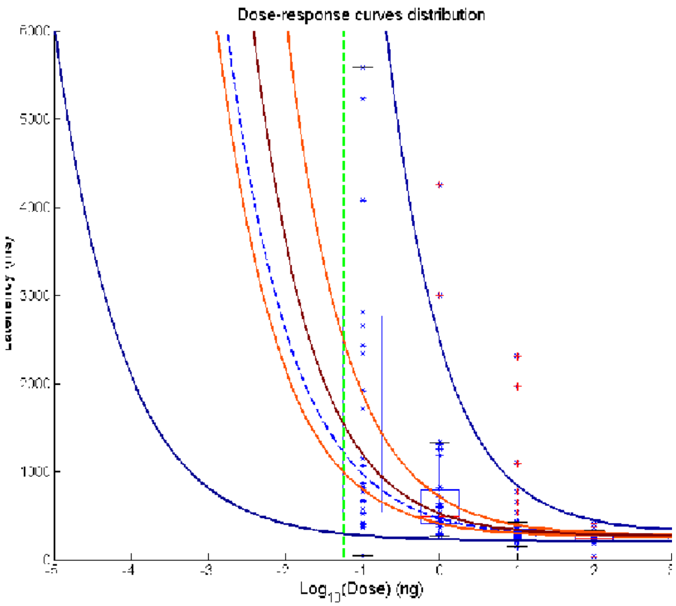
Matematical model and empirical values in accord.

Large overlaping between L_{max} and L_{min}

Confirmation of theoretical threshold

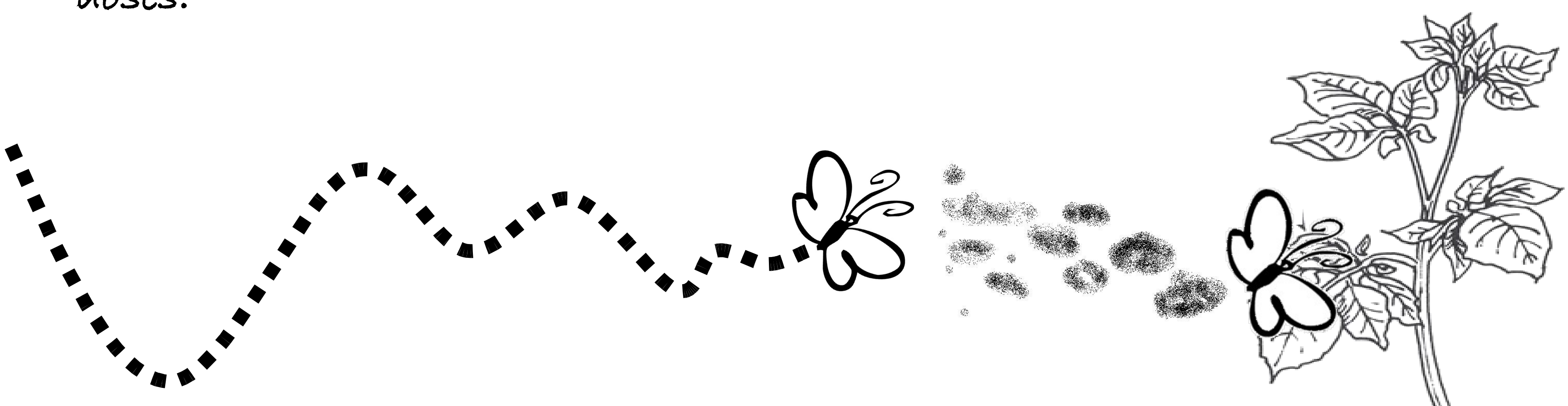
Mathematical model of ORN nerve



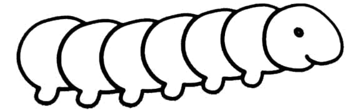


Conclusions

- All ORN respond more or less efficiently in a same range of stimuli.
- Single ORN do not gives reliable information on the dose, especially when looking to duration.
- A minimum population of ORNs gives a reliable image of the intensity of a stimulus.
- The variability: -> blend response delay in a population for ≠ doses.
  -> blend response duration in a population for ≠ doses.



Perspectives



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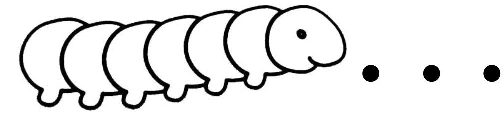
1.Finish to build a mathematical model of ORN population

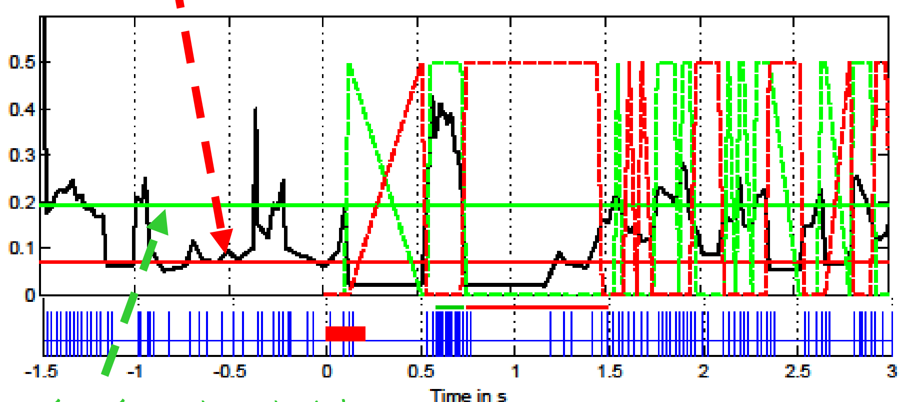
- The bases of mathematical model are put down.
- We must take into consideration parameters interdepondency.
- The link between maximum frequency and mean frequency has to be determined
- Finally a typical population response simulation will soon be possible.

Perspectives

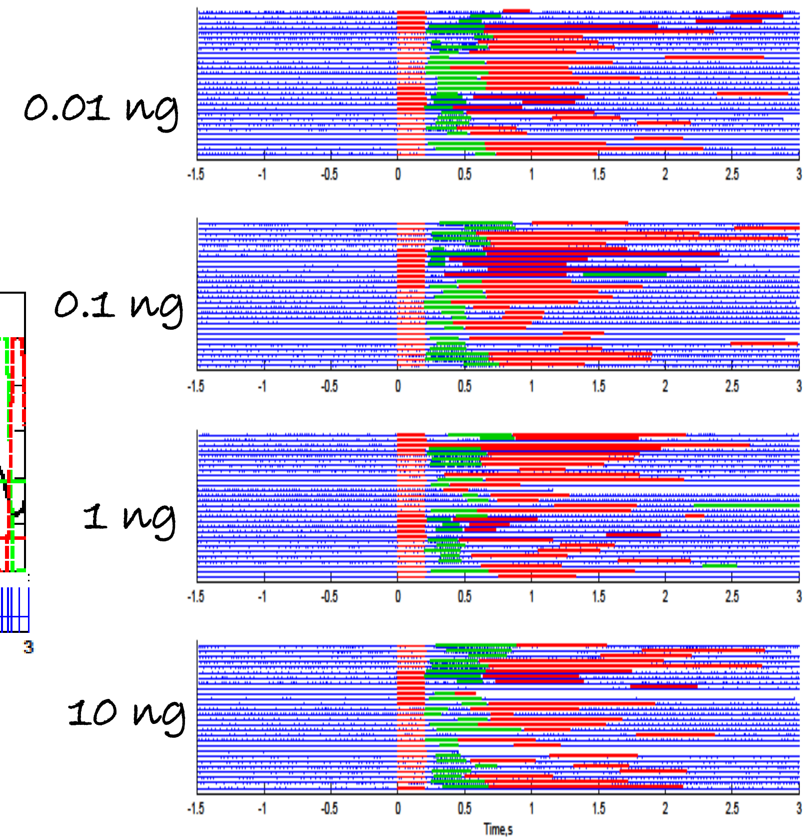


2.First results for PNs analyze

Inhibition threshold = first quartile of instataneous frequencies after the stimulus

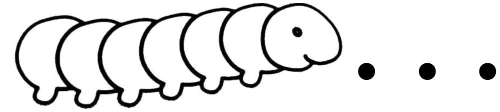


Excitation threshold = median of spontaneous instataneous frequencies



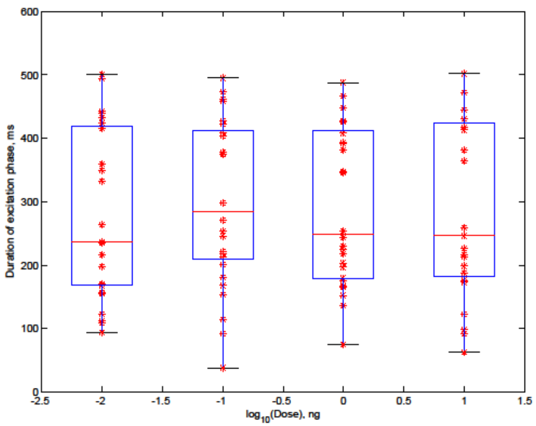
In a first look, the PN population do not differentiates doses.

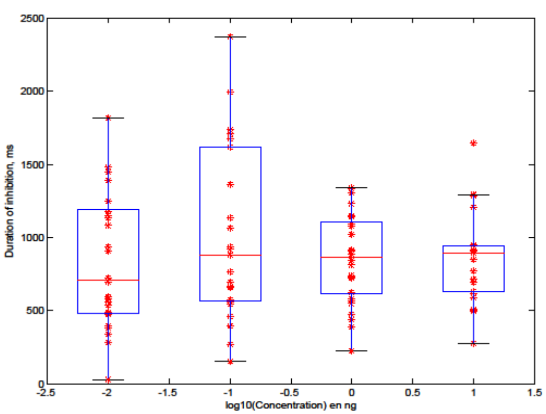
Perspectives



2.First results for PNs analyze

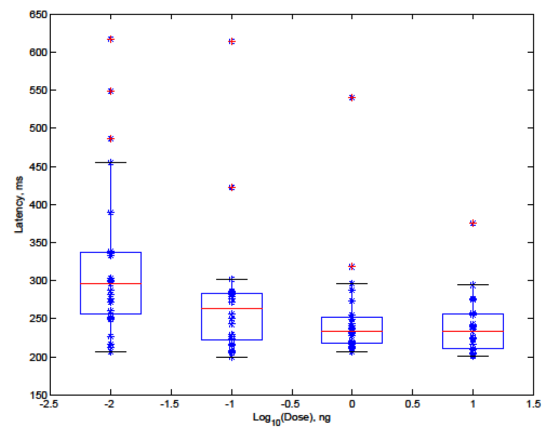
Duration of excitation and inhibition are not significantly ($p>0.3$) dependent of dose





A function to fit dose-response curve will be find for latency and frequency.

$$L = L_a . e^{-\lambda (C - C_0)} + L_m$$



$$F(C) = F_m \left(\frac{2}{1 + e^{-\log(n(C - C_0))}} - 1 \right)$$