A neuronal model for visually evoked startle responses in schooling fish

Master defense by
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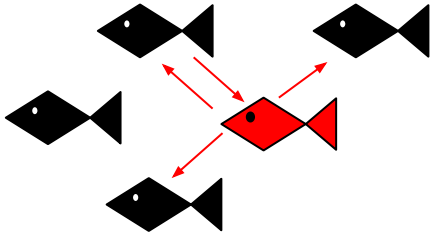
22.08.2018, Berlin

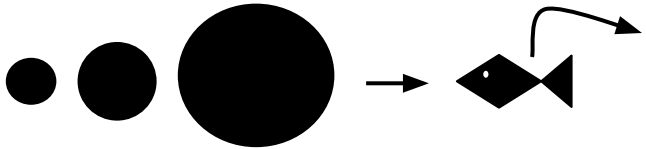
Motivation

high



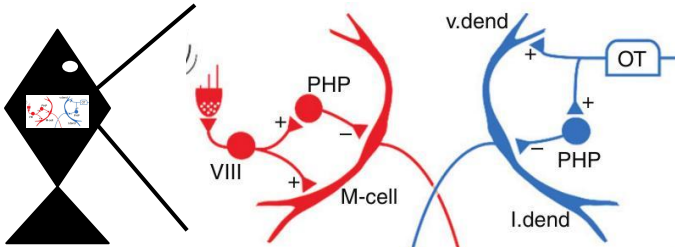
Collective behavior

Bridging scales



Individual behavior

low

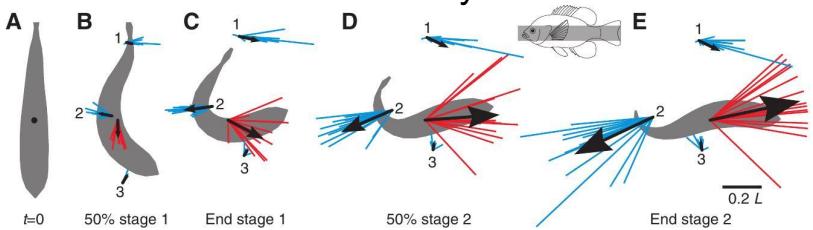


Neuronal mechanism

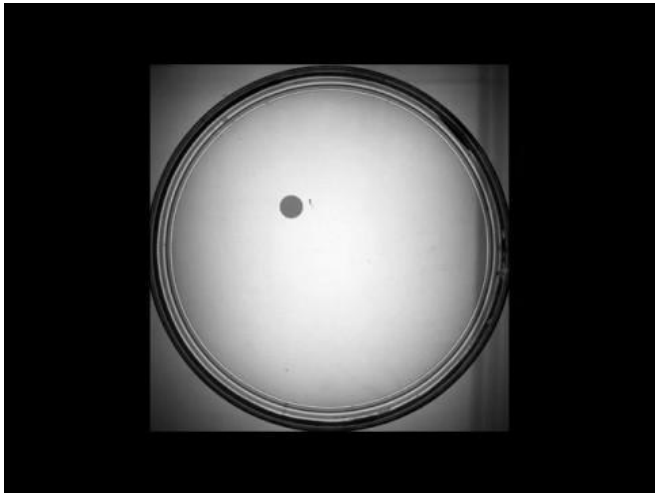
Pfaff et al. 2012

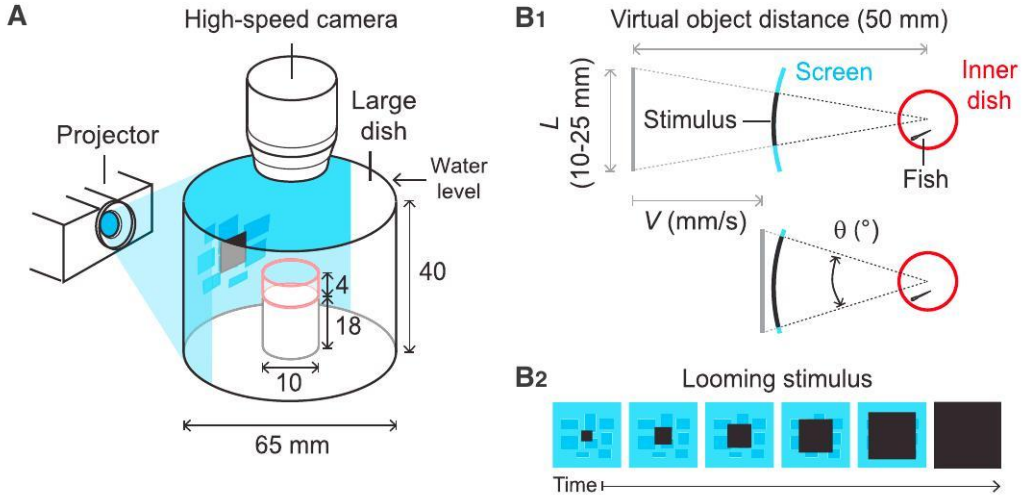
Startle Response

Tytell and Lauder 2008



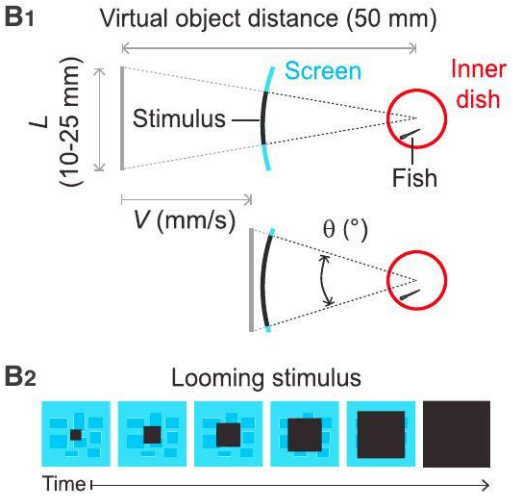
Dunn et al. 2015

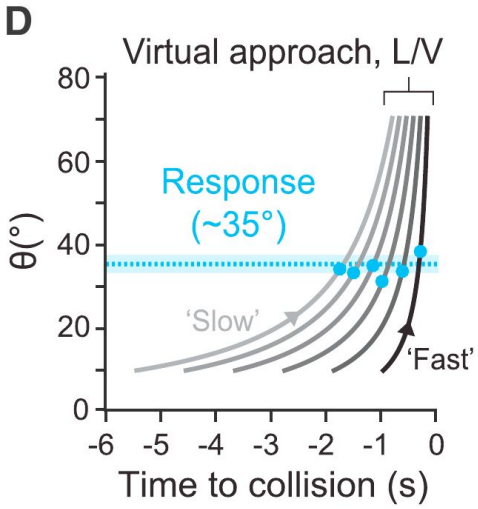




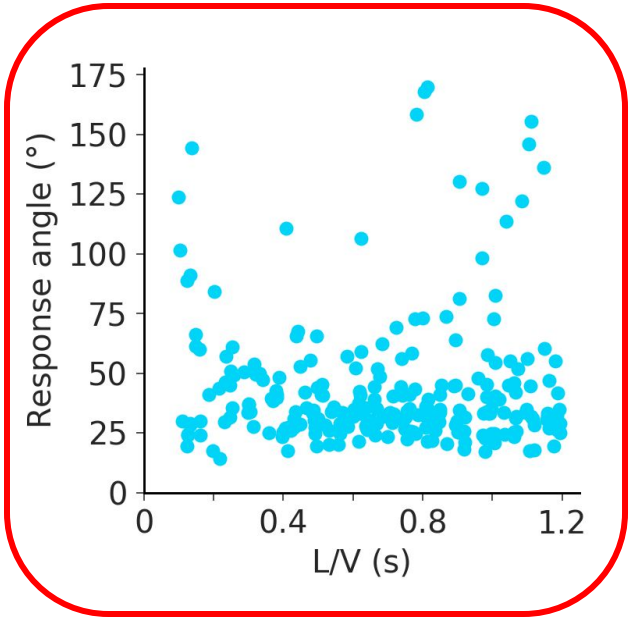
Bhattacharya et al. 2017

Data of interest: response angle

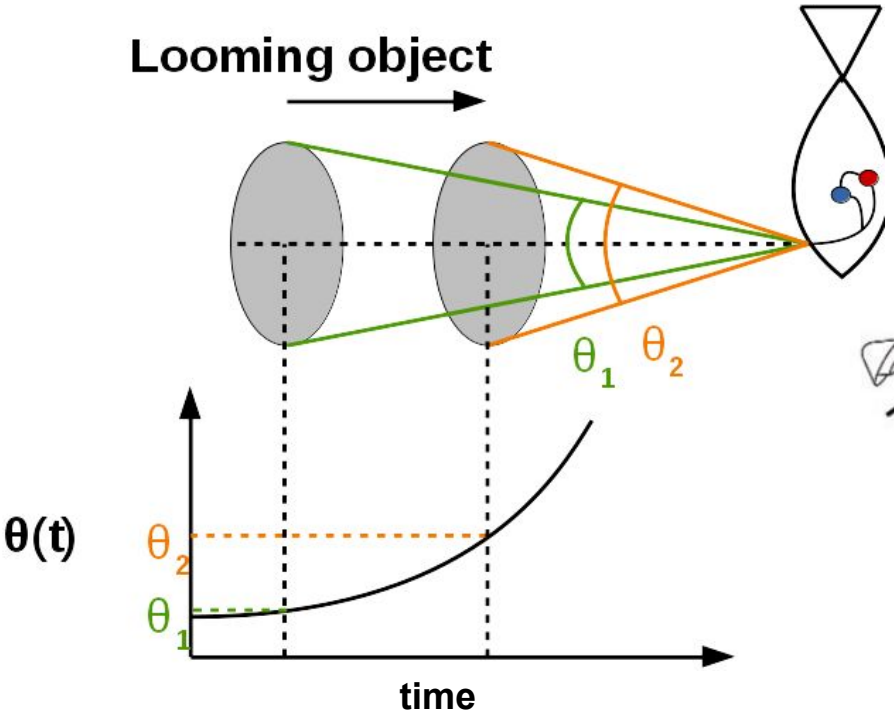


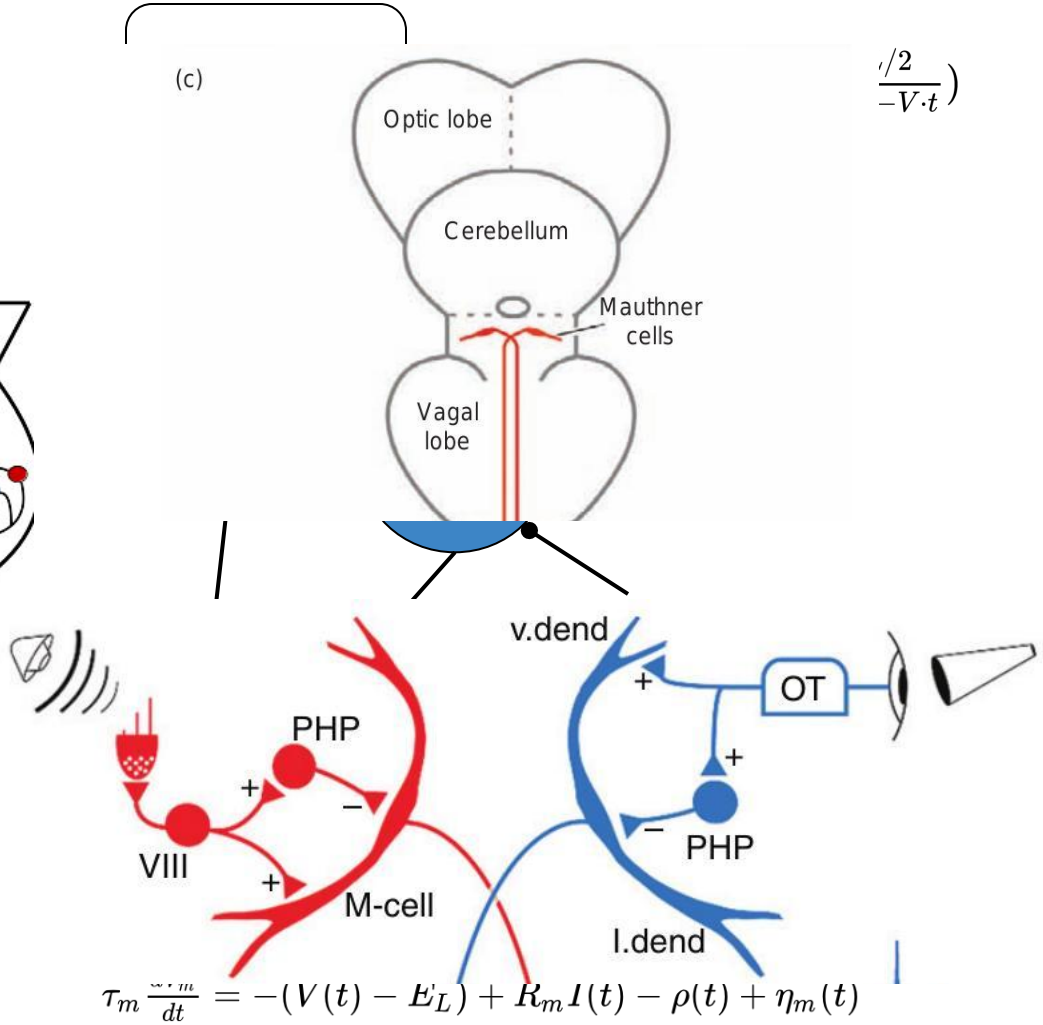


Goal: Reproduce this



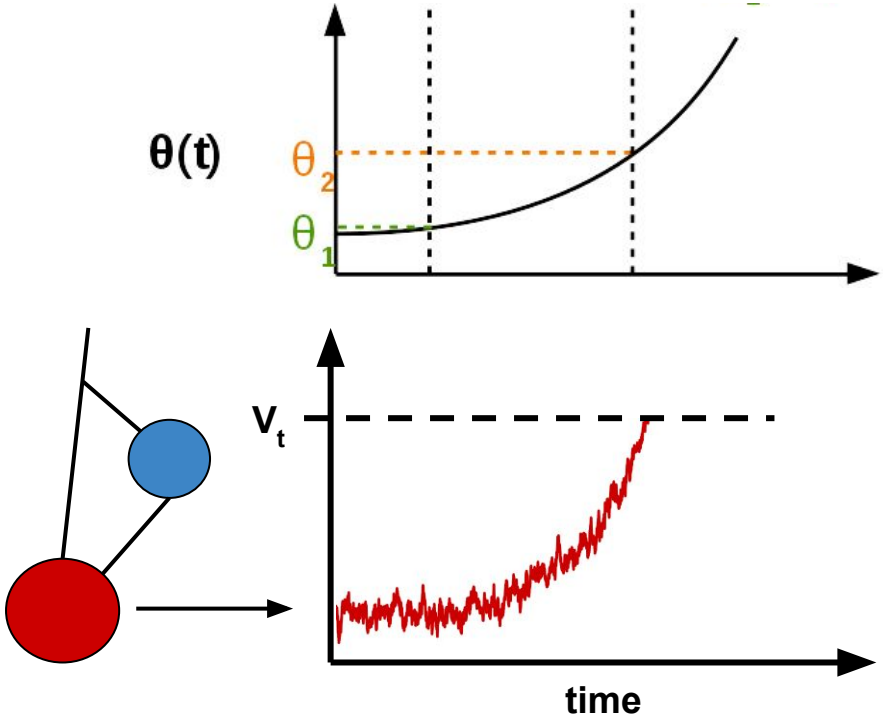
Neuronal Model





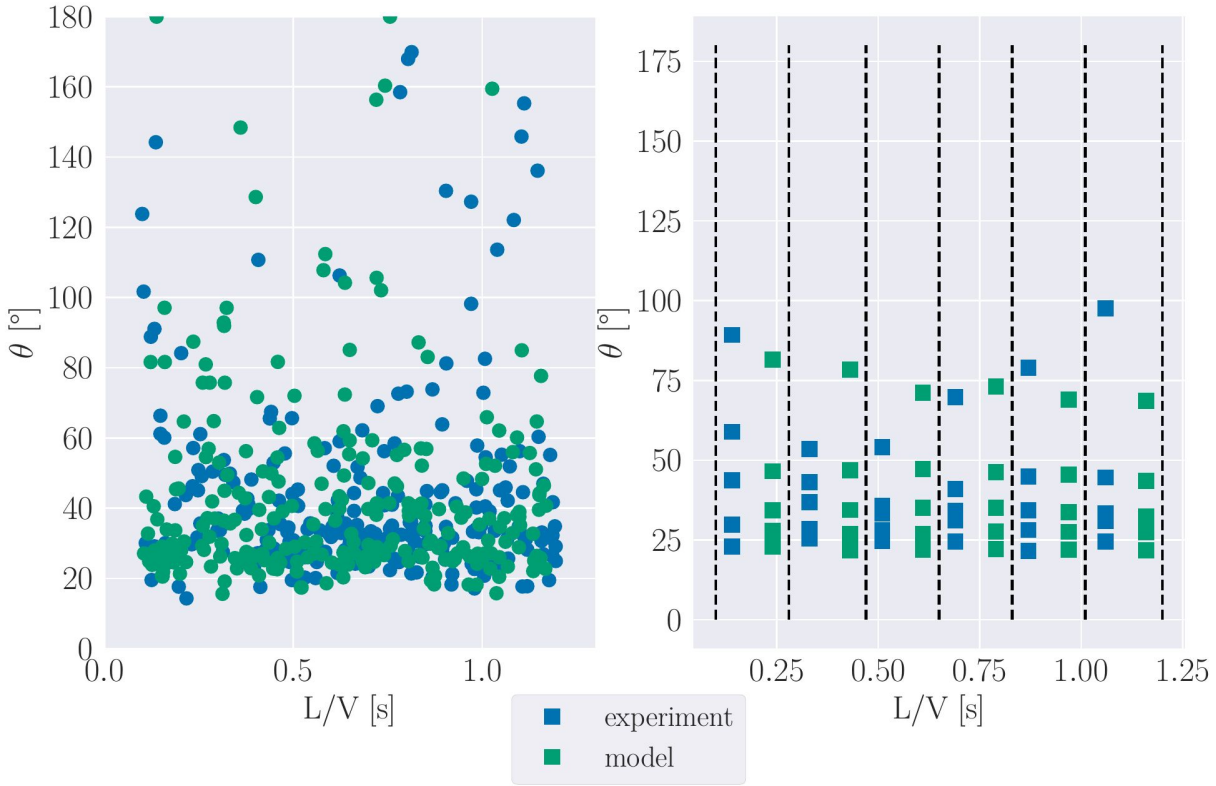
$$\tau_m \frac{dV_m}{dt} = -(V(t) - E_L) + R_m I(t) - \rho(t) + \eta_m(t)$$

Model response angle

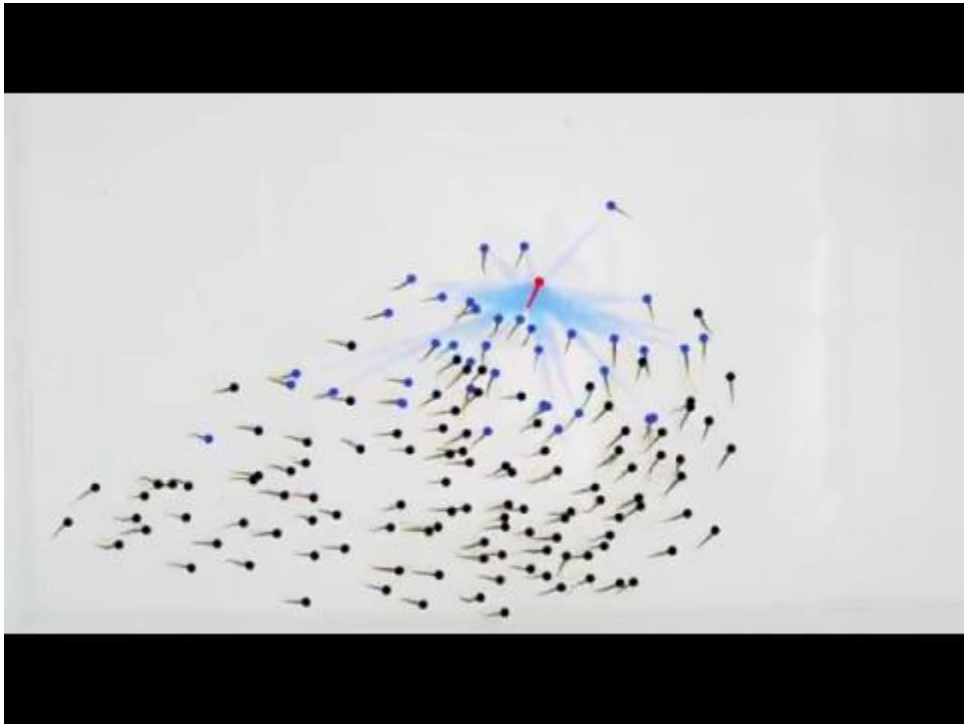


→ Model response angle: θ_2

Model fit result



Collective behvaior

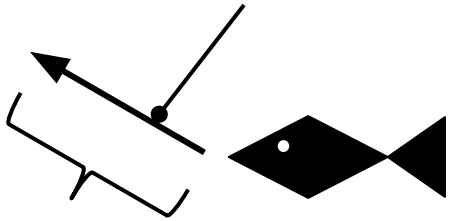


Rosenthal et al. 2015

Collective behavior model

- 2 Dimensions
- self-propelled agents
- 3 social forces

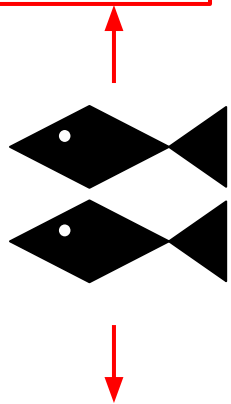
$$\vec{v}_i(t) = \begin{pmatrix} s_i \cos(\varphi_i(t)) \\ s_i \sin(\varphi_i(t)) \end{pmatrix}$$



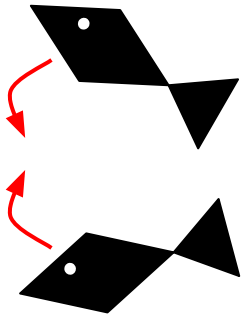
$$\frac{ds_i}{dt} = \alpha \left(\mu_s - s_i \right) + \eta_{i,s} + F_{i,s}$$

Collective behavior model

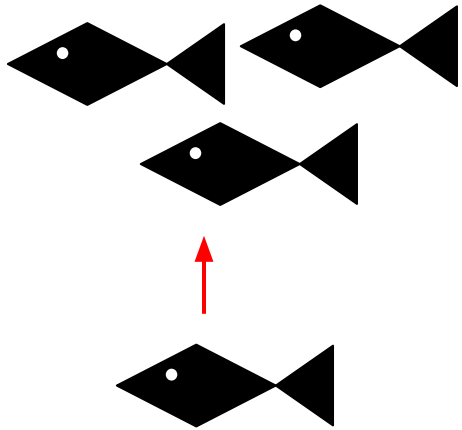
- 2 Dimensions
- self-propelled agents
- 3 social forces



Repulsion



Alignment

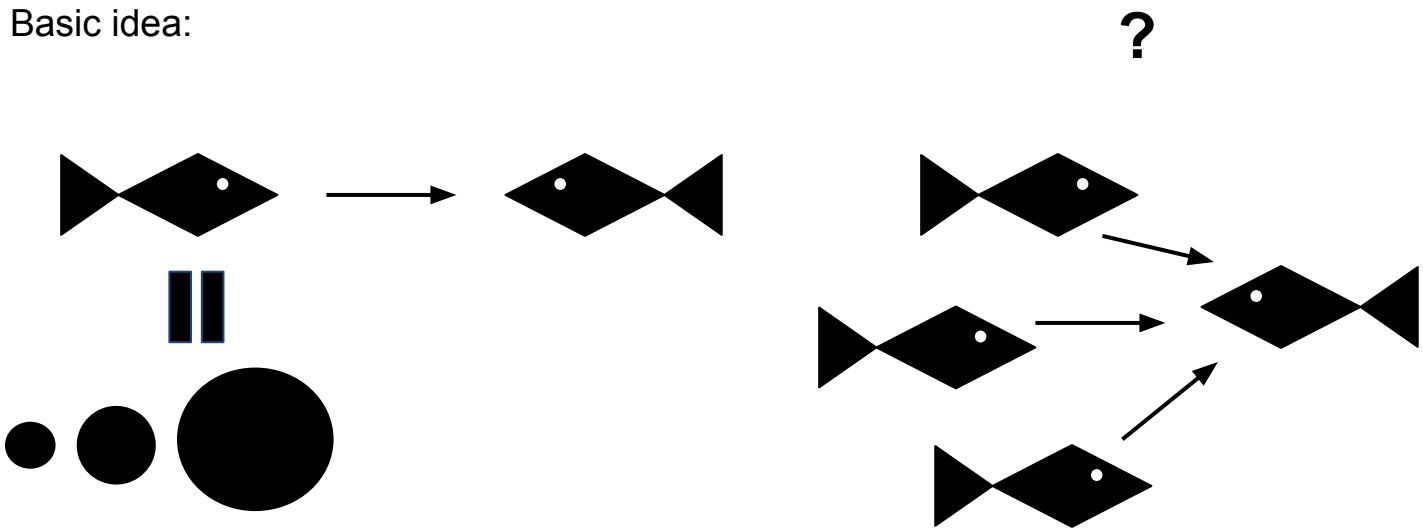


Attraction

Collective behavior model

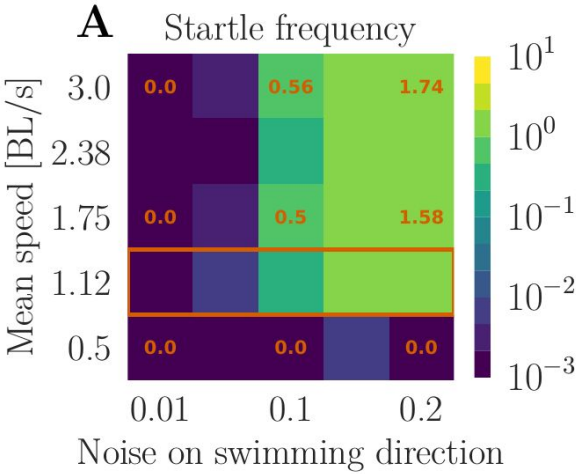
Integration of neuronal model

Basic idea:



Collective behavior model - simulation

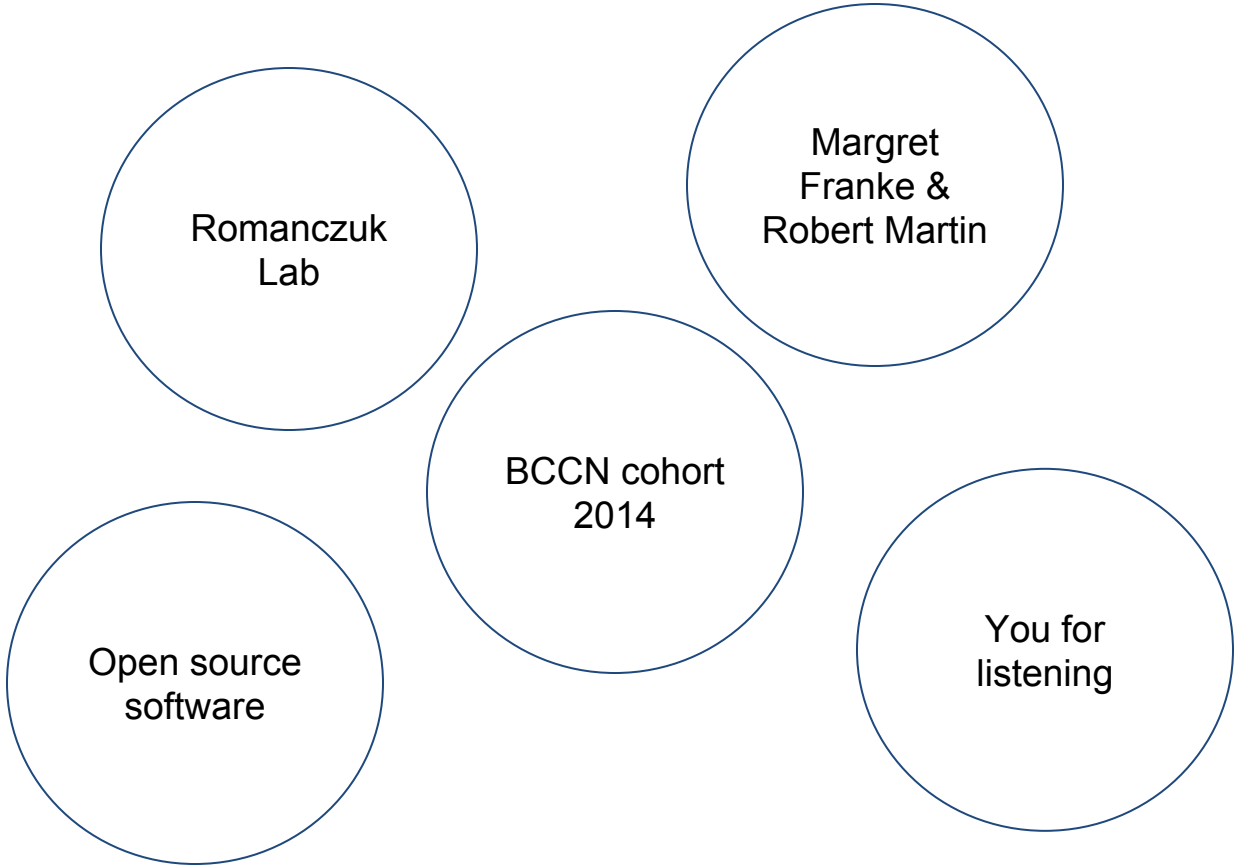
Collective behavior results



Discussion

- fitted neuronal model can reproduce experimental response angle distribution
    - but: many ways to extend/constraint it
- collective model + neuronal model can lead to experimental startle frequencies
    - needs more investigation

Thanks.


Romanczuk Lab
Margret Franke & Robert Martin
BCCN cohort 2014
Open source software
You for listening