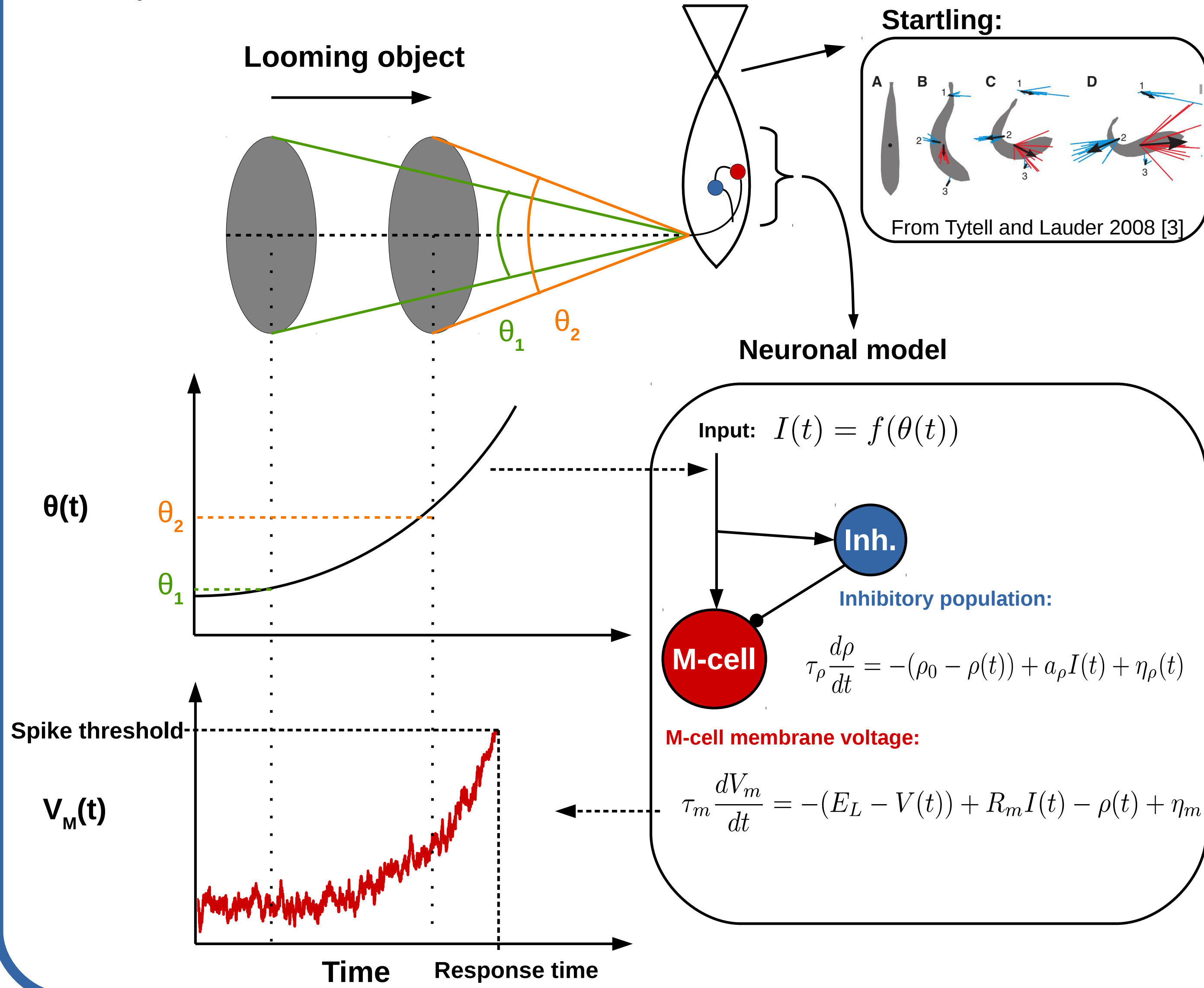


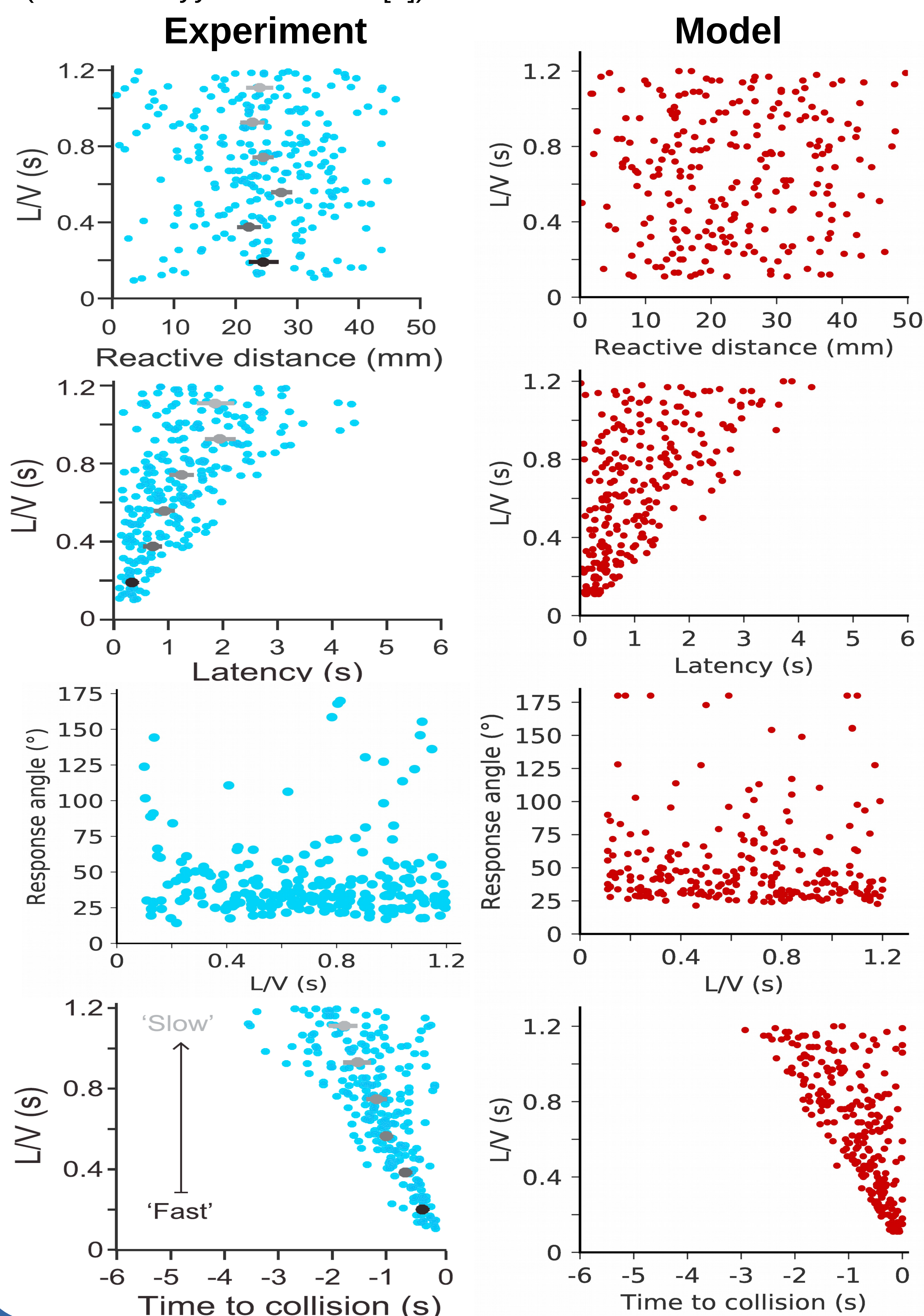
## 1) Introduction & Neuronal model

- The Mauthner-cell (M-cell) circuit has been identified to be responsible for the startle response in fish but we still lack a mechanistic understanding
- The startle response is known to spread in fish schools dependent on the network structure (Rosenthal et al. 2015 [1]).
- Here we:
  - Find a neuronal model that reproduces behavior in a visual looming stimulus experiment (Bhattacharyya et al. 2017 [2])
  - Combine the neuronal model with a collective behavior model to explore the initiation of startles in a fish school

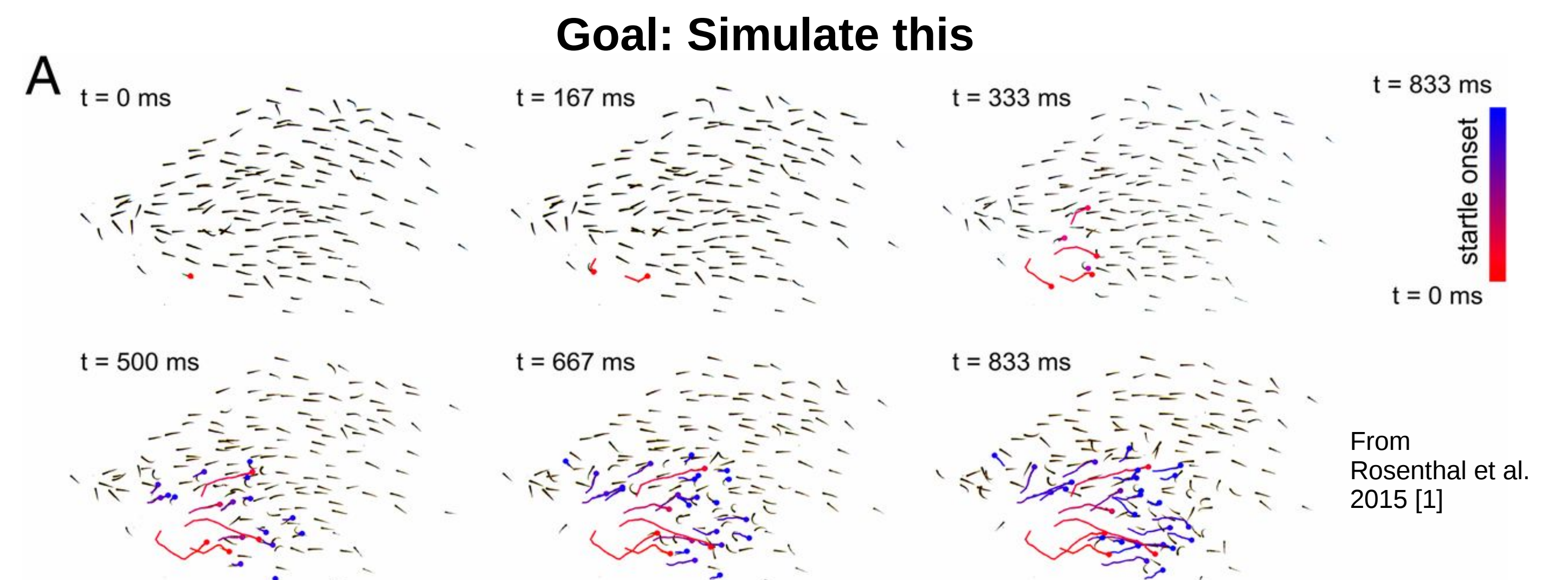


## 2) Neuronal model reproduces experimental response properties

Using the instantaneous visual angle as input for the neuronal model we can reproduce the patterns of response distance, response time and time-to-collision as well as the response angle that were found in an experiment with different approach speeds of a looming stimulus (Bhattacharyya et al. 2017 [2]).



## 3) Collective behavior model



Brownian motion + Social forces + Startle mechanism

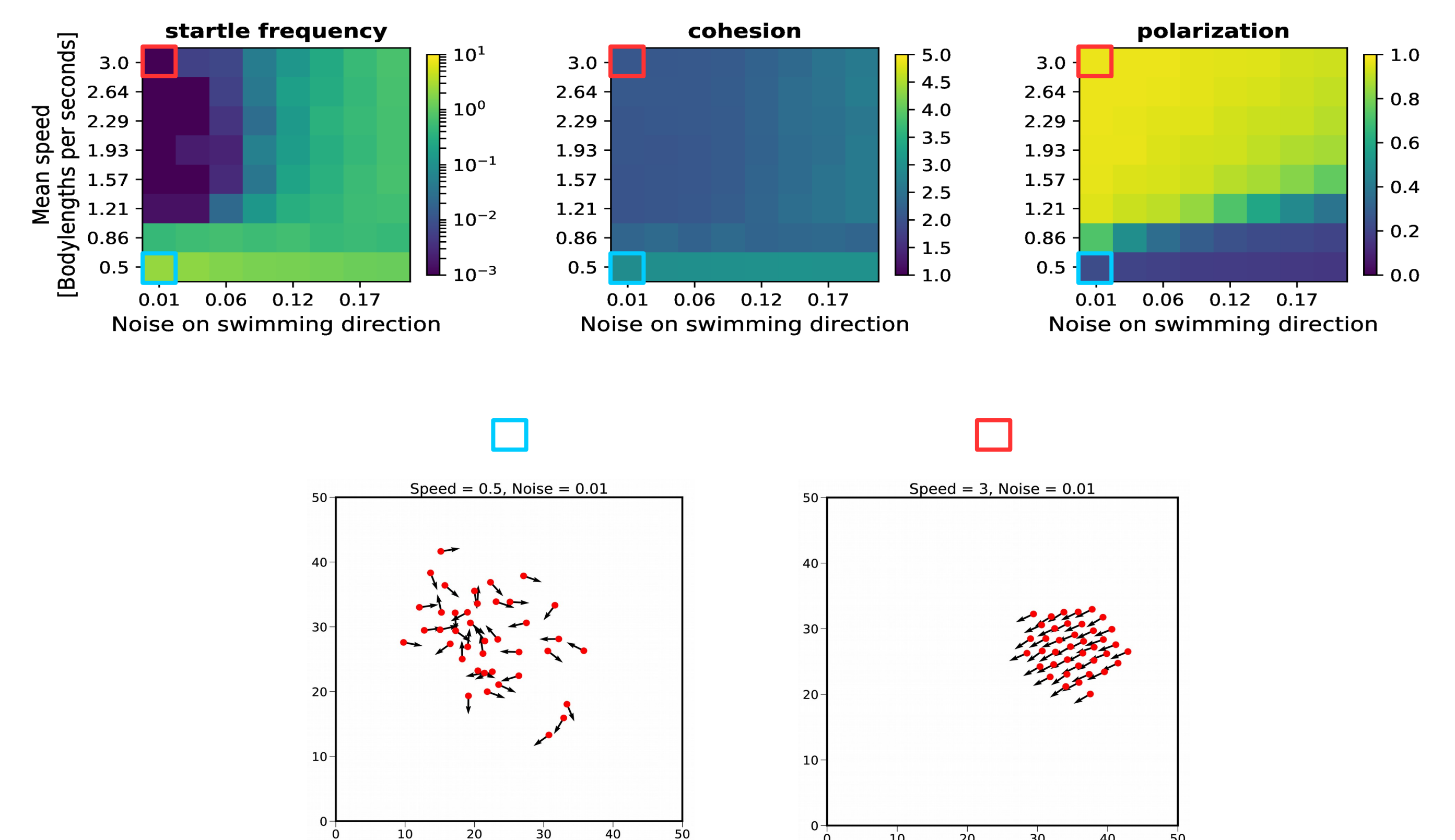
$$\frac{d\vec{r}_i}{dt} = \vec{v}_i(t)$$

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

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

$$\frac{d\varphi_i}{dt} = \frac{1}{s_i + c_s} (F_{i,\varphi} + \eta_{i,\varphi})$$

## 4) Collective behavior results



## 5) Discussion & Outlook

- A simple neuronal model can reproduce response properties of fish in a looming stimulus experiment
- We are able to combine the neuronal model with a individual-based collective behavior model in order to analyze startle initiation in fish schools
- First results suggest that the polarization of the school determines the startle frequency but further investigation is needed

Outlook Neuronal Model:

- How is the visual input related to the visual field of the fish?
- What happens if more than one stimulus is present at the same time?
- Can we also explain experimental response probabilities?

Outlook Collective Behavior Model:

- Are startle frequency and polarization also correlated in a temporal manner?
- How is the startle frequency related to the cohesion of the school?

## 6) References & Links

- Rosenthal et al. 2015, PNAS, 112:4690–4695, doi:10.1073/pnas.1420068112
- Bhattacharyya et al. 2017, Current Biology, 27 (18):2751 – 2762.e6, doi:10.1016/j.cub.2017.08.012
- Tytell and Lauder 2008, J. of Exp. Biology, 211(21):3359–3369, doi:10.1242/jeb.020917.

Github repository: <https://github.com/awakenting/master-thesis>