A neuronal model for visually evoked startle responses in schooling fish

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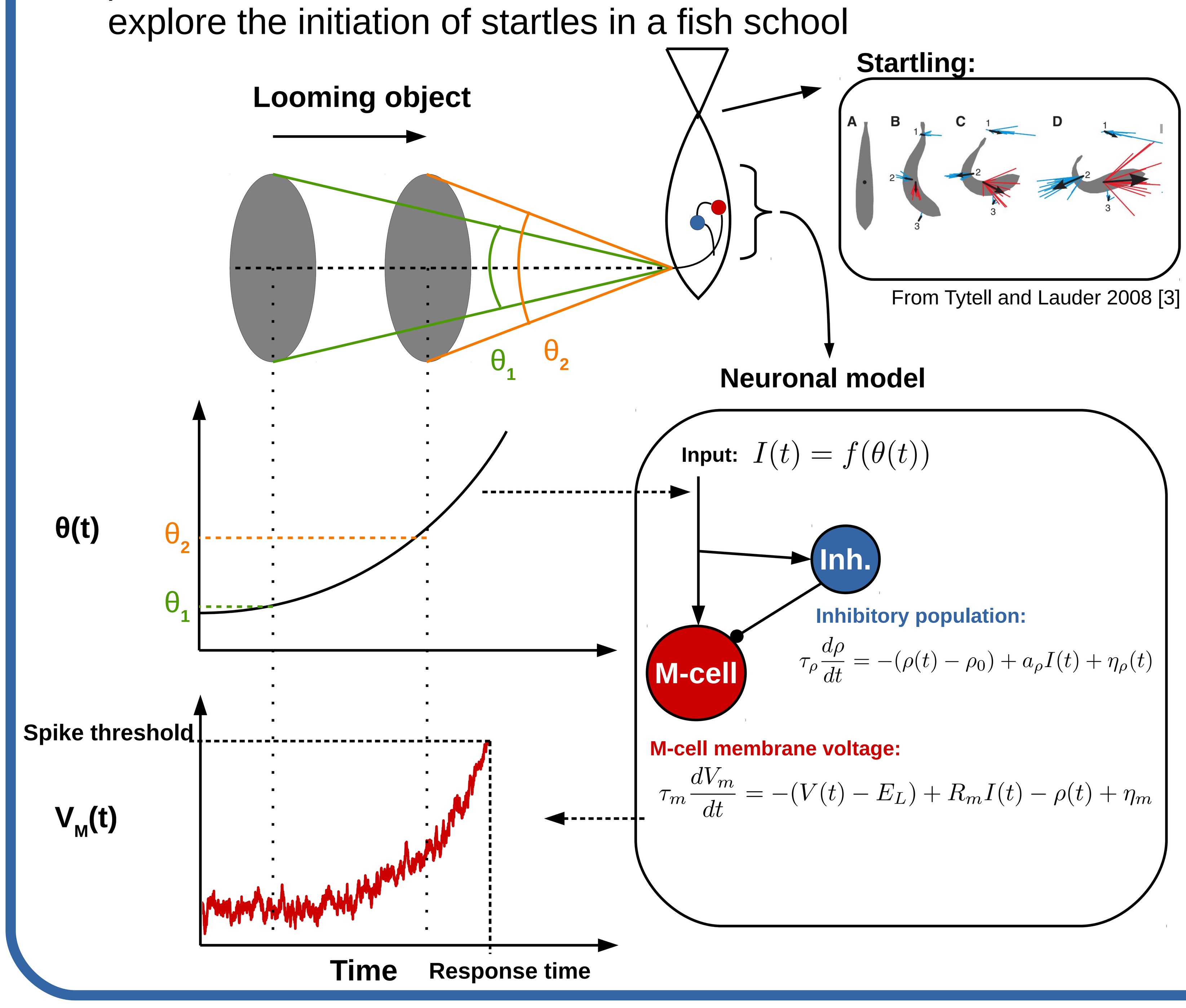
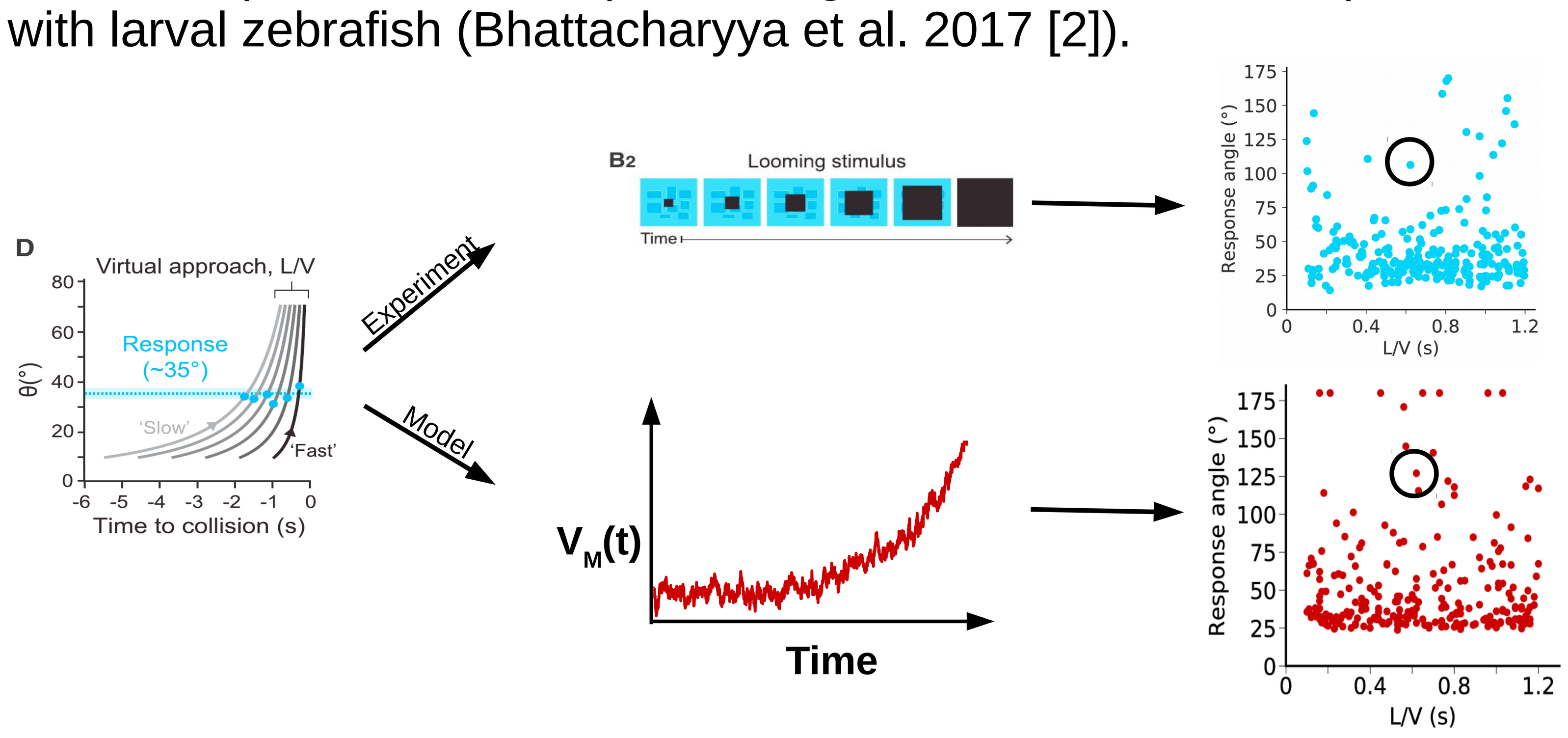
1) Introduction & Neuronal model

- 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:
  1) Fitted a neuronal model that reproduces behavior in a visual looming stimulus experiment (Bhattacharyya et al. 2017 [2])
  2) Combine the neuronal model with a collective behavior model to explore the initiation of startles in a fish school

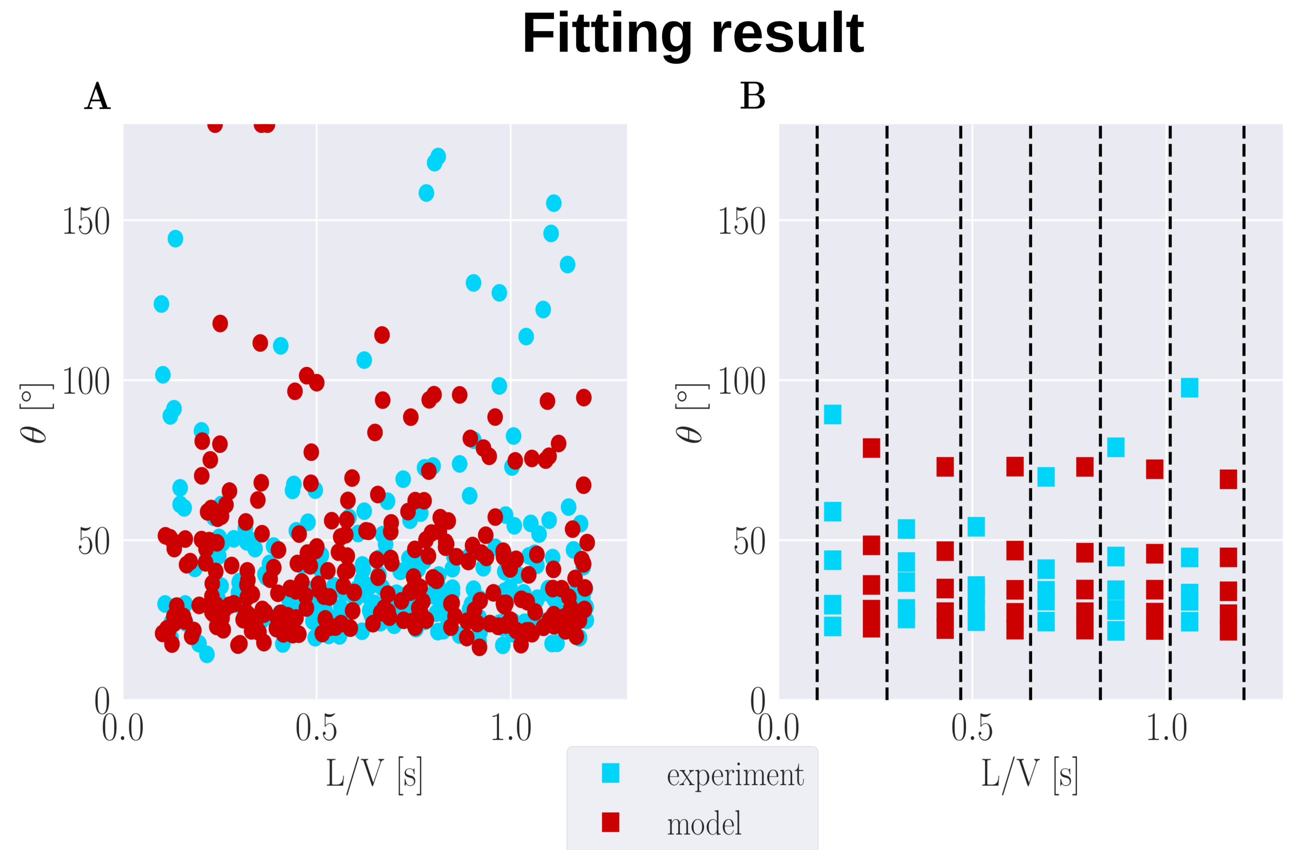


2) Fitted model reproduces experimental response angles

Using the instantaneous visual angle as input for the neuronal model we can reproduce the response angle distribution from experiments with larval zebrafish (Bhattacharyya et al. 2017 [2]).

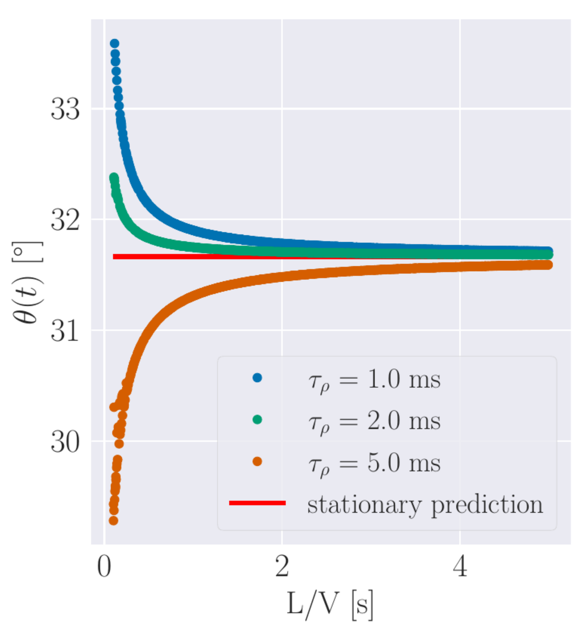


Fitting result



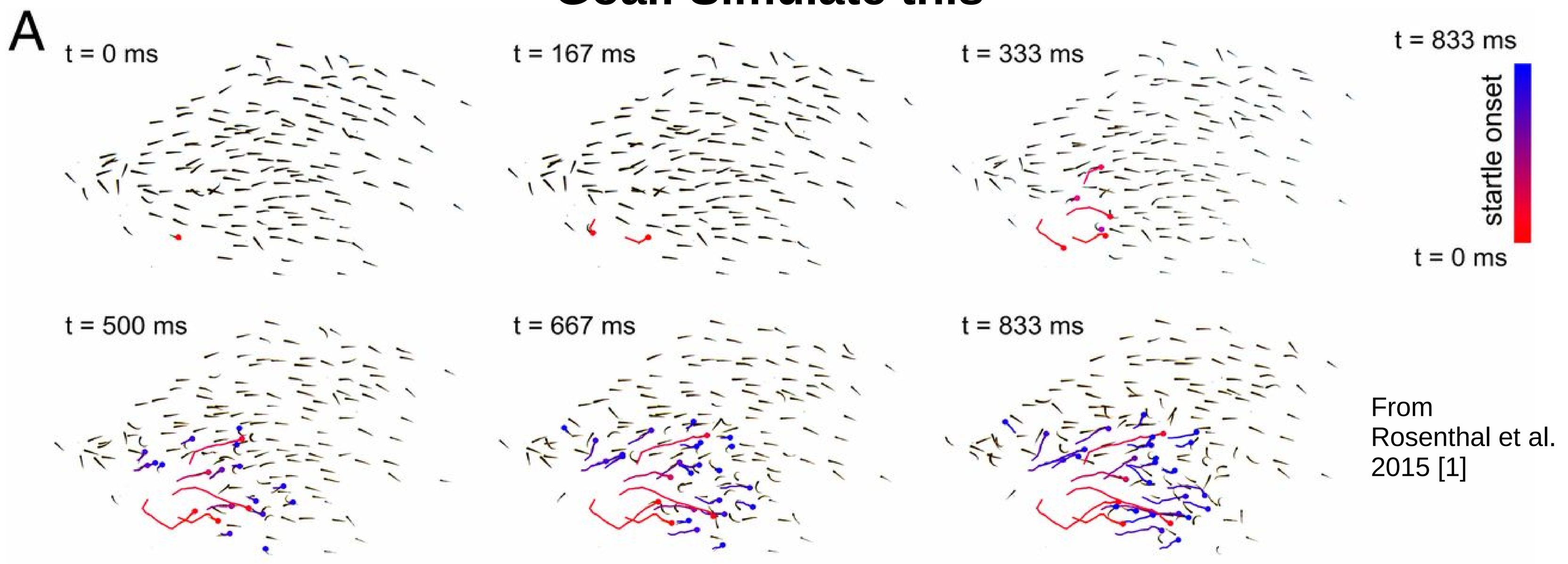
3) Model prediction

If the assumptions of our model are accurate, it predicts that faster stimuli than currently used in experiments would show larger deviations from the mean response angle of slower stimuli. How it deviates depends on the time constant of the inhibitory population activity.

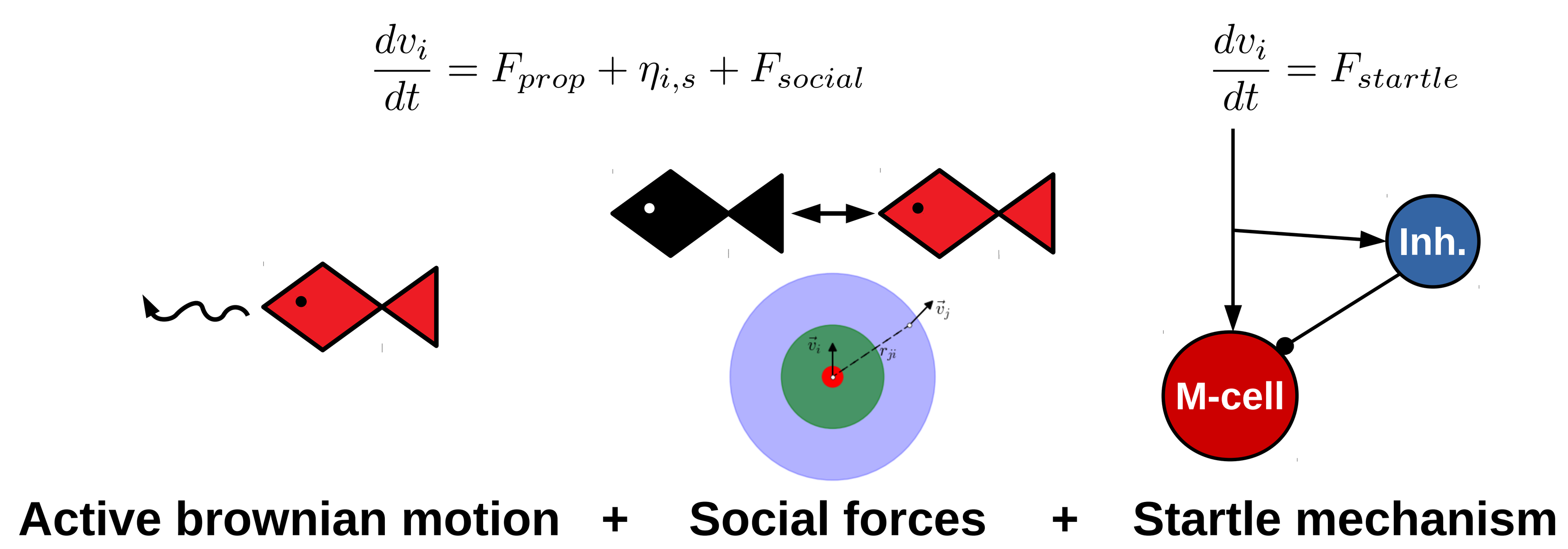


4) Collective behavior model

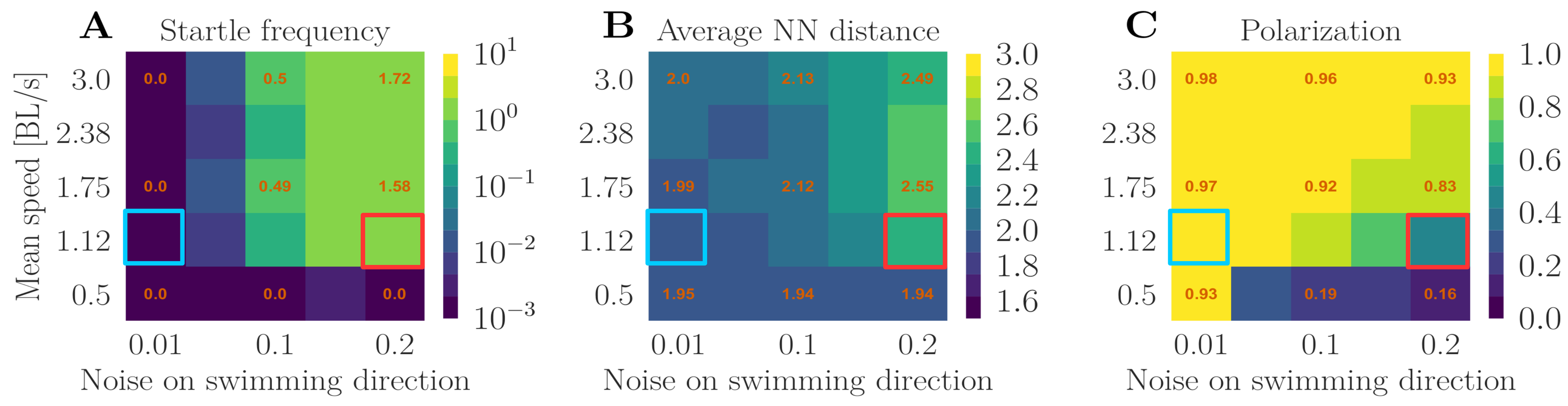
Goal: Simulate this

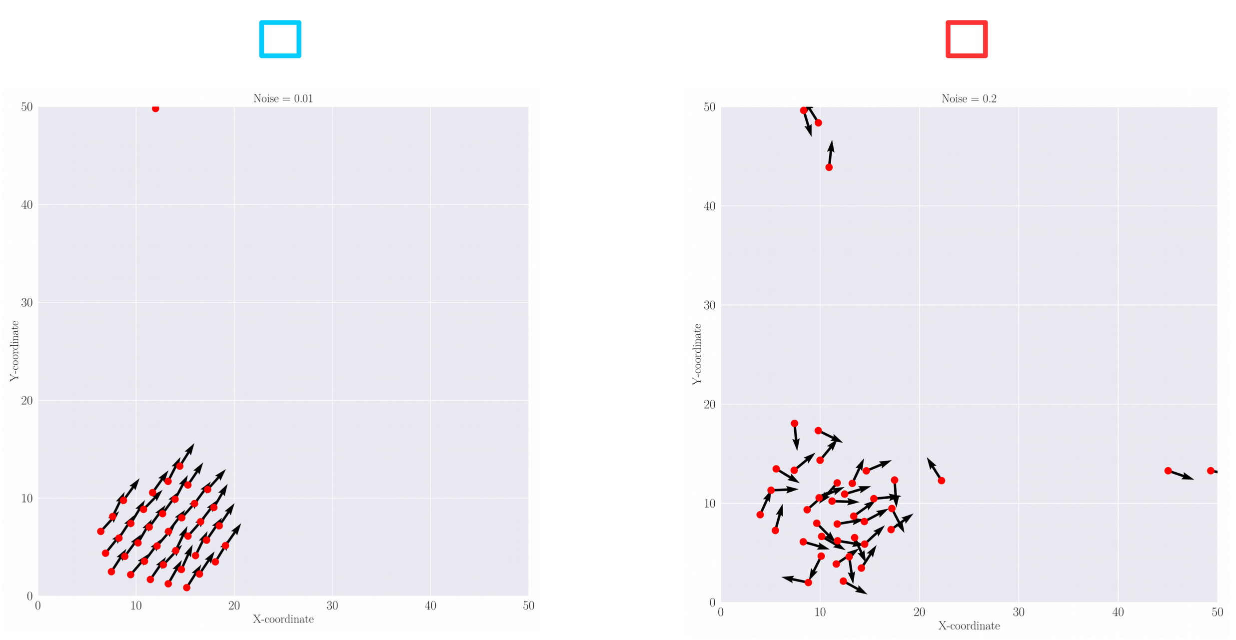


Model:



5) Collective behavior results





6) 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 startling frequency and polarization also correlated in a temporal manner?
- How is the startling frequency related to the cohesion of the school?

7) References & Links

[1] Rosenthal et al. 2015, PNAS, 112:4690–4695, doi:10.1073/pnas.1420068112
[2] Bhattacharyya et al. 2017, Current Biology, 27 (18):2751 – 2762.e6, doi:10.1016/j.cub.2017.08.012
[3] 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