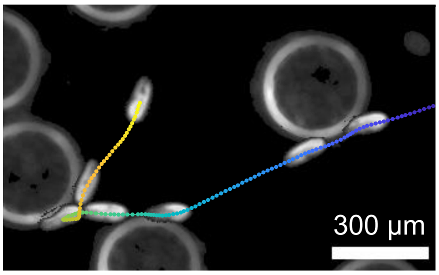
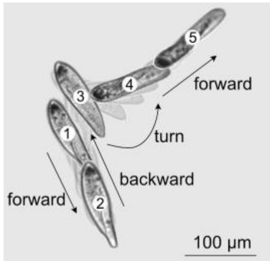
Master 1/2 internship proposal at Laboratoire Jean Perrin – LJP





Swimming behavior of Paramecium in crowded environments: mechanosensitivity and memory

This internship is part of the ANR project MECHAMO that aims at developing an integrated model of the spatial navigation of the micro-swimmer *Paramecium* by linking its behavior to its sensory transduction, and that involves R. Brette (Institut des Systèmes Intelligents et de Robotique, Sorbonne Université, Paris) and E. Meyer (Institut de Biologie, École Normale Supérieure, Paris).

Paramecium is a large unicellular eukaryote organism (100 – 300 µm long) that swims in fresh water by beating its cilia, and that can exhibit a mechanosensitive behavior as it can detect and avoid obstacles in its path with a mechanism called the "avoiding reaction (AR)": when it encounters an obstacle, it usually swims backwards for a short time, then swims forward in a new direction by rotating its body at a constant angular velocity (*see* Figure) [1,2]. This characteristic motion, that can also occur spontaneously, induces at long time scales a diffusive-like motion of the micro-swimmer. At the cellular level, the AR reaction is qualitatively well described as being triggered by action potentials produced by voltage-gated ion channels and whose initiation in the case of mechanical contacts, results from the opening of mechanosensitive ion channels in the membrane. The AR has however neither been measured precisely in a free environment nor characterized in the presence of obstacles. It is unclear how its properties depend on the geometric and mechanical features of the obstacles as well as on the local characteristics of the cell swimming (velocity, incidence angle) and on the spatial distribution of the mechanosensitive channels. More generally, the role of *Paramecium* mechanosensitivity on its foraging efficiency in crowded environments remains to be investigated.

Recent work in our group at LJP [3] with *Paramecium Tetraurelia,* have started to address these questions. By tracking paramecia in micro-engineered environments with cylindrical pillars as obstacles, we found in particular, that the mechanically induced AR occurred only ~10% of the time and that it could be either instantaneous or, most surprisingly, delayed. These results were however obtained by averaging trajectories of a large number of cells, not necessarily in the same physiological state and with different contact event history.

Here, we propose to go beyond a "population" level description of the mechanically induced AR by studying it at the level of the individual. For this, we will use an automatic tracking tool, currently in development at LJP, to track the motion of the same cell (wild types and mutants) over long times, when it is subjected to repetitive encounters with obstacles. The idea is to track a single cell placed in a swimming pool on a motorized translation stage and keep it at all times in the center of microscope images by moving the translation stage accordingly. With this tool, it will be possible on one hand to probe at relatively high magnification the contact interaction characteristics with obstacles of different geometries. On the other hand, it will allow to study how the AR reaction depends on the history of past events and probe if memory effects exist in *Paramecium* and over what time scales.

Comparison with theoretical predictions will then be done in particular in collaboration with R. Voituriez at LJP, by modelling paramecia as random walkers with a memory.

References

[1] Elices I., Kulkarni A., Escoubet N, Pontani L.-L., Prevost A. M., Brette R., *PLoS Comput. Biol.* **19** (2023).
[2] Brette R., *eNeuro* **8** (2021).
[3] N. Escoubet, R. Brette, L.-L. Pontani, A. M. Prevost, *R. Soc. Open Sci.* **10** (2023).

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