A sensory motor circuit for binocular motion integration in larval zebrafish

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Abstract

Zebrafish process whole field visual motion, extract the net direction of such stimuli and use this information to guide their swimming behavior to match the direction and speed of these external cues. This innate behavior, called the optomotor reflex (OMR) is ubiquitous in the animal kingdom and presumably serves to stabilize an animal's position in the world when it is being moved by external forces.
Here we use closed loop behavioral assays in freely swimming fish that allows specific and independent stimulation of the two eyes – with coherent as well as conflicting motion signals - and allows us to answer questions of how the two eyes interact to combine, suppress and filter the various permutations of motion stimuli.

We use whole brain imaging in tethered larvae to identify the complete neural circuitry underlying these various sensory motor transformations. Specifically we provide a working model of the complete circuit, that quantitatively captures the complete behavioral output as well as the response characteristics of the majority of the active neurons identified by independent cluster analysis.
This rate based computational model makes very specific predictions about connectivity and synaptic polarity of the functionally identified neurons, is easy to test and falsify and serves as an ideal platform and hypothesis generator for a whole range of future experiment.

Keywords: zebrafish, neural circuitry

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