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Study describes first maps of neural activity in behaving zebrafish

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In a study published today in the scientific journal *Neuron*, neuroscientists at the Champalimaud Foundation, in collaboration with neuroscientists from Harvard University, describe the first activity maps at the resolution of single cells and throughout the entire brain of behaving zebrafish.

"This opens up new possibilities for studying neural circuits in the brain," says Michael Orger, principal investigator at the Champalimaud Neuroscience Programme. "In order to understand how the brain works, it is imperative that we can record the activity of the cells of the brain –

the neurons, and at the same time be able to relate that to an animal's behaviour". Until recently, available methods allowed researchers to monitor activity in only a small fraction of the neurons in the brain, but "Now, we can systematically record activity through the whole brain of the zebrafish, which contains about one hundred thousand neurons, while at the same time we are monitoring its movements using high speed video."

Claudia Feierstein, a postdoctoral fellow in the lab of Dr. Orger explains, "by watching the brain while the fish tries to follow rotating visual patterns by moving its eyes and tail, we were able to identify the specific brain structures that are involved in these behaviours, and how different patterns of activity reflect the different aspects of sensory and motor processing."

One of the strengths of this method is that, because whole brain activity maps are recorded from a single fish, rather than pieced together across multiple experiments, it is possible to compare the neural circuit organization across different individuals. "When we talk about brain activity maps," says Dr. Orger "an important question is to what extent the circuits in different animals are similar. How precisely can we predict where we will find particular neurons from one brain to another?".

Surprisingly, the study revealed that, while the network of neurons mediating simple visual-motor behaviours is widely distributed across the brain, the pattern can be highly stereotyped between individuals. "If you identify a region with a particular pattern of activity in one fish, you can typically find neurons with the same activity within a few micrometers in the brain of another fish." says Ruben Portugues, a scientist from the group of Professor Florian Engert at Harvard, who coauthored the study. This has important practical consequences, because it makes it possible to build a detailed functional atlas of the brain, which allows researchers to locate and target specific groups of neurons. This map of functional "blocks" can also be aligned with existing maps of gene expression to assign behavioural roles to different cell types in the brain.

This systematic approach to mapping activity also enables researchers to discover rare cell populations that might have stayed hidden for decades. "We found a handful of neurons in the main visual processing area of the fish brain, called the optic tectum, that integrate motion information from both eyes. This was surprising since this area only gets direct information from one eye." Says Dr. Orger. "These cells are few in number, but may play an important role in the behaviour of the animal, since they allow him to decode how he is moving through the water." According to the researchers, the next step is to use optical and genetic targeting of interesting subpopulations of neurons, such as this one, and apply specific manipulations that will ultimately reveal how the brain processes sensory information to generate appropriate movements.

Provided by Harvard University

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