Current Topics in Zoology and Botany

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Algorithms and neural circuit mechanisms of spontaneous behavioral state-switching during sensory-motor decision-making in larval zebrafish

To understand how nervous systems translate sensory input into movement decisions, it is common practice in neuroscience to repeat trials as often as possible and then to average behavioral and neuronal responses. Such experimental designs work well under the assumption that the computational principles implemented in the brain remain constant over time, which, however, is unlikely to be the case for any animal species and any behavior. Here we have developed a novel assay for high-speed and high-throughput tracking of larval zebrafish over up to 12 hours. Larvae explore arenas under realistic or manipulated feedback configurations. When we present animals with constant gray, we find robust modulations over tens of minutes of how fish string together similar swimming decisions. Detailed analysis of the temporal patterning of these events allows us to build drift-diffusion-based statistical models that can capture behavior across various environmental configurations, such as adjustments of visual noise levels or luminance. When we present fish with classical optomotor or phototactic cues, we observe a strong trial-specific tendency of animals to sometimes move with and sometimes move against stimuli, challenging classical perspectives that such behaviors are only reflexive and critically required for course control stabilization. Our models reproduce these results, providing us with a novel framework to explain spontaneous behavioral state-switching during sensory-motor decision-making. Through a series of two-photon functional brain imaging experiments during behavior, we seek to better understand how behavioral states are represented at the level of individual neurons and neural networks and to build circuit models that can implement and modulate the observed dynamics. Our work exemplified the need to move beyond averaging strategies in systems neuroscience and to further explore decision-making events on the level of single trials.

Gastgeber: Prof. Dr. Björn Brembs