Quantitative
Eco/evo/etho
Discussions

Organisms Employ a Mode-Switching Strategy for Solving the Explore-vs-Exploit Problem

April 4th (Tuesday): 4-5pm ET

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Movement and sensing are linked in organisms as their sensors are embedded in their bodies. This inescapable link results in a behavioral conflict between producing costly movements for gathering information (“explore”) versus using previously acquired information to achieve a goal (“exploit”). Optimally trading-off exploration and exploitation is an intractable problem, and the strategies that animals utilize to resolve this conflict are poorly understood. We show that weakly electric fish (Eigenmannia virescens) use a mode-switching strategy that solves the explore–exploit conflict during a refuge tracking task, and that this strategy is modulated by sensory salience. Fish produced distinctive non-normal distributions of movement velocities characterized by sharp peaks for slower, task-oriented “exploit” movements and broad shoulders for faster, “explore” movements. Surprisingly, measures of non-normality increased (rather than decreased) with increased sensory salience. Reanalysis of published data revealed that this distinctive distribution of movement velocities is produced by diverse organisms from amoeba to humans. We propose a parsimonious, state-uncertainty based mode-switching heuristic that reproduces the distinctive velocity distribution and explains its relationship to sensory salience. This strategy likely manifests in diverse biological mechanisms, from single-cell motility to movement control in animals.

Noah J. Cowan received a B.S. from the Ohio State University, Columbus, and M.S. and Ph.D. degrees from the University of Michigan, Ann Arbor – all in electrical engineering. He was a Postdoctoral Fellow at the University of California, Berkeley. He is now a Professor of Mechanical Engineering at Johns Hopkins University. Prof. Cowan’s research interests include mechanics and multisensory control in animals and machines. He received the NSF PECASE award, the James S. McDonnell Foundation Scholar Award in Complex Systems, and two Johns Hopkins Discovery Awards. Prof. Cowan also received the William H. Huggins Award for excellence in teaching, and the Dunn Family Award, conferred for having “. . . an extraordinarily positive impact upon the lives of one or more undergraduate students.”

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