A Common Behavioral Model Underlies the Motility of a Diverse Set of Nematodes

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***Short Abstract* — Animal behavior emerges from many layers of biological organization—from molecular signaling pathways and neuronal networks to mechanical outputs of muscles. Naively, the large number of interconnected variables at each of these layers would seem to imply dynamics that are complex and hard to control or even tinker with. Yet, for organisms to survive in a competitive, ever-changing environment, behavior must readily adapt. We have quantitatively characterized motile behavior in a diverse set of nematodes spanning the lab strain *C. elegans* N2 to wild strains and distant species. We find that a simple physical model driven by conserved patterns in body shape can explain the motility of all the tested species. Intriguingly, the behavioral parameters vary in a correlated way that is consistent with a trade-off between exploratory and exploitative behavior.**

***Keywords* — behavior, motility, tracking, automated imaging, linear analysis, ecology, *C. elegans*, comparative biology**

I. Purpose

ACROSS the animal kingdom, natural behavior is both astonishing in its diversity and daunting in its complexity. Shaped by natural selection in response to ever-changing, competitive environments, behavioral patterns we observe today reflect the accumulated actions of evolution and are in principle high-dimensional. For example, even with only 100 binary muscles there are an astronomically large (2^{100}) number of postural states. Controlling each state independently is clearly impossible and thus simplifying, collective strategies must exist. In motor control, it is the correlated activity of motor neurons and muscles that results in effective movements. Here, we expand this idea and propose that strategies for behavioral control can be inferred from correlated variation in behavioral measurements. These strategies may be instantaneous as in the abrupt change of behavioral in response to a stimulus, gradual as an organism adapts to a new environment or even genetic as an entire population changes over evolutionary timescales.

II. Experiment

As our model system, we study the motile behavior of nematodes. These small, diverse animals share a highly conserved, simple body plan [1]. This feature allowed us to quantitatively characterize highly diverged species using the same sort of experiments used for the common lab strain *C. elegans* N2: by their movement [2-4,6] and body shape dynamics [5,6] on agar plates using automated video imaging. From this, we could then investigate behavioral variation over time, among individuals, and across species.

III. Results and Conclusions

Extending our previous work on *C. elegans N2* [5], we found that the body shape dynamics of all the species could be described by the linear combination of a small set of conserved postures. Similarly, the first-order statistics of the trajectory—the speed and bearing of the worm—of all the tested species could be described by a simple physical model accounting for variable speed, stochastic periods of reverse motion, and an anomalously diffusing bearing. Furthermore, these behaviors are driven by conserved patterns in the postures adopted by the worms. Finally, we found that the behavioral parameters varied over time, among individuals, and across strains and species in a correlated way that is consistent with a trade-off between exploratory and exploitative behavior [7]. This suggests a surprisingly simple underlying mechanism controlling variation in motile behavior that matches likely relevant ecological constraints.

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