Thermotactic Navigation and Behavioral Plasticity in Caenorhabditis elegans

Abstract

All motile animals have sensory mechanisms for sensing the temperature of their surroundings and have the ability to move from less favorable to more favorable temperatures. In this thesis I explored two aspects of thermosensory behavior in the 1 mm-long, soil-dwelling nematode C. elegans. First, I investigated temperature and food-dependent determinants of long-term plasticity in different modes of thermotactic behavior. Thermotactic behavior in C. elegans exhibits long-term plasticity. On a spatialthermalgradient, C. elegans tracks isotherms near a remembered set-point (Ts) corresponding to its previous cultivation temperature. When navigating at temperatures above its set-point (T > Ts), C. elegans crawls down spatial thermal gradients in what is called cryophilic movement. The Ts is reset by sustained exposure to a new temperature. Long-term plasticity in C. elegans thermotactic behavior has been proposed to represent an associative learning of specific temperatures conditioned in the presence or absence of bacterial food. Here, we used quantitative behavioral assays to define the temperature and food-dependent determinants of long-term plasticity in the different modes of thermotactic behavior. Under our experimental conditions, we found that starvation at a specific temperature neither disrupts Ts resetting toward the starvation temperature nor induces learned avoidance of the starvation temperature. We found that prolonged starvation suppresses the cryophilic mode of thermotactic behavior. In summary, we did not find evidence that long-term plasticity requires association between temperature and the presence or absence of bacterial food.

Second, I conducted a study of thermotactic behavior of C. elegans in a three dimensional environment. The navigational response of C. elegans in response to thermal, electrical, chemical, and mechanical stimuli has commonly been studied in two-dimensional analyses of crawling patterns on an agar surface. However, in their natural environments, soil nematodes like C. elegans burrow within a three-dimensional matrix of particles and water. By studying 3D locomotion, I sought to more closely reproduce natural C. elegans behavior than has been previously accomplished in a laboratory setting. I tested to what extent thermotactic phenomena are observed in a 3D setting. Using a stereoscopic tracking system, I examined the behavior of worms navigating a three-dimensional medium containing a linear thermal gradient. As expected, we found that worms were not confined to planar trajectories but moved in complex 3D trajectories. Worms displayed reversals and turns similar to those in 2D. By analyzing statistics of the final positions of the worms, we find that worm exhibit both cryophilic and thermophilic behavior in 3 dimensions. Additional experiments and analysis of tracking data will resolve the detailed behavioral strategies of three-dimensional navigation.