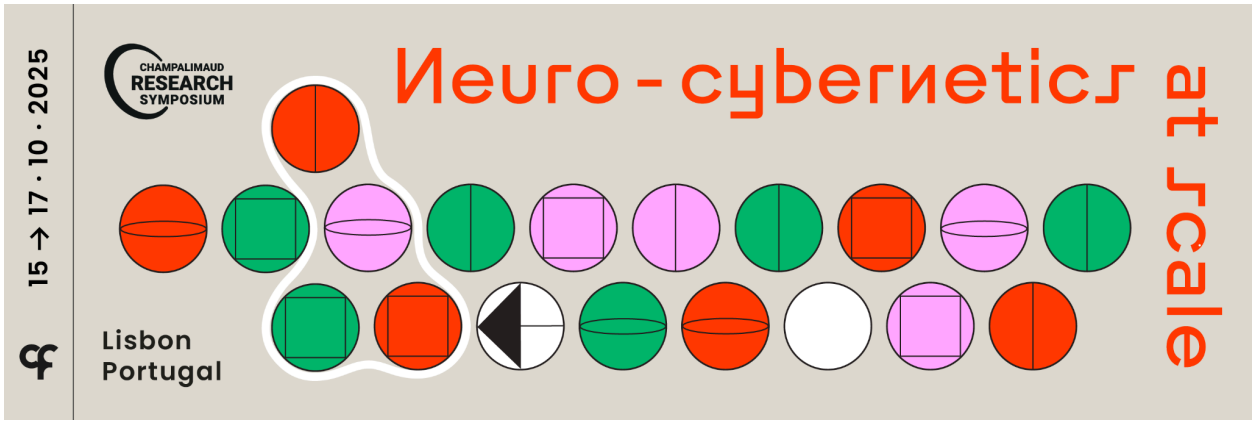

Head-body coordination for high-performance courtship pursuit in Drosophila

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Pursuit behaviors require the coordination of movements across the body, often balancing posture control for the body's mechanical stability with gaze control for image stabilization of the moving target, enabling accurate sensorimotor calculations critical for predatory and mating decisions. However, how visual information is integrated with ongoing movement across the body to direct the pursuer's subsequent actions remains poorly understood. We address this question by evaluating the role of head-body coordination on pursuit success, leveraging the elaborate courtship behavior of Drosophila melanogaster.

Through a combination of quantitative analysis of behavior, optogenetics, circuit manipulations, and physiology, we found that males move their heads in exquisite coordination with their bodies to keep a female within a specialized functional region in their retina. Masking this retinal region compromises pursuit, while fixing the head of males increases the steering demands of the body and the overall stability of pursuit. Moreover, when head-fixed males are challenged by the addition of competitors, their chances of copulation are reduced below the level expected by competition. These observations underscore the critical role of gaze control on pursuit performance in naturalistic conditions. Using a VR system in which aroused, tethered males track fictive females, we found that by fixing the flies' gaze at different angles, males integrate head position—rather than head velocity—with retinal information to orient toward female avatars. Analysis of large-scale electron microscopy datasets of the adult's fly brain, in combination with circuit manipulation, identified a circuit involved in the coordination of head and body movements, from the visual sensory pathway to the motor neurons of the neck that control head movements, and back to the brain.

In summary, our findings suggest that courting Drosophila males integrate retinal input with gaze direction, transforming these signals into a coordinate system suitable for guiding pursuit,

dynamically tuning head movements for steering stability while responding quickly to the female's uncertain movements.

head-body coordination, gaze stabilization, visuomotor integration