Roles of Coordination Between Stabilizing Circuits and Updating Circuits in Spatial Orientation Working Memory

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Spatial orientation plays a crucial role in animal navigation. Recent studies of tethered Drosophila melanogaster (fruit fly) in a virtual reality setting showed that the orientation is encoded in the form of an activity bump, i.e. localized neural activity, in the torus-shaped ellipsoid body (EB). Moreover, a fly can maintain short-term memory of its orientation with a stable and persistent activity bump in the absence of any visual cue, and update the memory in accordance with changes of the body orientation by shifting the location of the bump. Although the neural circuit that is responsible for shifting the bump has been extensively studied lately, how the nervous system shifts the bump while maintains its stability and persistence is poorly understood. We investigated this question using free moving fruit flies in a spatial orientation memory task, and manipulated two EB subsystems, C and P circuits, which have been hypothesized for stabilization and updating functions, respectively. We discovered that overactivating either circuit produced distinct behavioral deficits, confirming that the two circuits play important but different roles in the orientation working memory. Furthermore, suppressing either circuit disrupted the memory, suggesting that the C or P circuit alone is not sufficient to maintain the orientation working memory. The results are consistent with computer simulations of an EB model, which suggests that spatial orientation working memory requires coordinated activation of the stabilizing and updating neural processes.

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