

Medial precentral cortex neurons mediate the transformation of spatial information into action planning and execution

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Efficient, purposeful navigation through an environment is a complex process that can be recognized as a rapidly-executed series of uninterrupted locomotor actions through one or a series of choice-points. Such behavior most often demands integration of spatial information (e.g., present position within the environment) with the ongoing stream of sensory information, the current and planned locomotor action states, and decision-making processes guided by reward. Hippocampal and parietal cortical neurons robustly map the position of a rat within the larger environment and within the space of a route, respectively. Medial precentral cortex, a sub-region of rat prefrontal cortex obtaining afferents from parietal cortex and bearing efferents to primary motor cortex, is a structure that appears well-positioned to mediate transformations of such spatial information into current and/or planned locomotor actions. Prior reports indicate that neurons of this region predict choice in t-maze and stimulus-response tasks and that activity patterns are especially sensitive to the reward magnitude associated with completion of an action sequence. In the present work, the potential role of medial precentral neurons in action sequence execution and decision-making was examined by mapping their activity to specific positions along paths through one of two environments. In some rats (N=4), medial precentral neurons were recorded during traversals of squared-spiral tracks while in others (N=4), recordings were made as rats traversed the eight possible paths associated with a series of three spatially-separated left-turn/right-turn choices. In the former task, a generalized linear model approach was used to show that medial precentral neuron activity patterns recurred over all track sections associated with the same locomotor behavior, a contrast to the activity patterns of hippocampal and parietal neurons which discriminated all positions within the environment. For the latter task, information-theoretic analyses were used to show that medial precentral neuron activity rates were predictive of the rat's current and/or planned locomotor actions wherever those actions appear in the space of the environment. Together, the findings indicate that medial precentral cortex functions primarily to plan and execute specific locomotor actions based on current environmental position and expected reward magnitude. The firing properties of rat medial precentral neurons closely resemble those of primate premotor cortex and appear to play a critical role in the transformation of spatial cognition into action.