Dynamic and Functional Brain Mechanisms During Naturalistic Spatial Learning

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Abstract

We hypothesize that complex spatial learning during college-level instruction recruits evolutionarily conserved parietal–premotor mechanisms, with engagement scaling to instructional demands. We used fMRI and an authentic spatial lesson coded by rotation complexity, cognitive load, and linguistic density to dissociate brain systems underlying spatial instruction. Activation in the intraparietal sulcus and premotor regions tracked rotation complexity; frontal–cingulate regions tracked processing demands, and language regions selectively responded to linguistic density. Individuals with stronger spatial skills showed greater recruitment of the parietal–premotor circuit as spatial complexity increased, demonstrating that the neural system representing spatial, geometric, and quantitative content reflects individual differences during learning. These results reveal that the brain dynamically engages primitive mechanisms of spatial cognition during naturalistic instruction: parietal and premotor regions computing spatial and numerical relations remain malleable for acquiring high-level spatial cognition. This reveals cognitive functions linked to spatial learning and has implications for translating cognitive science into educational insights.

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