Cognitive and neural mechanisms of spatial learning and transfer in adults

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Abstract

Several cognitive theories explain successful learning of spatial visualization skills such as mental rotation. Spatial learning may occur through domain-specific changes to spatial transformation ability (in parietal cortex), embodied sensory-motor changes (in premotor cortex), or domain-general changes to executive functions (in prefrontal cortex). To evaluate these hypotheses, we analyzed brain activity during mental rotation using fMRI in 60 adults who completed 9 weeks of spatial visualization training. Mental rotation robustly activated bilateral parietal, premotor, and prefrontal areas both before and after training, with increased activity in the intraparietal sulcus, premotor cortex, and dorsolateral prefrontal cortex after training. However, improvements in spatial visualization and transfer to geometric reasoning were coupled with parietal and premotor changes, and not prefrontal changes. These results support the hypothesis that spatial learning is driven primarily by refinement of spatial transformation and sensory-motor imagery, although other brain regions may adapt secondarily as a byproduct of learning.

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