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The evolution of whole-brain community structure during sensorimotor adaptation

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Traditionally, sensorimotor adaptation was believed to be solely driven by an implicit learning process, characterized by a slow, automated reduction in sensory prediction errors. However, recent behavioral evidence suggests that explicit cognitive strategies also play an important role in adaptation, supporting faster learning and re-learning when encountering the task a second time (savings). While previous behavioral work has proven invaluable in characterizing the distinct computations supporting sensorimotor learning, its underlying neural bases remain poorly understood. To date, neural studies of adaptation learning have largely focused on changes in the activity of single brain regions or the interactions between several such regions, failing to fully capture the widely accepted notion that learning reflects a whole-brain process, involving the coordination of brain regions over a broad range of spatial and temporal scales. Moreover, it remains unclear which features of functional brain network organization underlie well known differences across participants in their capacities for learning and their expression of savings. Here, we used functional magnetic resonance imaging (fMRI) to investigate the whole-brain, large-scale temporal networks that govern visuomotor rotation learning and re-learning. Participants performed two separate MRI sessions, separated by 24 hours. On each trial, they moved a centrally located virtual cursor, via the hand, to contact one of eight possible targets. On each testing day, following baseline trials, we introduced an instantaneous 45 degree rotation of the hand cursor with respect to the hand and tracked participant learning during continuous MRI acquisition. Following earlier studies (Bassett et al, PNAS, 2011; Bassett et al, Nat Neurosci, 2015), we used time-resolved clustering methods to determine the community structure of multi-layer networks collated across sliding time windows during rotation learning on each day. We quantified the modularity of network structure, the extent to which brain regions changed community affiliation, and the probability that any two brain regions were assigned to the same community. We show that participants who exhibit the behavioral signatures of explicit, cognitive strategies during learning also exhibit greater flexibility in their network community structure, particularly in frontal and ventrotemporal brain areas. Our results suggest that individual differences in sensorimotor adaptation are linked to the adaptability of large-scale network structure.