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# Dynamic changes in brain network organization during visuomotor adaptation learning

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Learning a new motor skill frequently involves a progression from an initial adaptation stage, which is often error-riddled and highly cognitively demanding, to a less effortful stage marked by an increase in task success. These changes in motor performance are presumed to be mediated by complex interactions between various brain regions and circuits that are continuously changing over multiple time scales. However, our current understanding of the temporal evolution of brain networks over the course of learning and how these relate to behavioural performance remains sparse. Here, using functional MRI (fMRI), we investigated dynamic changes in coupling strength between brain areas and the expression of discrete brain configurations while subjects learned a visuomotor task, from its initial adaptation stages through to plateaus in performance. In accordance with prior work on sequence-based learning (Bassett et al., 2014), we predicted that the recruitment and organization of functional brain networks will change during task performance and that particular features of these dynamics will be correlated to subjects' learning parameters. Twenty-seven subjects, during one continuous fMRI acquisition, performed a visuomotor task that required movement of a cursor from a center target to one of eight possible peripheral targets using a small joystick. After 120 trials, a 45 degree visuomotor rotation--where feedback of the hand cursor was rotated with respect to the hand--was introduced and maintained for another 320 trials. Learning rates for each subject were determined by fitting their movement errors over time with an exponential function. Our analysis of the corresponding fMRI data revealed that although the repertoire of functional brain states was largely preserved across subjects, state-specific temporal features, such as the frequency of expression and number of transitions into particular states, were strongly correlated with task performance. In particular, we found that faster learning rates during initial exposure to the visuomotor rotation were associated with greater connection strengths between visual and sensorimotor areas. Similarly, the frequency of other functional network configurations were also found to be correlated with better initial learning in participants. Together, these results show that individual differences in motor learning is related to dynamic changes in brain network organization and suggest that visuomotor adaptation involves modification of functional coupling strengths between widely distributed brain regions.