Abstract

Most of the higher-order and intelligent cognitive behaviours such as reasoning, problem solving, and language involve acquiring and performing complex sequences of activities. Recent advances in neuroimaging techniques, especially the functional MRI, have made it possible to study the brain *in vivo* while subjects are engaged in meaningful behavioural tasks. In this thesis, we used *rn Xin* visuo-motor sequence learning paradigm to investigate the effect of change in complexity of the skill being acquired on various entities such as the nature of internal representation of skills, on the behavioural parameters and on the pattern of brain activation. In the *rn Xin* paradigm the correct order of pressing *m* keys (set-length) successively for *n* times (hyperset-length) is learned by trail-and-error process. We vary the complexity of the sequence to be learnt along the two dimensions — *m* and *n*, reflecting short-range and long-range prediction loads, respectively. Eighteen subjects were trained and tested on three sequence tasks — 2x6, 2x12 and 4x6. We hypothesized that in the complex sequence learning condition corresponding to increased set-length (i.e., *m*), the optimization process may be limited to the items within the *set* and may not span across sets. In contrast, we expected that in the complex condition corresponding to increased hyperset-length (i.e., *n*), sequence information may possibly be organized in a hierarchical fashion.

The behavioural results indicate that success rate and key-press response times (RT) revealed the learning related improvements from the early to the consolidation stages in all the sequence learning tasks (2x6, 2x12 and 4x6) and the complexity related effects when 2x6 task was compared to the 2x12 or 4x6 tasks. Although the number of movements and the success rate attained are observed to be similar across the complex tasks (2x12 and 4x6), the RT displayed differential behaviour in the consolidation stages of 2x12 and 4x6. Further, the subjects are observed to be faster in the 2x12 task as compared to the 4x6 task. These differences along with the results from chunking analysis pointed out that the hierarchical organization of complex movement sequences is more likely when the amount of information processed at any point of time is well within the working memory capacity. The results of functional MRI analysis revealed the involvement of cortico-cortical areas in the 4x6 task and the sub-cortical area near the hippocampus has a role in the acquisition stage of the 2x12 task. The posterior lobule of cerebellum, the superior parietal lobule and the Inferior frontal gyrus were found to have a specific role in the chaining across sets and the dorsolateral prefrontal cortex and the caudate nucleus loop may have a specific role in the within-set optimization. Thus the neuroimaging results revealed the recruitment of different, set of brain areas during acquisition and performance stages related to the two dimensions of complexity. Based on the results, we propose a theoretical model consisting of two levels. At one level simple associations are learnt and at the other level higher-order associations are formed.

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