MULTIPLE REPRESENTATIONS IN THE BASAL GANGLIA LOOPS FOR ACQUISITION AND EXECUTION OF SEQUENTIAL MOTOR CONTROL.

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********** abstract **********

The basal ganglia (BG) are known to play an important role in sequential motor control but their computational roles are poorly understood. In recent studies using "2x5 task", in which a monkey learned to press five sets of two LED buttons in a predetermined order, functional differentiation was observed between anterior and posterior BG (Miyachi et al., Soc Neurosci Abstr 20: 357, 1994), as well as presupplementary motor area (pre-SMA) and supplementary motor area (SMA) (Miyashita et al., Soc Neurosci Abstr 22: 1862, 1996), in acquisition and execution of the sequential movement. Here, we propose a computational model on the functions of those areas based on a theory of reinforcement learning (Nakahara, Ph.D. thesis, 1997). The central idea of the model is that a visuomotor sequence is easier to learn in spatial representation (e.g. visual coordinate) but is easier to control in body-based representation (e.g. joint angle coordinate). Based on anatomical and physiological evidence, we propose that the loop between anterior BG and the prefrontal cortex, perhaps together with pre-SMA, learns the sequence using visual coordinate. The loop between posterior BG and SMA learns the sequence using body coordinate. Although both loops concurrently learn the sequence, because of the difference in the speed of learning, the anterior loop is more critical in learning of new sequences and the posterior loop is more involved in performance of well learned sequences. We then performed computer simulations of the proposed model. The results replicated both behavioral and neurophysiological data, and further provided several predictions which are experimentally testable using the 2x5 task. Supported by JSPS, Grant-in-Aid from The Ministry of Edu. and Sci, and SPRF of RIKEN to HN, HFSP to KD, Uehara Memorial Foundation and JSPS Research for the Future Program to OH.