Learning and Transfer of Dexterous Manipulation

MARCO SANTELLO

School of Biological and Health Systems Engineering
Arizona State University

The coordination between digit forces and positions is critical for successful dexterous manipulation. However, very little is known about how humans learn to control both variables through consecutive manipulations, mainly because studies of grasping often constrain digit placement to fixed locations, e.g., on force sensors. Allowing subjects the choice of digit placement enables them to explore a wider range of relations between digit forces and positions. At the same time, the removal of digit placement constraints might result in significant trial-to-trial variability of digit position. Consequently, reliance on sensorimotor memories of digit forces from previous trials for anticipatory grasp control might not be sufficient to attain a consistent performance. This is because the points of force application in the current trial might be very different from those used in previous trials, thus requiring a digit force distribution that has not been previously experienced. I will review a series of recent studies that have examined the problem of digit position/force coordination using tasks that allow, or interfere with, learning of object manipulation and probe learning transfer to manipulations of the same object with different properties or performed using a different grip configuration. The theoretical framework that is currently emerging indicates that anticipatory control of object manipulation is learned through integration of sensorimotor memories with online feedback about digit forces and positions. Specifically, subjects can flexibly compensate for trial-to-trial variability in digit position by force modulation, and can switch grip type by successfully adapting the coordination between digit forces and position within a single trial. I will conclude my talk with open questions and directions for future research on the neural mechanisms underlying learning of dexterous manipulation and applications to neuroprosthetics and robotics.