17

Do we need finger individuation for precision grip?

Jing Xu[1], Timothy Ma[2], Sapna Kumar[2], Kevin Olds[2], Jeremy Brown[2], Jacob Carducci[2], Alex Forrence[2], John W. Krakauer[2]

[1]University of Georgia, Athens, Georgia, USA
[2]Johns Hopkins University, Baltimore, Maryland, USA

Hand dexterity is the hallmark of human skill and intelligence. From Pablo Casals' sublime cello playing to the mundane task of tying one's shoelace, the level of dexterity in humans stands out among our primate relatives. How we achieve such seamless skills is still a mystery. How to repair them once lost after neurological injury remains a formidable challenge. Traditionally, hand dexterity has been studied using two major paradigms, finger individuation and precision grip. Both have been treated as equal proxies of hand dexterity, thus have rarely been directly compared. However, our recent [1, 2] and a few other studies [3, 4] have found that impairment of these two aspects of hand function were not correlated, raising the question of whether they share the same control mechanisms or not. To carefully study the relationship between the two key components of the hand function, we have engineered a sensitive device to measure subtle isometric forces at all fingertips in three-dimension (3D). Using this device, we designed 3D Individuation and three Precision-grip tasks, simple grip, tunnel, and dialling, to directly compare these two functional aspects and examine in which way individuation ability may play a role in precision grip. We hypothesized that individuation and precision grip are operating on different control mechanisms, but individuation may participate in precision grip when the task demands more complex manipulation. Our preliminary results directly comparing individuation and the simple precision grip in 22 healthy younger participants showed that the temporal and spatial grip accuracies for precision grip were not correlated with the Individuation Index ($r\sim(0.07, 0.27)$). However, when precise positioning of fingers was required in the tunnel and dialling tasks, ability to individuate fingers was a significant factor in the initial positioning of fingers ($p<0.001$). Intriguingly, in these two tasks grip trajectory were jerkier than those in simple grips ($p = 0.008$), and individuation ability were negatively correlated with smoothness ($p < 0.01$). In the dialling task, trajectories became jerkier when the angle to be adjusted was smaller (20 deg. Compared to 45 deg.) ($p = 0.00005$). We conclude that the evolutionarily new finger individuation system entails a cost of increased movement variability in fine manipulation tasks.

[1]Xu, J. *et al.* Separable systems for recovery of finger strength and control after stroke. *J. Neurophysiol.* jn.00123.2017 (2017)
[2]Mawase, F. *et al.* Pushing the rehabilitation boundaries: hand motor impairment can be reduced in chronic stroke. *Neurorehabilitation and Neural Repair* (2020).
[3]Lang, C. E. & Schieber, M. H. Differential impairment of individuated finger movements in humans after damage to the motor cortex or the corticospinal tract. *J. Neurophysiol.* **90**, 1160–1170 (2003).
[4]Raghavan, P., Petra, E., Krakauer, J. W. & Gordon, A. M. Patterns of impairment in digit independence after subcortical stroke. *J. Neurophysiol.* **95**, 369–378 (2006).