

Do we need finger individuation for precision grip?

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Introduction

The human hand possesses a rich multidimensional repertoire of dexterous movements, much of which can be lost after stroke. Current clinical assessments are coarse-grained and based on evaluation of holistic, functional tasks; some studies employ fine-grained kinetic / kinematic analysis^{1-4,6-7}, but mostly only assess single-dimension movement.

Traditionally, two major proxies of hand dexterity, finger individuation¹⁻⁴ and precision grip⁵⁻⁷ are often taken as equivalent in assessing dexterity. However, this notion has been challenged by a few studies that have compared the two^{3,4}. Here we designed a sensitive device that can assess hand dexterity using isometric forces at all fingertips in three-dimensions (3D).

We used a Finger Individuation and a Precision Grip task to reveal a comprehensive assessment of critical components of hand dexterity in 3D.

The HAND

We have designed a new device, the Hand Articulation Neuro-training Device (HAND, JHU reference #C14603) that can detect micro-isometric forces at the fingertips in 3D. This device has a custom-developed highly sensitive fingerforce sensor.













The role of finger individuation in precision grip Control variables in precision grip are not correlated with individuation index

	Grip angle	Trajectory length	Temp desynch	Velocity (mean)	Velocity (peak)
r	0.21	0.09	0.13	0.15	0.65
р	0.59	0.82	0.73	0.69	0.06

The ability of individuate fingers in the precision grip is mildly correlated with

Individuation index							
	PTP-TI	PTP-TM	PTP-TR	PTS	Tripod		
r	0.58	0.47	0.36	0.57	0.71		
р	0.10	0.20	0.34	0.11	0.03		

Conclusions

To accurately access hand dexterity in the healthy and disease, we have designed a sensitive tool to assess hand dexterity in 3D.

Finger individuation in 3D showed differential impairment for fingers and movement directions.

The precision grip task can sensitively detect differences in dexterity between dominant and non-dominant hands in terms of coordination across fingers involved, e.g. accurate location, timing, trajectory smoothness, and velocity.

Critically, control of precision grip only partially relies on people's ability to individuate their fingers.

1	¥ [References: 1. Schieber (1991), <i>J Neurophysiol.</i> 2. Xu et al. (2017), <i>J Neurophysiol.</i>
here	tripod	3. Lang & Schieber (2003), J Neurophysiol.

Paretic

wrist neutral

(N=6)

flexion extension

4. Raghavan et al. (2006), J Neurophysiol. 5. Napier (1956), J Neurophysiol. 6. Santello (1998), J Neurophysiol. 7. Maier et al. (1993), J Neurophysiol.





PTP-TM PTP-TB

PTS-T

PTP-TI PTP-TM PTP-TB PTS-TI tripod