







Muscle synergies retrieved by multi-muscle electromyographic responses from direct brain stimulations applied during awake brain surgery

Jodie J. XIE¹, Subing HUANG², Rosa H. M. CHAN², Amy HS KONG³,

Peter Y. M. WOO⁴, Vincent C. K. CHEUNG¹

Institution(s):

¹School of Biomedical Sciences, and The Gerald Choa Neuroscience Centre, The Chinese University of Hong Kong, Hong Kong.

²Department of Electrical Engineering, City University of Hong Kong, Hong Kong.

³Department of Anaesthesiology and Operating Theatre Services, Kwong Wah Hospital, Hong Kong

⁴Department of Neurosurgery, Kwong Wah Hospital, Hong Kong.

Background

Key concerns of motor neuroscience:

- How is a wish to move translated into a motor plan/motor command by the central nervous system (CNS)?
- How can CNS compute and control complex motor commands into various movements?

Assumptions:

The activities of cortical motor neurons of M1 are represented in some "**basic building blocks**" which can be used by the CNS to simplify the motor control.



Fig.1 Schematic showing of the CNS structures and descending tracts involved in motor execution

Can the analysis of stimulation-elicited electromyograms (EMGs) reveal the neural mechanisms of basic building blocks in humans?

- Animal studies have identified these "basic building blocks" of voluntary movements from behavioral EMGs as muscle synergies.
- For humans, direct neurophysiological evidence for the existence of muscle synergies is lacking.
- Is it possible to use direct electrical stimulation (DES) to retrieve muscle synergies observed in daily activities?



Cheung et al. (2020) Nature Communications

Methodology



<u>Result</u>

Seven pre-op behavioral muscle synergies were identified. Among them, 2 could be matched to DES-evoked synergies with high similarity, and 3 could be explained by merging multiple DES-evoked synergies.



Discussion & Conclusion

Discussion

- Merging of DES-evoked (fundamental) synergies during voluntary behaviors may be driven by sensory feedback or different activated levels of neurons.
- Inadequate coverage of M1 during stimulation could account for the existence of specific behavioral synergies.



Conclusion

- It is possible to access muscle synergies observed during natural motor behaviors by direct stimulations
 applied to the motor cortical areas.
- EMG-derived muscle synergies are neuromotor control units encoded in the human motor system and utilized by the motor system for movement construction.