Decoding and manipulating sensorimotor cortex activity for neuro-rehabilitation in humans and non-human primates

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Abstracts:

Brain-Machine Interface (BMI) is a technology that decodes natural neural information from a targeted brain area, and translates it into machine control signals. BMI technology has not only achieved telepathy-like machine control (Hashimoto et al. BMC Neurosci 2010) and cyborg-like limb control, but also has achieved manipulation of a targeted cortical activity via visual/somatosensory feedback (Ono et al. Brain Topogr 2015; Ono et al. Front Neuroeng 2014; Ono et al. Clin Neurophysiol 2013). Repeated manipulation of the sensorimotor cortex activity through BMI in a week to month facilitates the remodeling process of the damaged sensorimotor nervous system, and functional motor recovery from severe pathoneurological conditions is often promoted in post-stroke hemiplegia (Ushiba & Soekadar, Prog Brain Res 2016), incomplete spinal cord injury, and dystonic writer's cramp (Hashimoto et al. BMC Neurosci 2014).

In order to solidify the neurobiological evidence of motor control, learning, and recovery through BMI, our joint research team with neurobiologists, Kenji Tanaka and Hideyuki Okano, has recently been taking an optogenetic approach of large-scale neural recordings from primary motor cortex (M1). So far, we confirmed stable recording of activating ~100 cortical neurons in the M1 Layer 5 from naturally behaving non-human primates, Common Marmoset. What we surprised here was that M1 cortical neurons processed limb movement direction information even in the post-movement period. The result suggests that M1 is not a simple final path of motor signal output to the muscles, but is an important node of post-movement processing such as error processing or motor memory.

A neurobiological nature of motor recovery will be explored with this advanced technology in near future, and clinical application of BMI in humans will be further driven by neurobiological evidences.