Mapping of the macaque brain using optogenetics and fMRI

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Optogenetics has become an indispensable tool for investigating brain functions. Although non-human primates are particularly useful models for understanding the functions and dysfunctions of the human brain, application of optogenetics to non-human primates is still limited. First, we tried to map the primary motor cortex (M1) of macaque monkeys using optogenetic intracortical microstimulation (oICMS). We generated an effective adeno-associated viral vector serotype DJ to express channelrhodopsin-2 (ChR2) under the control of a strong ubiquitous CAG promoter and injected into the layer 5 of the M1 after identifying somatotopic regions. ChR2 was strongly expressed in the anterior bank of the central sulcus, and oICMS through a homemade optrode induced prominent cortical activity. In addition, oICMS elicited distinct body movements and muscle activity in a somatotopically organized manner, which were comparable to those elicited by conventional electrical ICMS.

Second, we mapped brain regions activated by M1-oICMS using 7T ultra-high field functional magnetic resonance imaging (fMRI). oICMS of the M1 forelimb and hindlimb regions successfully induced robust blood-oxygen-level-dependent (BOLD) signals at local and remote regions. Prominent remote signals were found in the contralateral cerebellum, which polysynaptically receives projections from the M1 through the cerebro-cerebellar projections. The activated regions in the cerebellar cortex were somatotopically organized, concordant with the somatotopic map in the cerebellar cortex previously reported.

The present study suggests that optogenetic stimulation and its combination with fMRI are promising tools for mapping the macaque brain.