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Talk Title:
Neural dynamics of motor cortex for flexible feedback motor control

Abstract:
A hallmark of our motor system is its ability to flexibly change motor responses to the sensory input. This input-output association is called the "control policy" and is assumed to be prepared according to the behavioral context, but the neural mechanism for the preparation of the control policy is still largely unknown. Previously, we showed that the motor cortical areas, including the dorsal premotor areas, have a causal function for setting a control policy to generate appropriate feedback motor responses to a mechanical perturbation applied to limb. However, it was still unknown how control policies are prepared in the motor cortical areas and how it is utilized when a mechanical perturbation is applied. In this study, we first constructed a recurrent neural network (RNN) model that reproduces the flexible motor response of monkeys to mechanical perturbations applied to the limb, and analyzed the dynamics of the neural state of the network using principal component analysis. The results showed that in response to contextual signals the neural state of the trained RNN progresses and waits for the forthcoming mechanical perturbation depending on the contextual signals. Then, after the mechanical perturbation was applied, the neural state deviated further to generate an appropriate motor output. Importantly, the trajectories of the neural states during the preparation and response phases were orthogonally aligned, suggesting that the preparation of the control policy can be achieved in a separate neural dimension from that for the motor response. To investigate whether a similar mechanism exists in the fronto-parietal cortical system of non-human primates, we recorded electrocorticograms (ECoGs) from a macaque monkey performing a flexible motor response task to a mechanical disturbance of the limb. The dimensional reduction analysis showed that the cortical activity spanned orthogonal dimensions during the preparatory and response phases. These results suggest that the control policy is prepared as a state of fronto-parietal cortical activity that is separated from the dimension of motor response.

Biographical Information:
After studied neuroscience at Kyoto University, Dr. Takei started his electrophysiological

researches in non-human primates in the laboratory of Dr. Kazuhiko Seki at the National Institute for Physiological Sciences and the National Institute for Neuroscience. Then, he did post-doctoral training in Dr. Stephen H Scott's lab at Queen's University on motor control theory and neural circuit manipulation (cooling). In 2018, he started a research group in Dr. Tadashi Isa's lab at Kyoto University, combining electrophysiological studies with theoretical and neural network modeling, and launched his own lab at Tamagawa Univeristy in 2021.