R&D item

# 1． Establishment of a VR system to visualize brain function network dynamics

## Progress until FY2023

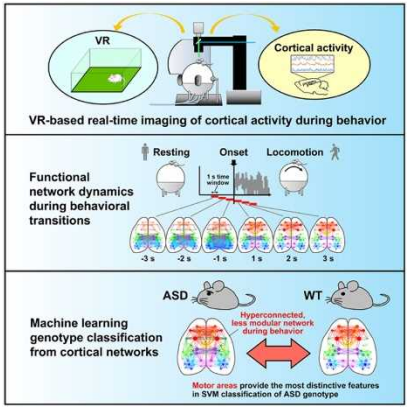
### 1. Outline of the project

In this R&D item, we will develop a virtual reality (VR) system that can visualize brain function network dynamics by providing various stimuli to mice in action. Furthermore, by combining two VR systems to form a metaverse space, we will quantify the "mental" state of mice when they communicate with other mice in a social environment as changes in their brain function networks.

**Image of a mouse exploring a virtual space**

### 2. Outcome so far

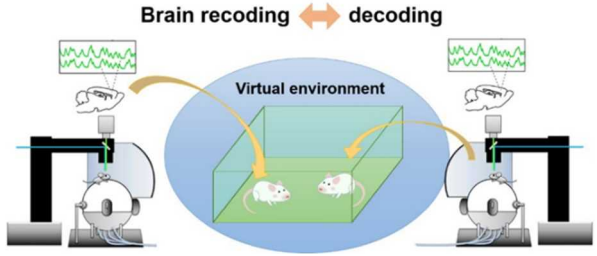
Based on the VR system for visual tasks that the Takumi Group has constructed, we have built a "multimodal VR system" that can provide other sensory information, such as whisker stimuli and odor stimuli, in an integrated and separated manner. The construction of a system that can visualize various sensory stimuli to mice in real-time is unique, and the results were published in Cell Reports, a leading international journal. Using visual stimulation, the system can record cortical neural activity in real-time as the mouse moves freely in a VR space. We succeeded in recording cortical neural network dynamics in response to mouse movements. Using machine learning, we could also predict mouse behavior from the images of the neural network dynamics. Furthermore, when we analyzed autism model mice, we found changes mainly in the motor system module. This suggests motor awkwardness in autism. Machine learning can also predict wild-type and autism models and is considered a fundamental technology for novel diagnostic methods.




We verified that test mice exhibit social interaction by displaying a mouse avatar in a section of the virtual space of a VR system and adding animations that mimic mouse movements and information on the odor of mouse urine. The control group was presented with an object model with added movements and odor information of neutrality. We analyzed the sensory input information (sociosensory stimuli) involved in social interaction based on the combination of visual, tactile, olfactory, and other stimuli.

We also built a machine learning model to predict the walking motion state of mice based on dynamic network information in the brain.

In addition, to investigate the social behavior of two mice in a virtual space, we constructed a prototype of an interactive social virtual reality (iSVR) system using two multimodal VR systems that can separate and integrate sensory stimuli. By linking the two VR systems on a computer, the two mice can actively and passively interact in a way closer to reality.




**Interactive social virtual reality (iSVR) system**

### 3. Future plans

Using this iSVR system, it will be possible to examine the functional cortical network and social behavioral phenotype of mice when they exhibit social interactions in a virtual space. In other words, brain activity and behavior can be recorded simultaneously by two individuals by synchronizing the VR system. This system is expected to reveal the dynamics of the brain functional network during social interactions, which have not been analyzed by conventional methods.

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