Supported by Grants-in-Aid for Scientific Research on Innovative Areas (MEXT) 文科省科学研究費補助金新学術領域研究
"Mesoscopic neurocircuitry : towards understanding of the functional and structural basis of brain information processing" 「メゾスコピック神経回路から探る脳の情報処理基盤」

The First Open International Symposium

Title :Neuronal circuits at the intersection of theory and experiment
テーマ : 理論と実験の両方を含む先端的な神経回路研究の紹介

Date : 7/7/2012 (Sat) 10:00 - 17:00 / 17:15－Meeting
Venue : Koshiba Hall, University of Tokyo

Program

10:00-10:10	Akinao Nose (University of Tokyo)	Introduction
10:10-11:00	Gilles Laurent (Max Planck Institute for Brain Research)	Olfactory dynamics, codes, and sparse memories.
11:00-11:35	Akinao Nose	Optogenetic dissection of motor circuits that regulate larval locomotion in Drosophila
11:35-12:10	Yuichi Iino (University of Tokyo)	Sensorimotor mechanisms of chemotaxis in C. elegans
12:10-13:40	Lunch	
13:40-14:30	Howard Eichenbaum (Boston University)	The hippocampus in space and time
14:30-15:05	Yuji Ikegaya (University of Tokyo)	Inter-pyramid spike transmission stabilizes the sparseness of cortical network activity
15:05-15:25	Coffee break	
15:25-16:00	Tomoki Fukai (RIKEN Brain Science Institute)	Information representations in the microcircuit of rat motor cortex
16:00-16:50	Erin Schuman (Max Planck Institute for Brain Research)	Local Translation in Neurons
16:50-17:00	Gilles Laurent	Closing remark
17:15-		Meeting for exchanging opinions freely

Lectures (the order in the program)

Speaker: Gilles Laurent

Position: Max Planck Institute for Brain Research

Title: Olfactory dynamics, codes, and sparse memories.

Abstract: unfixed

Speaker: Akinao Nose

Position: Department of Complexity Science and Engineering, Graduate School of Frontier Science, Department of Physics, Graduate School of Science, the University of Tokyo

Title: Optogenetic dissection of motor circuits that regulate larval locomotion in *Drosophila*"

Abstract: Understanding how motor pattern is regulated by the central circuits remains a major goal in neuroscience. While previous studies in several species have implicated specific classes of interneurons in the regulation of locomotion, their roles and activity pattern during ongoing behavior remain poorly understood. The Drosophila larval peristalsis is generated by a traveling wave of motor activity from the posterior to anterior segments. The pattern of peristalsis, including rhythm and speed, is remarkably stereotypic, providing an excellent system in which to investigate motor control. We used calcium imaging to search for interneurons that show wave-like or oscillating activity and thus may be involved in the locomotion. One class of interneurons identified, period-positive median segmental interneurons, or PMSIs, displayed a wave-like activity, concomitant with the propagation of muscular contraction. PMSIs are a group of ~15 local interneurons in each segment. They seem to be pre-motor inhibitory interneurons since they form potential synaptic contacts with motor neurons (visualized with GFP Reconstitution Across Synaptic Partners) and secrete glutamate, a neurotransmitter known to inhibit motor neurons. Consistent with this, photo-activation of these neurons with ChR2 induced local relaxation of the musculature in a segment-specific manner. When the activity of PMSIs was inhibited optogenetically with NpHR or thermogenetically with the temperature sensitive Shibire, the speed of locomotion was greatly reduced. Electrophysiological recordings showed that the duration of motor neuron bursting was prolonged when the activity of PMSIs was inhibited by the optogenetic purturbation. These results suggest that PMSIs control the speed of larval locomotion by regulating the duration of motor bursting in each segment. PMSIs share a number of functional and morphological characteristics with vertebrate V1 neurons, including the expression of the transcription factor Engrailed, implying that the role of this class of interneurons in locomotion may be phylogenetically conserved.

Speaker: Yuichi Iino

Position: Department of Biophysics and Biochemistry, Graduate School of Science, the University of Tokyo

Title: Sensorimotor mechanisms of chemotaxis in *C. elegans*

Abstract: C. elegans shows chemotaxis to odorants and salts including NaCl. Chemotaxis to salts has long been considered a stereotyped behavior, but we have recently found that it is a highly plastic behavior. When worms are cultivated at certain salt concentration with ample food, and thereafter tested on salt concentration gradient, they are attracted to the salt concentration at which they had been cultivated. Therefore, worms can memorize the salt concentration, and migrate down the salt concentration gradient when the current concentration is higher than the memorized concentration, and if the current concentration is lower, they do the opposite. How is this plastic behavior generated?

Two behavioral mechanisms, klinokinesis and klinotaxis, have been found for chemotaxis to higher salt concentrations in C. elegans. In klinokinesis worms respond to temporal change of salt concentration, dC/dT. When dC/dT is negative, the probability of turning behavior increases. In klinotaxis, worms respond to spatial gradient of the chemical, and slowly curve towards the side with higher salt concentration. We analyzed the behavior of animals cultivated at different salt concentrations and found that both klinokinesis and klinotaxis are reversed when cultivated at low salt concentration. By calcium imaging of sensory neurons and downstream interneurons, we find that experience-dependent change occurs between the sensory neuron and the primary interneuron. Artificial stimulation of the sensory neuron or interneuron by using channelrhodopsin supported this view.

Then, how is the spatial gradient detected in klinotaxis? Because worms sense chemicals at one point at the anterior end of the body, comparison between two sensors is unlikely. By stimulating the sensory neuron by using chanelrhodopsin in synchrony with head swing, it was suggested that spatial gradient is detected by a concentration change during head swing. Again, this behavior was reversed depending on cultivation concentration.

The above observations were made on C. elegans cultivated in the presence of food. On the other hand, when worms are cultivated without food, they avoid the previously experienced salt concentration. We have found that insulin/PI 3-kinase pathway is essential for causing starvation-dependent behavioral switching, and it acts in the sensory neuron. Recent findings on the molecular mechanisms of the regulation of the insulin pathway will be briefly described.

Speaker: Howard Eichenbaum

Position: Center for Memory and BrainBoston University

Title: The hippocampus in space and time

Abstract: In humans, hippocampal function is generally recognized as supporting episodic memory, whereas in rats, many believe that the hippocampus creates maps of the environment and supports spatial navigation. How do we reconcile the episodic memory and spatial mapping views of hippocampal function? Here I will discuss evidence that, during learning of what happens where, hippocampal place cells map the locations of events in their spatial context. In addition, I will describe recent findings that, during learning of what happens when in spatial and non-spatial sequences, hippocampal neurons encode specific moments in the course of temporally extended experiences ("time cells", as contrasted with "place cells") and map specific events within their temporal context. These findings support an emerging view that the hippocampus supports episodic memory by creating a "scaffolding" for the organization of events within their spatial and temporal context.

Speaker: Yuji Ikegaya

Position: Laboratory of Chemical Pharmacology, Graduate School of Pharmaceutical Sciences, The University of Tokyo

Title: Inter-pyramid spike transmission stabilizes the sparseness of cortical network activity

Abstract: Because cortical synapses are weak and stochastic, a postsynaptic neuron cannot fire action potentials without synchronous inputs. In contrast to this classic view, I present evidence that in a noisy network, a single action potential from a single excitatory neuron is capable of inducing action potentials in a few selected excitatory postsynaptic neurons. Multiple whole-cell recordings from hippocampal CA3 pyramidal cells (PCs) revealed a long-tailed amplitude distribution of unitary excitatory postsynaptic conductances (uEPSGs) with a small fraction of extremely large uEPSGs. These outliers tended to reciprocally connect PCs and were strong enough to evoke action potentials in the postsynaptic PCs. The probability of inter-PC spike transmission (IpST) reached 80%, depending on the network state. Computer simulations estimated that the strongest 20% of connections convey 80% of the total spike information, whereas the many other weak connections collectively act as a source of synaptic noise that gates IpST.

Speaker: Tomoki Fukai

Position: RIKEN Brain Science Institute

Title: Information representations in the microcircuit of rat motor cortex

Abstract: Uncovering the function of cortical microcircuits is of fundamental importance as they are the functional modules of cortical information processing. An essential feature of cortical microcircuits is their laminar organization that crucially controls the flows of information within and between local circuits. We constructed several nonlinear kernels to extract information on arm movement from neurons simultaneously recorded in the motor cortex of behaving rats. We applied the kernel methods to multiunit spiking activities recorded from the superficial and deep cortical layers to show their differential use of spike correlations for motor information coding. We then demonstrate that neurons in the different layers exhibit quite different phase-locking patterns to theta-coupled gamma oscillations of local field potentials. We propose that the superficial and deep cortical layers encode different features of movements in different manners at the level of population activity.

Speaker: Erin Schuman

Position: Max Planck Institute for Brain Research

Title: Local Translation in Neurons

Abstract: An individual neuron possesses thousands of synapses. Each synapse possesses 100-500 different types of protein- that vary in their copy number, synthesis, and degradation rates. I will discuss evidence that locally synthesized proteins participate in the establishment, maintenance and plasticity of synaptic connections. My talk will include a discussion of recent transcriptome data from my lab as well as techniques for labeling newly synthesized proteins using click chemistry.