***Field:* Neuroscience/ Medicine**

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Session Topic:

Neural Communications

Session: Neural Communication

Planning Group Members:
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Speakers:
Andreas Draguhn, University of Heidelberg
Joachim Gross, Heinrich-Heine-University Düsseldorf
Takao Hensch, Riken Brain Science Institute
Kiyoshi Nakahara, The University of Tokyo

The brain consists of a huge number of neurons and is capable of performing remarkably fast and complex computations to subserve both simple sensory and motor as well as complex cognitive and processing. Structurally and functionally neurons are designed to communicate with each other and to form network assemblies. Coordinated communication within and between them is the basis of brain functions. Accumulating evidence from animal and human experiments suggests an important role of neural oscillations and synchronization in establishing functional connectivity. Neural synchronization occurs at multiple levels ranging from spiking of closely spaced pairs of neurons to the mass action of distant brain regions. This session deals with the investigation of neuronal activation and connectivity at the cellular and the systems level and their behavioural consequences.

Andreas Draguhn introduces cellular mechanisms of neuronal network oscillations and will focus on the role of a specific type of high frequency network oscillations called “ripples” in the representation and storage of information.

Neural oscillations and communication can be measured non-invasively in human subjects using magnetoencephalography. Joachim Gross introduces this technique and presents data on oscillatory brain networks underlying specific aspects of movement control.

Neuronal circuits are shaped by experience during critical periods of early postnatal life. Takeho Hensch presents evidence for the concept that critical period plasticity is best viewed as a continuum of local circuit computations ending in structural consolidation of inputs.

Using functional magnetic resonance imaging in humans and monkeys, Kiyoshi Nakahara, presents comparative data on brain control of eye movements and cognitive functions. These studies elucidate similarities and differences of neuronal networks between humans and monkeys.

In summary, this session pinpoints mechanisms and functional significances of coordinated neuronal communication in the brain.

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Speaker:
Takao Hensch, RIKEN Brain Science Institute

Critical period mechanisms of brain development

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At no time in life is the brain so easily shaped by experience than in infancy and in early childhood. It is during these “critical periods” that neural circuits acquire language, musical abilities and other basic brain functions, such as vision. Unraveling mechanisms that limit such dramatic plasticity to early life would pave the way for novel paradigms or therapeutic agents for rehabilitation, recovery from injury or improved learning in adulthood. Conversely, a deeper insight into early postnatal brain development provides valuable inspiration for effective brain-based education methods for our children – perhaps the greatest potential contribution of neuroscience to society.

Depriving one eye of vision during a well-defined critical period early in life permanently reduces visual acuity. Both the physiological and anatomical representation of the eye within neocortex is lost, leading to the competitive success of the open eye. To understand the cellular and molecular mechanisms that produce changes in connectivity within cortical circuits, we are pursuing the pharmacological or genetic disruption of candidate plasticity proteins using a mouse model. For the first time, we have achieved a direct control over the timing, duration and closure of this classical brain plasticity.

By focusing on how neuronal circuits are sculpted by experience during critical periods of early postnatal life, we have identified a single, underlying GABAergic cell type triggers plasticity that is mediated by structural rewiring through the action of proteases acting upon the extracellular matrix (ECM). These findings not only signal a paradigm shift that considers the balance of excitation-inhibition in cortical plasticity but also bear broad relevance across other brain systems and for translational research into human development, disease and life-long learning.

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Kiyoshi Nakahara, The University of Tokyo

Direct Functional Comparisons of Human and Monkey Brain

In search for biological basis of cognitive functions, macaque monkeys have been widely used as an experimental model, mainly in anatomical, electrophysiological and lesion studies, whereas investigations of the human brain have mainly relied on brain imaging and neuropsychological methods. To integrate these two lines of investigation, a natural and promising approach is to make direct comparisons of brain between the two species, both anatomically and functionally.

Functional magnetic resonance imaging (fMRI) is the most widely used non-invasive brain imaging method in human studies, and the recent advent of this method in non-human primates has opened the way for making such a direct comparison of brain activation. Whereas most of these comparative imaging studies have been carried out in sensory domain such as visual system, our group have been attempting to apply this method to comparisons of higher cognitive functions.

First, I will present functional comparison of brain networks for saccadic eye movements. Using fMRI, multiple regional brain activation was found in frontal and parietal cortex during saccadic eye movements in both humans and monkeys, and I will discuss possible correspondence of eye movement system between the two species [1].

Next, I will present application of fMRI to comparative investigation of prefrontal cortex (PFC), which is evolutionally most developed in primates among other mammals, and supports high-level cognitive functions. Flexible changes of behavior (cognitive set shifting) in adapting to current situation is one of the characteristic functions of the PFC. Our fMRI experiments revealed brain activation related to cognitive set shifting in focal regions of the PFC in both monkeys and humans [2].

These possible functional homologues were located in cytoarchitectonically equivalent regions in the posterior part of the ventrolateral PFC. The “comparative fMRI” presented here would be a powerful tool to elucidate similarities and differences of neuronal networks between humans and monkeys, and may provide insights into the evolution of cognitive function unique to humans.

References

1. 1. Koyama M., Hasegawa I., Osada T., Adachi Y., Nakahara K. & Miyashita Y. Functional magnetic resonance imaging of macaque monkeys performing visually guided saccade tasks: Comparison of cortical eye field with humans. *Neuron*. **41**, 795-807 (2004).

2. Nakahara K., Hayashi T., Konishi S. & Miyashita Y. Functional MRI of macaque monkeys performing a cognitive set-shifting task. *Science* **295**, 1532-1536 (2002).