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Friends of the
Max Planck Institute for Brain Research

newsletter 1/2018

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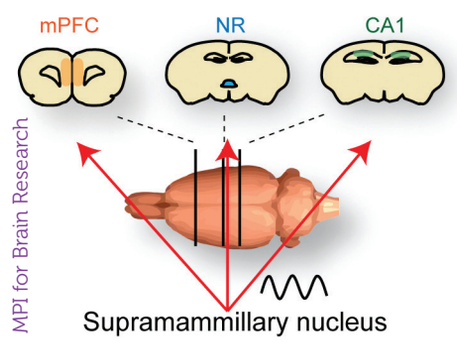
Route planning involves the prefrontal cortex, hippocampus and thalamic nucleus. The supramammillary nucleus is required to mediate the communication between the distant areas.

How we decide on where to go

route *planning is a key element for spatial navigation. Neurons in the hippocampus and surrounding structures, such as place cells or grid cells, become active depending on the animal's instantaneous position, and are considered part of internal maps in the brain. However, the information from these neurons is not sufficient for goal-directed navigation. To determine the next move toward a destination, these maps must interact with action planning systems in different cortical areas. Hiroshi Ito, research group leader at our Institute, not only has identified the prefrontal-thalamo-hippocampal circuit involved in this process, but has also provided proof for the communication mechanism between the brain areas, pointing to the supramammillary nucleus as a gateway to all three structures.*



Planning a route involves three brain areas and a mediator.

Finding our way to an unknown or even known location is a challenge we face nearly every day. In order to successfully navigate, we not only need to be aware of our current location and map our surrounding, but also need to decide which way to go. Besides humans, a wide range of other species from the animal kingdom, including mammals, need to make this choice. While 2014 Nobel Laureates John O'Keefe, as well as May-Britt Moser and Edvard Moser have identified the so-called place cells and grid cells in the mammalian cortex to determine the position in a specific environment, information about the brain areas and mechanism which facilitate the decision to take the correct route to the destination is still under investigation.

Previous work by Hiroshi Ito in the Moser's Lab already identified a neural circuit that functionally links between the brain's spatial representation system in the hippocampus and the action planning system in the prefrontal cortex. The neuroscientists found that a thalamic nucleus works as a connecting link between the prefrontal cortex and the hippocampus. The prefrontal-thalamo-hippocampal circuit allows transfer of information about the next route plans from the prefrontal cortex to the hippocampus. As animals need to cope with changing behavioral demands, multiregional interactions in the brain should be accordingly dynamic. The underlying mechanism for the communication between the three-fold connections has not been elucidated up till now.

continued

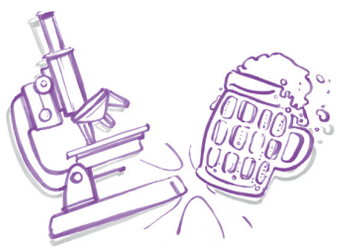
Ito and colleagues now provide proof that cortical synchrony is a key mechanism for behavior-dependent functional coupling in the prefrontal-thalamo-hippocampal circuit. Hiroshi Ito: "The key idea of cortical synchrony for dynamic cortical interactions dates back to the 1980s and was proposed by my respected colleague Wolf Singer. In accordance with his theory, we found enhancement of spike-time coordination at the theta frequency band (6-12 Hz) in the prefrontal-thalamo-hippocampal circuit whenever the rodents were required to choose a next movement direction at a T-junction of our maze."

The prefrontal cortex, the thalamic nucleus reuniens, and the hippocampus are however anatomically quite distant from each other, which raises a question of how these structures can interact in an efficient way. The authors found that neurons in the supramammillary nucleus fire at the theta rhythm and give rise to inputs in all three structures of the circuit. "We could even proof the importance of this structure when we deactivated the supramammillary nucleus via optogenetics. Theta-rhythm spike coordination was then impaired, which resulted in failure of communication from the prefrontal cortex to the hippocampus about the next route.", Ito says.

Researchers have now shed light on how route decision-making in the mammalian brain is coordinated and how closely these three brain areas work together. Ito says: "Spike-time coordination, or synchrony, is likely the key mechanism for gating signal flow between brain regions, controlling operations of the cortex for flexible behaviors of animals."

Bar of Science - Join us!

on September 13, young researchers from the Max Planck Institute for Brain Research will present their research at five different bars in Frankfurt. The public lectures are free of charge and registration is not required.



Join us for the Bar of Science on Sept. 13

18.30 hours: Café Crumble, Kiesstraße 41, Frankfurt-Bockenheim
Maria Tosches: *„From genes to mind: the mystery of brain evolution"*
Paul Donlin-Asp: *„Your brain: an amazing protein making machine"*

20.00 hours: Old Fashioned Bar Frankfurt, Klappergasse 35, Frankfurt -Sachsenhausen Verena Senn: *„Optogenetik – Lichtschalter im Gehirn"*

20.00 hours: Denkbar, Spohrstraße 46A, Frankfurt-Nordend
Marcel Lauterbach: *„Filme aus der Nanowelt"*
Andreas Nold: *„Alzheimer und die toxische Helferzellen im Gehirn — trügt der Schein?"*

20.00 hours: Ypsilon, Berger Straße 18, Frankfurt-Bornheim, Anfangszeit 20.00 Uhr
Jan Kirchner: *„Der seltsame Fall des Phineas Gage – Einführung in die Kognitionswissenschaften"*

20.00 hours: Billabong, Graf-von-Stauffenberg-Allee 46b, Frankfurt-Riedberg,
Raunak Basu: *„How do you plan your way to your favorite bar?"*
Or Shahar: *„Into the brain of a transparent fish"*

The Bar of Science serves as an opening act for the nation-wide Max Planck Day on September 14 in which 82 Max Planck Institutes in 32 cities all over Germany show what kind of research is performed there. More information about these festivities can be found here: wonachsuchstdu.mpg.de

Friends of the Max Planck Institute for Brain Research

Prizes and awards for Institute's members

also in 2018, researchers at the Max Planck Institute for Brain Research have received many prizes and awards.

Max Planck Research Group leader Julijana Gjorgjieva has been awarded a prestigious ERC Starting Grant for the NeuroDevo project. One of her postdocs, Marina Elaine Wosniack, received a Capes-Humboldt Research Fellowship to study the neural circuits underlying *Drosophila* (fruit fly) larvae locomotion.

Group leader Tatjana Tchumatchenko has been recognized by Focus Magazine as one of the 25 young innovators who will shape Germany in the future. In addition, she received funding from the DFG to investigate contrast invariance.

Julijana Gjorgjieva (middle) is praised by her colleagues for receiving the ERC Starting Grant

Hiroshi Ito has been awarded a Young Investigators Grant from the Human Frontiers Science Program of more than one million USD in total. Together with fellow scientists from the United States and Argentina, he will initiate a three-year project to investigate the interplay between space and time in the brain.

Selected recent publications

Ito H.T., Moser E.I., Moser M.B. (2018). Supramammillary Nucleus Modulates Spike-Time Coordination in the Prefrontal-Thalamo-Hippocampal Circuit during Navigation. *Neuron* 8: 576-587 (see also article on spatial navigation in this newsletter)

Tosches, M.A., Yamawaki, T.M., Naumann, R.K., Jacobi, A.A., Tushev, G. and Laurent, G. (2018). Evolution of pallium, hippocampus and cortical cell types revealed by single-cell transcriptomics in reptiles. *Science* 360: 881-888.

Kraynyukova, N. and Tchumatchenko, T. (2018) Stabilized supralinear network can give rise to bistable, oscillatory, and persistent activity. *PNAS* 2018; published ahead of print.

Poorthuis, R.B., Muhammad, K., Wang, M., Verhoog, M.B., Junek, S., Wrana, A., Mansvelder, H.D. and Letzkus, J.J. (2018) Rapid Neuromodulation of Layer 1 Interneurons in Human Neocortex. *Cell Reports* 23:951-58

Tushev, G., Glock, C., Heumueller, M., Biever, A., Jovanovic, M., and Schuman, E.M. (2018). Alternative 3'UTRs modify the localization, regulatory potential, stability, and plasticity of mRNAs in neuronal compartments. *Neuron* 98: 495-511

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Arjan Vink

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Besides scientific talks and lab tours, there was the possibility to explore the city of Bordeaux, in this case through a guided tour

IMPRS students visit Bordeaux

after Prague (2013), Lisbon (2016), the graduate students from the International Max Planck Research School for Neural Circuits now visited Bordeaux as part of their binannual retreat. Between April 24 and 28, they met various scientists from the Bordeaux Neurocampus and were introduced to their research via talks and lab tours. In addition, they explored Bordeaux and its attractions. One of the highlights was a visit to the nearby village Saint-Émilion, which included a guided tour through a vineyard and wine tasting.

BORDEAUX neurocampus


The University of Edinburgh

2018 Ethics in Science Lecture

in order to commemorate its dark past during Nazi Germany, the Max Planck Institute for Brain Research organizes annual lectures on ethics. Previous Ethics in Science Lectures were delivered in 2015 by Paul Weindling (Oxford Brookes University) and Jean-Pierre Changeux (École Normale Supérieure, Paris) in 2016. This year, Sarah Chan (University of Edinburgh) will present her view on the ethics of medical research. Her lecture is scheduled on October 5 and will start at 4 pm.

Sarah Chan will give the 2018 Ethics in Science Lecture titled „Toward a Global Germline Ethics: Facing humanity's genome-edited future?"

2018 Upcoming Lectures

(all Lectures start at 11.00 hours at the Institute's Lecture Hall)
13.11.18 David Foster Behavioral and Systems Neuroscience, Berkeley Psychology, US) Neuroscience Lecture
26.11.18 Maria Barna (Departments of Developmental Biology and Genetics, Stanford University, USA) Minerva Lecture
W: www.brain.mpg.de/news-events/lectures-and-other-events.html

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