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Max Planck Institute for Brain Research

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content

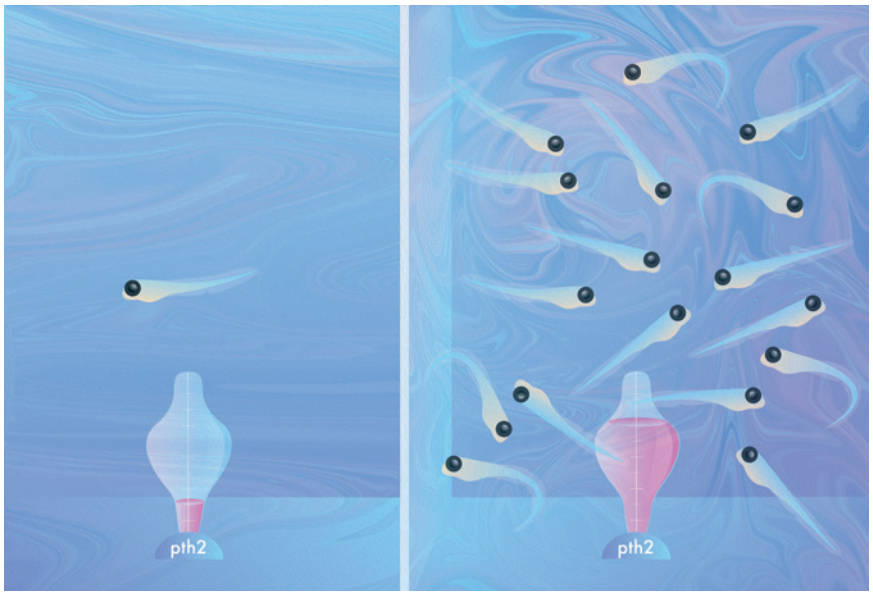
Science News

What social distancing does to brain

have you recently wondered how social distancing and self-isolation may be affecting your brain? An international research team led by Erin Schuman (Department of Synaptic Plasticity) discovered a brain molecule that functions as a "thermometer" for the presence of others in an animal's environment.

Varying social conditions can cause long-lasting changes in animal behavior; however, the brain systems that sense the social environment are not well understood. To probe whether neuronal genes respond to dramatic changes in the social environment, the team raised zebrafish either alone or with their kin for different periods of time. "We found that parathyroid hormone 2 (Pth2), a relatively unknown neuropeptide, consistently changed its expression in fish that were raised in social isolation. Curiously, pth2 gene expression tracked not just the presence of conspecifics, but also their density - when zebrafish were isolated, pth2 disappeared in the brain, but its expression levels rapidly rose, like a thermometer reading, when other fish were added to the tank," explains Lukas Anneser, lead author of the study.

On a quest to find the sensory modality the animals use to detect others and drive changes in gene expression, the scientists discovered that zebrafish "feel" the presence of others via mechanosensation and water movements - which turns the brain hormone on.



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Charting the developing brain

how can you build neuronal networks that are more complex than anything known today? Researchers at the laboratory of Moritz Helmstaedter (Department of Connectomics) have mapped the development of inhibitory neuronal circuitry, and report the discovery of distinct circuit formation principles. Their findings enable scientists to monitor the change of neuronal network structures with time, capturing moments when an individual grows and adapts to its environment.

The team analyzed a total of thirteen 3-dimensional datasets from the cortex of mice during different stages of development: after birth, at time points comparable to baby, child, teenager and young adult. They used methods called "connectomics" to map out the neuronal circuitry found in the gray matter of the cerebral cortex, where most of the cerebral synapses are placed. By focusing on synapses of a type of nerve cells called interneurons, which are known to inhibit the activity of other neurons in highly specific ways, they were able to track the development of synaptic partner choice for these particular types of nerve cells.

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These insights were possible in spite of the fact that the mapping of connectomes is a "snapshot" technique. "That we were able to still extract a clear developmental profile from this data illustrates the density of information present in connectomic data," says Anjali Gour, the graduate student who led the work. "We hope to be able to map much more precisely the normal and disrupted network formation in cortical circuits in order to understand possible alterations in psychiatric disease, and possibly identify the phenotypes of connectopathies," anticipates Helmstaedter.

Proteins in motion

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proteins are the essential substrate of learning and memory. However, while memories can last a life-time, proteins are relatively short-lived molecules that need to be replenished every couple of days. This poses a huge logistic challenge for over 85 billion neurons in the brain: billions of proteins need to be continuously produced, shipped, addressed and installed at the right location in the cell. Computational neuroscientists of Tatjana Tchumatchenko's group (Theory of Neural Dynamics), in collaboration with experimentalists of the Schuman and

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Helmstaedter departments, have now addressed a bottleneck in the protein trafficking system, dendritic branch points. They find that surface diffusion of proteins is more effective in providing proteins to distal dendritic sites than cytoplasmic diffusion.

"Dendritic arborization of neurons is one of the fascinating features that evolved to increase the complexity of the interactions between neurons. However, a more complex dendritic arbor also increases the difficulty of the logistical task to supply proteins to each part of the neuron," says Tchumatchenko.

What happens when proteins encounter dendritic branch points? Fabio Sartori, the lead author of the study, has the answer: "Branch points are like cross roads for traffic, some of the proteins will turn right, others will turn left. Cross roads for cars can be traffic bottlenecks. Similarly, the more branch points proteins meet on their journey, the lower the total protein number downstream. As a result, a neuron needs to produce more proteins to maintain a minimal protein number at distal synapses."

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Using walls to navigate the room

we perceive the world relative to our own body from a self-centered perspective. Yet our brain is able to transform this information into a world-centered, cognitive map of the environment, guiding us independent of where we look or the direction we face. The mechanism behind this has remained unsolved for decades. Now, scientists at the Memory and Navigation Circuits group led by Hiroshi Ito discovered a neural circuit in the rodent brain that may play a key role in translating both perspectives and help the animal to detect boundaries to avoid collision.

"Animals use landmarks in the environment as a reference point to identify the self's position and navigate their surroundings. In rodents, this ability is supported by very specialized types of neurons that fire only when the animal is at a precise location in the environment, even in an open arena", explains Ito.

"By recording from a brain area in the rat, called the retrosplenial cortex, we discovered a new type of neuron that signals the location of the room's boundaries such as walls from the animal's perspective", says graduate student Joeri van Wijngaarden, lead author of the study. "These border cells fire only when the boundary is at a particular distance and direction away from the animal. However, what struck me most", shares van Wijngaarden, "is that there is a close relationship between the activity of these border cells and the animal's following motion. When the rat approaches a wall to the left, border cells in the right hemisphere are activated, just before the animal turns right. Conversely, border cells in the left hemisphere are active just before left turns, so as to avoid collision".

Selected Honors and Awards

Erin Schuman has been awarded the **ALBA-FKNE Diversity Prize 2020** for her contribution to advancing gender equality in brain research. The prize highlights a scientist or group that has made outstanding contributions to promoting diversity in brain sciences.

Heisenberg Professorship for Johannes Letzkus
Research group leader Johannes Letzkus (Neocortical Circuits Group) has been awarded a Heisenberg Professorship by the German Research Foundation. In August 2020, he has accepted a Professorship at the Faculty of Medicine of the University of Freiburg.

Grants and Fellowships

Please visit our website **www.brain.mpg.de** for a list of all recently awarded grants and fellowships.

The **2020 Scientific Discovery Awards** (PhD and Postdoc Prizes) will be awarded by Matthias Kaschube, Chairman of the Friends association, at the virtual MPI holiday party in the afternoon of December 17.

PhD Graduations

Congratulations to Drs. Kenrick Yap (Deller Lab, IMPRS), Tamas Dalmay (Letzkus Lab, IMPRS), Mantian Wang (Schuman Lab, IMPRS) and Florian Drawitsch (Helmstaedter Lab) for defending their doctoral theses!
Upcoming thesis defenses: Maximilian Heumüller (Schuman Lab, IMPRS) and Caspar Glock (Schuman Lab, IMPRS).

Minerva Re-Opening

After closing for a few months due to the pandemic, Minerva bistro has re-opened under new management by Franjo Medic in June 2020.

Minerva bistro serves international-Mediterranean cuisine, and is located on the ground floor of the MPI for Brain Research. Minerva is open to the public. However, due to governmental restrictions associated with the Covid-19 pandemic, the bistro currently serves take-away to non-institute members. More info can be found on our website **www.brain.mpg.de**.

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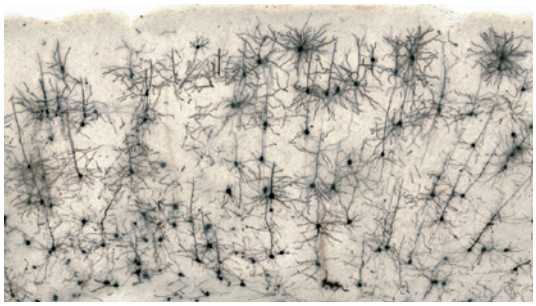
Company Anniversary

In the late summer of 2020, Christina Thum caught up celebrating her 25th company anniversary at the MPI for Brain Research. Outside, of course, and with all Covid-19 precautions required at the time! Thum has worked as a research assistant with the laboratories of former group leaders Heinz Stephan and Hermann Rohrer. Since 2015, Thum splits her time between the Schuman (Synaptic Plasticity) and Laurent (Neural Systems) departments. One of Thum's "specialties" is histology - she prepares amazing tissue stainings.



When asked what Thum likes most about her work at the institute, she said: "*I find it great that after such a long time I can still pursue my two scientific passions, histology and cell biology. But it's also fun to learn new methods from time to time because new people bring in new projects.*"

Above left: Thum receiving her anniversary certificate.
right: Neurons in the cerebral cortex of a mouse brain, stained using the Golgi method, an old silver staining technique, and imaged with light microscopy. © MPI for Brain Research / C. Thum and S. Junek

Newly Elected Representatives

In the fall of 2020, the MPI for Brain Research has elected a new works council as well as new equal opportunity officers (EOOs).

Andreas Umminger, Chairman of the newly elected works council explains: "*The employer and works council work together in a spirit of trust for the benefit of the employees and the company.*"

News members of the works council are: Elena Ciirdaeva (Schuman Lab), Nataliya Golovyashkina (Animal Facility), Dieter Herzberger (Facility Management), Anita Kulak (Schuman Department), Thomas Olstinski (Helmstaedter Lab), Mathieu Renard (Laurent Department), Smaro Soworka (Helmstaedter Department), Andreas Umminger (Mechanical Workshop), Florian Vollrath (Imaging Facility).

The **equal opportunity officers** foster and supervise the implementation of gender equality principles at the institute. "*I believe that in a vibrant and successful research environment diversity must be valued and fostered - giving all individuals equal career and development opportunities, irrespective of their gender and family choices,*" says Spanò. "*By actively promoting gender equality on all levels of our institute, I hope to contribute to a more equitable work environment and research culture,*" she adds.

Teresa Spanò (Schuman Lab)

Ashley Bourke (Schuman Lab)

Outreach Spotlight
Meet the Science

Pictures of the 'Meet the group'.

since 2016, the institute collaborates with the St. Angela School (Königstein) on the outreach program 'Meet the Science'. The project aims to promote the interest of high school students in the MINT area by providing authentic insights in the everyday work of a scientist at the MPI for Brain Research. The students participate in the monthly institute seminar, where scientists report on their research progress. They intensively prepare for each seminar date which includes an exclusive and interactive introduction on the research topic by the seminar speaker or colleagues familiar with the topic, discussions with the scientists, laboratory visits and, finally, the presentation at the institute seminar. The students take turns in preparing a report. Due to the pandemic, we have switched to a virtual format of 'Meet the Science'. The program is coordinated by Irina Epstein at the MPI for Brain Research and
Bärbel Ziemann-Becker at St. Angela School.

"The 'Meet the Science' project is terrific: it offers our female students a direct insight into science and research. The immediate experience of the work of the scientists at the institute and the opportunity to talk to them are highly appreciated by the participants - also with regard to their upcoming professional orientation!", Ziemann-Becker noted with enthusiasm.

After three visits, the students receive a Meet the Science certificate.

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Holiday Charity

in 2020, like every year prior to the winter break, the MPI for Brain Research members participate in a donation project. Donations are given to teenage girls of the FeM Mädchen*haus Frankfurt, where girls from disadvantaged backgrounds aged between 11 and 21 find shelter, can go to after school, and get advice or support in difficult life situations. The girls provide a wish list (gifts up to a certain value), and institute members can sign up to buy and wrap the presents. The gifts will be picked up before the holidays.

This year, there is also the option to donate by signing up for a mask with the logo of FeM Mädchen*haus.

Wishlist for the FeM Holiday Charity 2020.

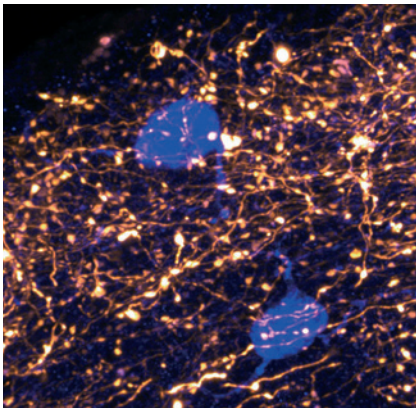
Selected Publications

Gour A., Boergens K.M., Heike N., Hua Y., Laserstein P., Song K., Helmstaedter M. **Postnatal connectomic development of inhibition in mouse barrel cortex.** Science. (December 3, 2020)

Anneser, L., Alcantara, I., Gemmer, A., Mirkes, K., Ryu, S., and Schuman, E.M. **The neuropeptide pth2 dynamically senses others via mechanosensation.** Nature. (December 2, 2020)

Sauer, A., T. Grent-'t-Jong, M. Wibral, M. Grube, W. Singer and P.J. Uhlhaas: **A MEG study of visual repetition priming in schizophrenia: Evidence for impaired high-frequency oscillations and event-related fields in thalamo-occipital cortices**. Frontiers in Psychiatry (23. Nov. 2020)

Pardi M.B., Vogenstahl J., Dalmay T., Spanò T., Pu D., Naumann L.B., Kretschmer F., Sprekeler H., Letzkus J.J. **A thalamocortical top-down circuit for associative memory**. Science. (November 13, 2020)

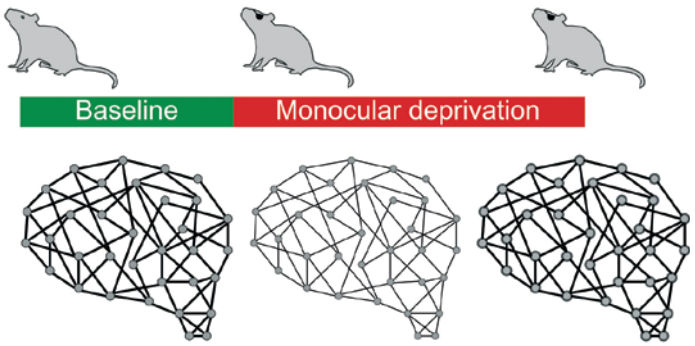


In the top-most layer of the neocortex, memory-related information is relayed by synapses from the thalamus (orange), which are in turn controlled by local 'gatekeeper' neurons (blue).

Van Wijngaarden J.B.G, Babl S.S., Ito H.T. **Entorhinal-retrosplenial circuits for allocentric-egocentric transformation of boundary coding**. eLife. (November 3, 2020)

Sartori F., Hafner A.S., Karimi A., Nold A., Fonkeu Y., Schuman E.M., Tchumatchenko T. **Statistical laws of protein motion in neuronal dendritic trees**. Cell Reports. (November 17, 2020)

Y. Wu, K. B. Hengen, G. G. Turrigiano and J. Gjorgjieva. **Homeostatic mechanisms regulate distinct aspects of cortical circuit dynamics**. PNAS. (September 11, 2020)



Disruption of visual input affects aspects of network activity that can be recovered by distinct homeostatic mechanisms.

Shapcott, K.A., J.T. Schmiedt, K. Kouroupaki, R. Kienitz, A. Lazar, W. Singer and M.C. Schmid: **Reward-related suppression of neural activity in Macaque visual area V4**. Cerebral Cortex. (July 30, 2020)

L. Montangie, C. Miehl and J. Gjorgjieva. **Autonomous emergence of connectivity assemblies via spike triplet interactions**. PLoS Comput Biol. (May 8, 2020)

K.P. Siju, V. Štih, S. Aimon, J. Gjorgjieva, R. Portugues and I.C. Grunwald Kadow (2020). **Valence and state-dependent population coding in dopaminergic neurons in the fly mushroom body**. Curr Biol. (May 6, 2020)

Keogh, R., J. Bergmann and J. Pearson. **Cortical excitability controls the strength of mental imagery**. eLife. (May 5, 2020)

Klein, L., F. Pothof, B. C. Raducanu, J. Klon-Lipok, K. A. Shapcott, S. Musa, A. Andrei, Aarts A. A. A. Paul O., Singer W., and Ruther P. **High-density electrophysiological recordings in macaque using a chronically implanted 128-channel passive silicon probe**. Journal of Neural Engineering. (April 28, 2020)

Alvarez-Castelao, B., tom Dieck, S., Fusco, C.M., Donlin-Asp, P.G., Perez, J.D., and Schuman, E.M. (2020). **The switch-like expression of Heme-regulated kinase 1 mediates neuronal proteostasis following proteasome inhibition**. eLife. (April 24, 2020)

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