

Foreword



My path to becoming a neuroscientist started “far far away” as an astronomy undergraduate at the Pontificia Universidad Católica in Chile. Curious to learn more about the fates of stars, the elements of the periodic table, I decided to move to Germany to study biochemistry in Tübingen. While trying to find a field to satisfy my interest in interdisciplinary research, I met two neuroscientists that fueled my fascination for an almost mystical question: how does the brain compute or “think”? Thus, I decided to do a PhD at the Max Planck Institute of Neurobiology and continued my training as a postdoc at Harvard University.

These days, I am specifically interested in understanding the neuronal basis of behaviors. I envision that this work will reveal general rules of neuronal computation. If this ends up being successful, science might be able to distill the complexity of brain functions into basic computational principles in a not-so-distant future.

In January 2017 I started my lab at IST Austria, where I keep on trying to make some sense of what happens between our ears. For this goal, a variety of techniques must be combined, ranging from refined microscopy experiments to quantitative behavioral readouts, sophisticated data analysis approaches and novel genetic tools with insightful ideas and concepts. Such a multidisciplinary endeavor is not only nurtured by the diverse scientific environment at IST Austria but indispensable for successful research.

Maximilian Jösch | Assistant Professor, IST Austria



European Research Council



Thomas A. Henzinger reappointed as President of IST Austria

During its meeting on November 28, 2016, the Board of Trustees of the Institute of Science and Technology Austria (IST Austria), reappointed Prof. Thomas A. Henzinger for a third four-year term as President of the Institute. His new term of office will start on September 1, 2017.

Professor Henzinger, accepting the leadership of the Institute for another term, said: “The reappointment by the Board of Trustees is a great honor for me. The last years were a tremendous experience. I am very grateful for the confidence vested in me by the board members, and by the scientists who decided to join IST Austria. I also wish to take this opportunity to thank the entire staff of the Institute, whose commitment and dedication has made the rapid development of IST Austria possible. But our goal is lofty and much work remains to be done. In the coming years I will continue to do my best to lead IST Austria in its mission to become a globally renowned center for basic research in science.”

IST Austria scientists obtain 10 ERC grants in 2016

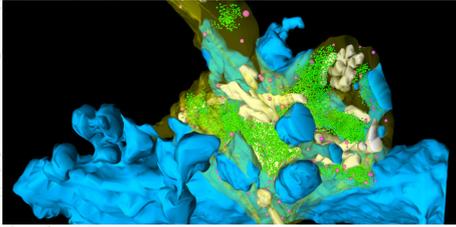
With a total of ten ERC (European Research Council) grants awarded to its professors in the year 2016, IST Austria looks back on exceptional success in the European competition for research funding. ERC grants are considered to be the most prestigious science grants in Europe. IST Austria researchers received grants in all three major ERC funding categories: three Advanced Grants, two Consolidator Grants and five Starting Grants.

President Thomas Henzinger is delighted by the exceptional success: “I want to specifically call the attention to the fact that in the year 2016, ERC grants were won in all disciplines that are currently represented on campus: biology, neuroscience, physics, mathematics, and computer science. All six neuroscientists and all seven computer scientists on campus have now been funded by the ERC.” The total number of projects funded by the European Research Council at IST Austria has risen to 31, for 45 faculty members currently under contract.

Professor László Erdős receives Leonard Eisenbud Prize

The American Mathematical Society awarded László Erdős and Horng-Tzer Yau (Harvard University) the Leonard Eisenbud Prize. Presented every three years, the award recognizes work that brings mathematics and physics closer together. In the 1950s, when Eugene Wigner was studying energy levels in atomic nuclei, he represented their statistical behavior by the eigenvalues of a matrix in which the entries were chosen at random.

There are many ways of randomly choosing the entries in a matrix. In simulations, researchers observed the same statistical patterns emerging from the matrices, regardless of which way was used for the random choice of the entries. These patterns seemed to be “universal,” and the question of whether the observations could be nailed down in a mathematical proof became known as the “universality conjecture.” It is this conjecture that Erdős and his long-term collaborator settled in their prize-winning work.



Full detonation in the hippocampus

Altering synaptic plasticity leads to a computational switch in a hippocampal synapse: the presynaptic neuron turns into “detonator” mode, causing its postsynaptic partner to fire more readily. This new insight by Nicholas Vyleta, previously a postdoc at IST Austria and now at Oregon Health and Science University, Carolina Borges-Merjane, postdoc at IST Austria, and Peter Jonas, Professor at IST Austria,

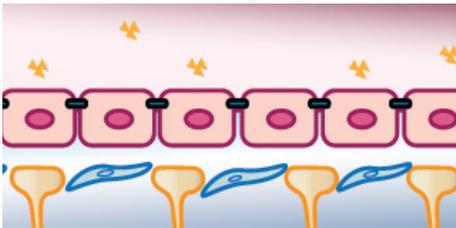
was published in the open-access journal *eLife*.

Synapses form connections between neurons. A single postsynaptic neuron can be connected with thousands of presynaptic neurons. At the synapse, information is transferred from the presynaptic to the postsynaptic neuron. When one of these presynaptic neurons sends out a single action potential, the postsynaptic neuron fires.

In their study, the authors investigate the synapse between granule cells and CA3 pyramidal cells in the hippocampus, using a method to simultaneously stimulate the individual presynaptic terminal and record from the connected postsynaptic CA3 neuron. Under normal conditions, a single action potential from the granule cell does not induce fir-

ing in the CA3 neuron. Instead, the granule cells are ‘conditional detonators’: burst firing of action potentials from a granule cell is required to get the CA3 neuron to fire as well.

When the researchers altered the synaptic plasticity of the granule cell by stimulating a single presynaptic terminal to fire at high frequency for only one second, causing post-tetanic potentiation (PTP), the picture changes. The granule cell turns into a full detonator: a single action potential causes the CA3 neuron to fire. Short-term synaptic plasticity in the form of PTP produces a computational switch at the studied synapse. This change is prolonged, lasting for tens of seconds. This could be critical for information coding, storage and recall in the network formed by granule cells and CA3 neurons.



New form of autism found

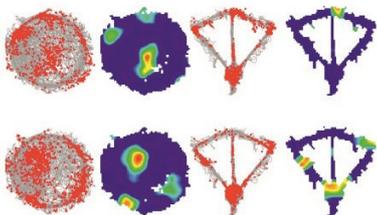
Autism spectrum disorders (ASDs) affect around one percent of the world’s population and are characterized by a range of difficulties in social interaction and communication. In a new study published in *Cell*, a team of researchers led by Gaia Novarino, Professor at IST Austria, identifies a new genetic cause of ASD. She explains why this finding is significant: “There are many different genetic muta-

tions causing autism, and they are all very rare. This heterogeneity makes it difficult to develop effective treatments. Our analysis not only revealed a new autism-linked gene, but also identified the mechanism by which its mutation causes autism. Excitingly, mutations in other genes share the same autism-causing mechanism, indicating that we may have underscored a subgroup of ASDs.”

A gene called *SLC7A5* transports a certain type of amino acids, the so-called branched-chain amino acids (BCAA), into the brain. To understand how mutations of *SLC7A5* lead to autism, the researchers studied mice in which *SLC7A5* is removed at the barrier between the blood and the brains. This reduces the levels of BCAAs in their brain, and interferes with protein synthesis in neurons. Con-

sequently, the mice show reduced social interaction and other changes in their behavior, which are also observed in other autism mouse models.

Notably, the researchers were able to treat some of the neurological abnormalities in the adult mice missing *SLC7A5* at the blood-brain barrier. After delivering BCAAs straight into the mice’s brains for three weeks, the authors observed an improvement in behavioral symptoms. The researchers’ results contrast with the idea that ASDs are always irreversible conditions. The way they treated symptoms in the mice cannot, of course, directly be used in humans. But they show that some of the neurological complications presented by mice missing *SLC7A5* can be rescued, and so it is possible that – eventually – patients may be treated as well.



New system for forming memories

Until now, the hippocampus was considered the most important brain region for forming and recalling memory, with other regions only contributing as subordinates. But a study published in *Science* finds that a brain region called the entorhinal cortex plays a new and independent role in memory. A team of researchers led by Jozsef Csicsvari, Professor at IST Austria, showed that, in rats, the

entorhinal cortex replays memories of movement independent of input from the hippocampus.

When a spatial memory is formed, cells in the medial entorhinal cortex (MEC), especially grid cells, act like a navigational system. They provide the hippocampus with information on where an animal is and give cues as to how far and in what direction the animal has moved. Rats encode location and movement by forming networks of neurons in the hippocampus that fire together. When a memory is recalled for memory stabilization, the MEC has been considered as secondary to the hippocampus. In the hippocampus, such recall occurs during the so-called “sharp wave/ripples,” when neuronal networks fire in a highly synchronized way. According to the view prevailing until now, the hippocampus is

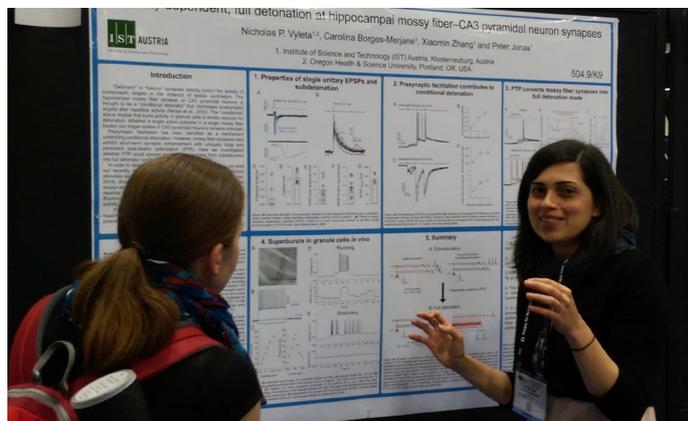
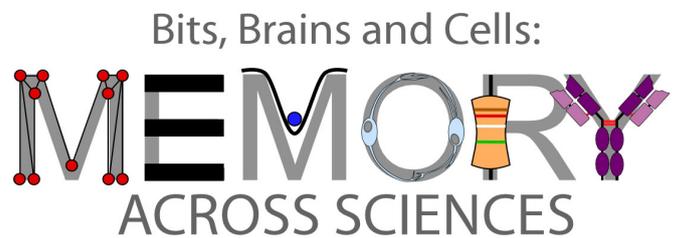
the initiator of this replay and coordinates memory consolidation, while the MEC is just a relay post that spreads the message to other brain areas.

To ask whether replay also occurs in the MEC, the researchers studied memory recall in rats moving in a maze. They showed that neurons in the superficial layers of the medial entorhinal cortex (sMEC), a part of MEC that sends input to the hippocampus and contain the grid cells, fire during the memory task and encode routes as bursts of firing. Surprisingly, the authors find that replay firing in the sMEC is not accompanied by replay firing in the hippocampus. During both sleep and waking periods, the sMEC triggers its own replay and initiates recall and consolidation independent of the hippocampus.

Young Scientist Symposium 2017

Save the Date: the Young Scientist Symposium will be back for the 6th time on May 12, 2017 at IST Austria. The one-day conference will be about “Bits, Brains and Cells: Memory across Sciences” and will cover all main research areas of IST Austria (including Biology, Neuroscience, Mathematics, Physics, and Computer Science). The multi-disciplinary list of speakers promises exciting insights into “memory” in different fields – from classical neuroscience and immunology to catalytic computation, quantum memory and DNA-based data storage. The event will be organized entirely by young scientists, and is open to academics at all stages of their career.

For information and registration, please visit the [symposium website](#).



Neuroscience 2016

Neuroscience 2016 was a tremendous success for IST Austria! Neuroscientists from the Jonas, Csicsvari, Shigemoto, and Hippenmeyer Groups presented 15 posters on November 12-16 at the San Diego Convention Center. Organized by the Society for Neuroscience, last year's conference with 30,353 attendees from 80 countries was the largest marketplace for ideas and tools for neuroscience worldwide. Assistant Professor Simon Hippenmeyer and five other neuroscientists held a minisymposium session at Neuroscience 2016, presenting exciting open questions and emerging findings in how the cerebral cortex grows. They were also invited by The Journal of Neuroscience to write a review on current studies in corticogenesis.

For more photos please visit the [IST Austria Facebook page](#).

COLLOQUIUM SPEAKERS

PAST SPEAKERS (November - January): Marcel Salathé, École Polytechnique Fédérale de Lausanne (Nov 7) | Alfonso Martinez Arias, University of Cambridge (Nov 21) | Frank Morgan, Williams College (Nov 21) | Felix Otto, Max Planck Institute for Mathematics in the Sciences (Dec 5) | Tanya Zeevinsky, Columbia University (Dec 12) | Matthias Troyer, ETH Zurich and Microsoft Research (Dec 19) | Laure Saint-Raymond, École Normale Supérieure (Jan 16) | Patricia Wittkopp, University of Michigan (Jan 30)

FUTURE SPEAKERS (March - May): Elaine Ostrander, National Institutes of Health (Mar 6) | Frank Juellcher, Max Planck Society (Mar 13) | Fiona Doetsch, University of Basel (Mar 20) | Erik Sahai, The Francis Crick Institute (Mar 27) | Daniel A. Fletcher, University of California, Berkeley (Apr 3) | Claudia Bagni, Katholieke Universiteit Leuven (Apr 10) | Ottoline Leyser, University of Cambridge (Apr 24) | L Mahadevan, Harvard University (May 8) | Konrad Lehnert, University of Colorado Boulder (May 15) | Dianne Newman, California Institute of Technology (May 22)

SELECTED RECENT PUBLICATIONS

Barton, Nicholas H: How does epistasis influence the response to selection. In: *Heredity*. Nature Publishing Group, 2017, 96-109.

Chatterjee, Krishnendu, Novotný, Petr, Zikelic, Djordje: Stochastic Invariants for Probabilistic Termination. In: *POPL: Principles of Programming Languages*. ACM, 2017, 145-160.

Edelsbrunner, Herbert, Iglesias-Ham, Mabel: Multiple covers with balls II: Weighted averages. In: *Electronic Notes in Discrete Mathematics*. Elsevier, 2016, 169-174.

Henzinger, Thomas A, Otop, Jan: Model measuring for discrete and hybrid systems. In: *Nonlinear Analysis: Hybrid Systems*. Elsevier, 2017, 166-190.

Hilbe, Christian, Traulsen, Arne: Only the combination of mathematics and agent based simulations can leverage the full potential of evolutionary modeling: Comment on “Evolutionary game theory using agent-based methods” by C. Adami, J. Schossau and A. Hintze. In: *Physics of Life Reviews*. Elsevier, 2016, 29-31.

Kazda, Alexandr, Kolmogorov, Vladimir, Rolinek, Michal: Even Delta-matroids and the complexity of planar Boolean CSPs. In: *ACM-SIAM Symposium on Discrete Algorithms (SODA)*, 2017.

Martín del Campo Sanchez, Abraham, Cepeda Humarez, Sarah, Uhler, Caroline: Exact goodness-of-fit testing for the Ising model. In: *Scandinavian Journal of Statistics*. Wiley-Blackwell, 2016, preprint.

Midya, Bikashkali, Konotop, Vladimir V: Modes and exceptional points in waveguides with impedance

boundary conditions. In: *Optics Letters*. The Optical Society, 20, 2016, 4621-4624.

Moser, Thomas, Seiringer, Robert: Triviality of a model of particles with point interactions in the thermodynamic limit. In: *Letters in Mathematical Physics*. Springer, 2016, Epub ahead of print.

Renkawitz, Jörg, Sixt, Michael: Formin' a nuclear protection. In: *Cell Press*, 6, 2016, 1448-1449.

Zagorski, Marcin, Burda Zdzislaw, Waclaw Bartłomiej.: Beyond the hypercube: Evolutionary accessibility of fitness landscapes with realistic mutational networks. In: *PLoS Computational Biology*. Public Library of Science, 12, 2016, Article Number: e1005218.

A full list of publications from IST Austria can be found at publist.ist.ac.at.

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