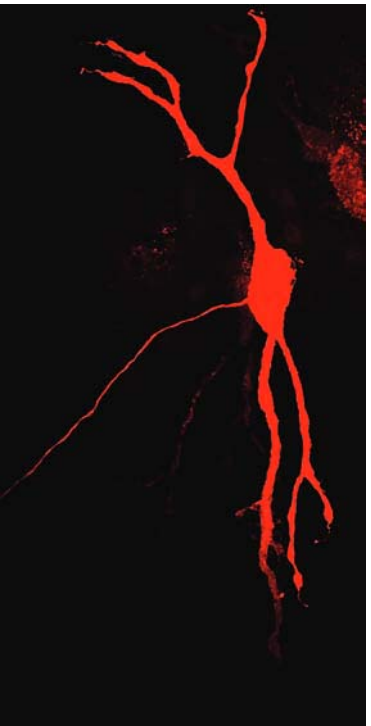
Bernstein Network Computational Neuroscience

Bernstein Newsletter

06/2014

How nerve cells flexibly adapt to acoustic signals

Did the bang come from the front or from the right? In order to localize sound sources, nerve cells in the brain stem evaluate the different arrival times of acoustic signals at the two ears. Being able to detect temporal discrepancies of up to 10 millionths of a second, the neurons have to become excited very quickly. In this process, they change the electrical voltage that prevails on their cell membrane. If a certain threshold is exceeded, the neurons generate a strong electrical signal – a so-called action potential – which can be transmitted efficiently over long axon distances without weakening. In order to reach the threshold, the input signals are summed up. This is achieved easier, the slower the nerve cells alter their electrical membrane potential.



A neuron in the brain stem, that processes acoustic information. Depending on the situation, the cell generates action potentials in the axon (thin process) either close to or far from the body.

These requirements – rapid voltage changes for a high temporal resolution of the input signals, and slow voltage changes for an optimal signal integration that is necessary for the generation of an action potential – represent a paradoxical challenge for the nerve cell. "Nature solved this problem by spatially separating the two processes. While input signals are processed in the cell body and the dendrites, action potentials are generated in the axon, a cell process," says Christian Leibold, leader of a study that also involved the participation of Benedikt Grothe, and Felix Felmy from the Bernstein Center and the Bernstein Focus Neuronal Basis of Learning in Munich and the LMU Munich.

But how sustainable is the spatial separation? In their study, the researchers measured the axons' geometry and the threshold of the corresponding cells and then constructed a computer model that allowed them to investigate the effectiveness of this spatial separation. The researchers' model predicts that depending on the situation, neurons may flexibly adapt their mode of operation. At low input frequencies, they generate most outgoing action potentials close to the cell body. Following inhibitory or high frequency excitatory signals, the cells produce many action potentials more distantly. This way, they are highly sensitive to the different types of input signals – and thus allow us to perceive both small and large acoustic arrival time differences well, and thereby localize sounds in space.

Lehnert S, Ford MC, Alexandrova O, Hellmundt F, Felmy F, Grothe G & Leibold C (2014): Action potential generation in an anatomically constrained model of medial superior olive axons. Journal of Neuroscience, 34 (15): 5370 – 5384.
doi: 10.1523/jneurosci.4038-13.2014

Research data for everyone

Are there researchers who voluntarily share their complete, raw data sets online before even having evaluated the data themselves? Until some time ago, this was unthinkable. Even today, many scientists shy away from permissive data sharing before their results are published – helping strengthen their professional reputation. Magdeburg psychologist Michael Hanke from the Otto von Guericke University Magdeburg has now embarked on a different route altogether with Jörg Stadler from the Leibniz Institute for Neurobiology and colleagues. They will publish the most comprehensive set of raw brain imaging data on natural language processing in the inaugural issue of the new open-access journal Scientific Data of the Nature Publishing Group. It is already freely available for analyses from the website http://www.studyforrest.org.

"We have received funds from the Federal Ministry of Education and Research to collect data. Now we see it as our duty to maximize the impact from this research for society," Hanke explains, whose project was funded in the framework of a German-US-American Collaboration within the Bernstein Network. The brain researchers will now receive professional acknowledgements through citations of their data article.

This open science approach has the advantage of accelerating progress in science. Competing research labs can simultaneously work on a subject without obstructing other scientists' research plans through delaying the publication of data sets. Also, when scientists are asked to share data, they do not need to laboriously reconstruct past data collections – some inquiries are made years after the first publication – since the raw data have already been prepared for sharing. This saves time and cost, which can be used to further scientific developments.

The published Magdeburg data set focuses on the processing of acoustic stimuli. In the study, participants listened to an audio movie of the classic feature film Forrest Gump. Meanwhile, their brain activity was measured using functional magnetic resonance imaging (fMRI) as it processed language, music, emotions, memories, and visual imagery. Thus, the recordings do not isolate a single aspect of brain function, but instead reflect the real complexity of information flow in everyday listening experiences. In addition to the fMRI data, the scientists provide comprehensive anatomical descriptions of the participants' brains, as well as measurements on breathing and heartbeat. These help indicate the portions of the film when the listener was more excited or relaxed.

With these data, it is possible to study emotion processing during listening experiences – or analyze completely different research questions. Besides Hanke, at least two other research groups in England and Australia are currently evaluating this data. He does not know their specific lines of inquiry, however, there is one thing he is positive about: "professionals from other disciplines – such as engineers – have a very different approach to our data while also possessing the required skills to optimally analyze them for their own use." In order to promote such inter-disciplinary research the Magdeburg Center for Behavioral Brain Sciences has sponsored an award of 5000 EUR for the best use of the published data set.

Hanke M, Baumgartner FJ, Ibe P, Kaule FR, Pollmann S, Speck O, Zinke W & Stadler J (2014): A high-resolution 7-Tesla fMRI dataset from complex natural stimulation with an audio movie. Scientific Data, 1:140003.
doi: 10.1038/sdata.2014.3

A game of ping pong for the eyes

Have you ever tried to keep your eyes still while looking out the window of a moving train? It does not work: our eyes move involuntarily without a break. Scientists led by Stefan Glasauer at the Bernstein Center and LMU Munich in collaboration with colleagues from the Washington National Primate Research Center at the University of Washington in Seattle are now unraveling the basis of this so-called optokinetic reflex: there are certain brain cells encoding both the speed of the landscape and the eye movement.

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Enjoying the landscape when traveling by train – while this activity sounds like pure relaxation, in reality, it requires maximum performance of our eyes' motor system. To prevent blurring of the passing image, our eyes need to follow the environmental pace with many repetitive brief movements. The Munich scientists describe that neurons in the posterior parietal lobe play an important role in the conversion of the landscape stimuli into a control signal for the eye muscles.

"By means of electrophysiological recordings, we could show that nerve cells of the so-called MSTd area combine information about the motion of the visual stimulus on the retina with the eye movement speed," Lukas Brostek – first author of the study – explains. The way how this is done clearly differs from cell to cell – hereby enabling the generation of completely new signals. Using computer models, the researchers demonstrated that the observed distribution of signal combinations corresponds exactly to the one required to calculate the velocity of the ambient scene. This is the information the brain ultimately requires to control eye movements.

Several areas of the brain are involved in the control of the optokinetic reflex. The necessary information processing includes essentially three steps: In a first step, the speed of a visual stimulus on the retina is calculated. In a second step, the proper eye motion is combined with this information to obtain the environmental velocity. This is the process, the researchers were now able to localize in the brain. "The neurons we have recorded from provide the basis for the final step – the unconscious control of eye muscles. Hereby they ensure that our eye movements match the environmental motion and that we can recognize a passing scenery instead of seeing it blurred," Glasauer says.

Brostek L, Büttner U, Mustari MJ & Glasauer S (2014): Eye velocity gain fields in MSTd during optokinetic stimulation. Cerebral Cortex, published ahead of print January 27
doi: 10.1093/cercor/bhu024

Bernhard Seeber

© Bernhard Seeber

A simply furnished room with a plain stool in its center. It is surrounded by 96 small loudspeakers mounted on tripods, which form a closed and complete circle. The most diverse sounds emerge from them. Dark curtains cover the walls of the room and suppress the feeling of space. Bernhard Seeber stands in a hearing laboratory: a virtual acoustic chamber. "I am investigating sound processing in the human auditory system," the scientist explains, "and use the findings to improve hearing devices and audiosystems." Since August 2012, Bernhard Seeber holds the Professorship of Audio Information Processing at the Technische Universität München (TUM), which was launched within the framework of the Bernstein Network.

Hearing has played a special role since early on in the life of Bernhard Seeber. As the son of an otologist, he started playing the guitar at the age of ten. Soon he also became interested in music electronics. Consequently, Seeber began studying electrical engineering and information technology at TUM. "However, during my studies I realized that I am more intrigued by the psychophysics of hearing than by building amplifiers and effect processors," Seeber says. The engineer then focused his diploma thesis on this area by examining masking effects and the frequency selectivity of the ear.

During his PhD with Hugo Fastl at TUM, Seeber developed a new method to study auditory localization ability. In this technique, the listener indicates the perceived direction of a sound by positioning a movable visual pointer – such as a picture of a loudspeaker – on a screen using a trackball. "The indirect pointing with the trackball causes a decoupling from the human proprioceptive directional system and the method achieves a high accuracy," Bernhard Seeber says. Since it is easy to use, it has been successfully used over the years to study the perception of patients with hearing aids or cochlear implants (CI). For his dissertation he was honored with the thesis award of the German Information Technology Society.

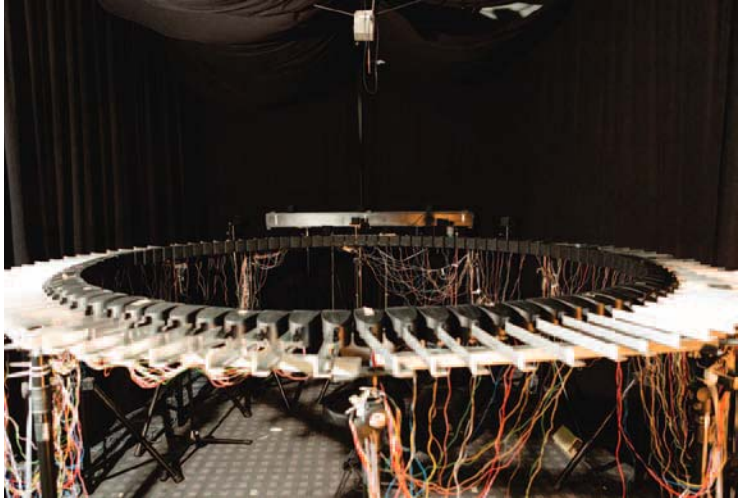
After receiving his PhD in 2003, Bernhard Seeber moved to the University of California at Berkeley, USA. In Ervin Hafter's lab he devoted himself to the study of simultaneous sound sources and the impact of sound reflections on binaural perception in healthy listeners as well as in users of hearing aids and cochlear implants. To this end, he developed his first virtual acoustic chamber, the Simulated Open Field Environment. This laboratory allows simulating complex sound fields which are played back through loudspeakers, including sound reflections that exist in natural spaces. This way, Seeber can generate the most diverse and complicated every day listening experiences in the lab – without the need of using headphones. This is a prerequisite for testing hearing aids in realistic situations. "For medical research, this lab was unique when we created it first ten years ago," Seeber recalls. Even today, this lab builds the foundation of his research.

After spending four years in the United States, Seeber moved to Great Britain to start his own research group at the MRC Institute of Hearing Research in Nottingham. In the summer of 2012, he returned to the Technische Universität München. One of his current research foci includes the processing of room

reverberation. Healthy individuals have strong mechanisms to suppress the interference caused by sound reflections. „In patients with hearing impairment or cochlear implants, these mechanisms do not function well. Therefore, they have severe problems understanding and locating the spokesman in space," Bernhard Seeber explains. "Especially when there is a discussion between several people in a group – a typical situation in a classroom or a restaurant – it is difficult for them to follow the speakers." Seeber is currently working on algorithms that better represent the relevant auditory cues in the pulse pattern of cochlear implants with the aim to make spatial perception more reliable in noisy and reverberant situations. In this project, he collaborates with Werner Hemmert and Lutz Wiegrebe from the Bernstein Center Munich.

Modeling and signal processing for auditory implants is also the topic of the third Bernstein Sparks Workshop that is organized by Seeber and Hemmert on June 20, 2014 in connection with the CI 2014 conference (see also page 17). "The idea for the workshop arose from my experience with this CI conference series, in which I took part in Stockholm in 2010," Seeber says. Although most presentations dealt with clinical research questions, many participants were basic scientists. "With the workshop I want to promote a mutual understanding and exchange between both research fields. Of course, its focus lies on neuroscience, and the contributions will deal with model-based and neuroscientific approaches for new stimulation strategies."

In addition to the development of CIs, Bernhard Seeber is pursuing a second main research project in the context of the Bernstein professorship. He is interested in the information healthy listeners can extract from sound reflections. "Every room has a specific reflection pattern. We may perceive it shortly when we move from one room to the next until our auditory system has adapted to it," Seeber illustrates. The reflection pattern enables us to decide with closed eyes whether the room we are standing in is large or small, or how far we stand from a wall. "The question is, how do we do that and which role does adaptation play?"



Using the Simulated Open Field Environment, Seeber can simulate the acoustics of rooms with sound reflections in a natural fashion. Additionally, fitted curtains can be drawn in front of the speakers and may be used as a screen for video projectors – the subject is then submerged in an audio-visual environment. The picture shows the lab of Hugo Fastlas Seeber's own lab is still under construction.

© Bernhard Seeber

Aside from research, Bernhard Seeber is keen to raise the public awareness for hearing and its protection. Besides engaging in the Network Hearing Impairment in Bavaria, he organized an interactive audio demonstration that can simulate various hearing situations at the Münchner Stadtmuseum for this year's International Noise Awareness Day. The visitors were able to communicate with each other via microphones and simultaneously experience through headphones, how the sounds are perceived by hearing impaired persons or CI users. An effective step into the broad public, Seeber believes: "Hearing forms the basis for our communication – thus, an understanding of its importance and a careful handling of noise are extremely important. We cannot repair the hearing system – so far we can only try to minimize any damage."

Personalia

Niels Birbaumer (BFNT Freiburg-Tübingen, Eberhard Karls Universität Tübingen) received the Eva Luise Köhler Award for Rare Diseases 2014 for his project "Combined Brain-Computer-Interface for brain communication for patients suffering from amyotrophic lateral sclerosis". The award is endowed with € 50.000 to specifically support exceptional and promising research.
www.nncn.de/en/news/nachrichten-en/niels-birbaumer-eva-luise-kohler-award

BCCN Berlin achieves extension of the Research Training Group (RTG) 1589 "Sensory Computation in Neural Systems" established in 2010 for additional 4.5 years.
www.nncn.de/en/news/nachrichten-en/grk1589

Peter Diehl (BCCN Berlin, Technische Universität Berlin) received the Erwin-Stephan-Preis of the Technische Universität Berlin that recognizes rapid completion of studies with excellent results. Peter Diehl achieved the Master's degree in the Computational Neuroscience program at the BCCN Berlin in less than two years with best marks. The prize is endowed with € 2.500.
www.nncn.de/en/news/nachrichten-en/peter-diehl-receives-erwin-stephan-preis

Onur Güntürkün (BFNL Sequence Learning, Ruhr-Universität Bochum) received the Communicator Award 2014 conferred by the German Research Foundation (Deutsche Forschungsgemeinschaft, DFG) and the Donors' Association for the Promotion of Sciences and Humanities in Germany for the exemplary communication of his research on the biological foundations of animal and human behaviour. The award is endowed with € 50.000 and is the most important prize for science communication awarded in Germany.
www.nncn.de/en/news/nachrichten-en/onur-gunturkun-receives-communicator-award

Anton Sirota (CIN and University of Tübingen) has accepted the offer from Ludwig-Maximilians-Universität München for the new W3-Chair for "Cognition and Neural Plasticity", which links the Bernstein Center Munich with the Munich Cluster for Systems Neurology (SyNergy).
www.nncn.de/en/news/nachrichten-en/anton-sirota-new-w3-professor-at-bccn-munich

Ulman Lindenberger (BFNL complex human learning, Max Planck Institute for Human Development, Berlin) is co-director of the new Max Planck UCL Centre for Computational Psychiatry and Ageing Research that was founded by the Max Planck Society and University College London (UCL). Arno Villringer (BCCN Berlin) is involved in the Coordination Committee of the new Centre as representative of the Max Planck Institute for Human Cognitive and Brain Sciences in Leipzig.
www.nncn.de/en/news/nachrichten-en/new-research-centre

19 members of the Bernstein Network participate in the new Priority Programme (Schwerpunktprogramm, SPP) 1665 "Resolving and manipulating neuronal networks in the mammalian brain – from correlative to causal analysis". The programme is funded by the German Research Foundation (Deutsche Forschungsgemeinschaft, DFG) for an initial period of three years. An extension of up to six years is possible.
www.nncn.de/en/news/nachrichten-en/new-priority-programme

Join the Bernstein Association

Since 2004, the Federal Ministry of Education and Research (BMBF) has been supporting the establishment of Computational Neuroscience in Germany through a special funding initiative, which has evolved with great success into the Bernstein Network. In order to sustain and further develop the Bernstein Network beyond the start-up phase funded by the BMBF, the members of the non-profit Bernstein Association for Computational Neuroscience have decided to open the association and transform it into a scientific society: every scientist working in Computational Neuroscience or related fields may now become a member.

Membership in the Bernstein Association offers the following advantages:

- Reduced registration fees for the annual Bernstein Conference
- Reduced registration fees for Bernstein Workshops and courses
- Bernstein Newsletter with latest research news, network news, and activities of the Bernstein Network Computational Neuroscience (4 times a year)
- Regular Bernstein info e-mails that inform about latest news and events, job vacancies and new calls

The Bernstein Association supports science, research, and education in Computational Neuroscience, disseminates research themes and findings to the public, and promotes career opportunities of junior scientists.

Thus, the Bernstein Association annually awards the Brains for Brains Young Researchers' Computational Neuroscience Award to students who have a peer reviewed publication or conference abstract that was submitted before they started doctoral studies. The award is endowed with a travel grant for a one-week trip to Germany, including the participation in the Bernstein Conference and individually planned visits to up to two German research institutions in Computational Neuroscience as well as € 500 prize money.

The Valentino Braitenberg Award for Computational Neuroscience has been initiated by Carla Braitenberg, daughter of the name giver, and is now biannually conferred by the Bernstein Association. It is targeted at scientists whose research has significantly influenced neurosciences. In the spirit of Valentino Braitenberg's research, special emphasis is given to theoretical studies elucidating the functional implications of brain structures and their neuronal network dynamics. The award consists of the participation in the Bernstein Conference including the "Valentino Braitenberg Lecture", prize money to the amount of € 5.000 (kindly donated by Autonome Provinz Bozen Südtirol), a certificate and a golden neuron pin, and the book "Tentakel des Geistes – Begegnungen mit Valentin Braitenberg". Next nomination deadline is June 16, 2014.

Further information and the membership application form can be found under the URL:
www.nncn.de/en/bernstein-association/become-a-member

Looking back at the 6th BrainScaleS CodeJam in Jülich

The 6th BrainScaleS CodeJam Workshop was held from 27 to 29 January 2014 at the Jülich Supercomputing Centre (JSC) at the Forschungszentrum Jülich with the focus on high performance computing (HPC). To catalyze open-source collaborative software development in computational neuroscience and neuroinformatics, the CodeJam has gathered 70 researchers, students, and engineers from seven countries to share ideas, present their work, and write code together.

The workshop introduced the opportunities brought by the JSC's supercomputers to a widespread audience from the computational neuroscience and neuroinformatics community. HPC hardware solutions for neuroscience such as the SpiNNaker architecture for modelling of neural networks, massively parallel Blue Gene/Q architecture, and Hybrid Multiscale Facility for neuromorphic computing were discussed, as well as HPC software solutions for neuroscientific applications (e.g., Pandas, Numba and others).

The 6th CodeJam also covered other topics relevant to HPC, such as using Blue Gene Active Storage for neuroscience applications, HPC-capable neural simulators (e.g., NEST and NEURON), as well as neural modeling and simulation workflows.
www.nncn.de/en/news/nachrichten-en/julich-brainscales-codejam-2014

3rd Bernstein Sparks Workshop takes place in Munich

The 3rd Bernstein Sparks Workshop "Modeling and Signal Processing for Auditory Implants" will take place within the framework of the 13th International Conference on Cochlear Implants and other Implantable Auditory Technologies (CI2014) on June 20th, 2014. The workshop will cover the topic from modeling the auditory periphery to models of auditory perception, and discuss their application for designing new stimulation strategies. Leading scientists involved in the modeling and developing algorithms for auditory implants will be brought together.

Local organizers of the workshop are Bernhard Seeber and Werner Hemmert (both BCCN and TU München). They are supported by the Bernstein Coordination Site (BCOS), the BCCN Munich, the Competence Center Bio-X and the Competence Center for Neuroengineering of the TU München.

Bernstein Sparks Workshops are aimed at taking up new exciting topics that may pave the way for major breakthroughs in brain research, and providing a forum for intense discussions of these issues.
www.nncn.de/en/news/events/3rd-bernstein-sparks-workshop-modeling-and-signal-processing-for-auditory-implants

Upcoming Events

Date	Title	Organizers	URL
June 4, 2014, Berlin	MenschMaschine-Visionen: Technik, die unter die Haut geht - 18th Berlin Colloquium of Daimler und Benz Stiftung	Daimler und Benz Stiftung, scientific head: T. Stieglitz (Bernstein Center Freiburg)	www.daimler-benz-stiftung.de/cms/veranstaltungen/berliner-kolloquium.html
June 4 – 5, 2014, Jülich	Bernstein Network – Simulation Laboratory Neuroscience HPC Workshop	A. Do Lam-Ruschewski, A. Lührs, A. Morrison, B. Orth, A. Peyser, W. Schenck (all: Simulation Laboratory Neuroscience – Bernstein Facility Simulation and Database Technology), Bernstein Coordination Site (BCOS)	www.nncn.de/en/news/events/bernstein-network-simulation-lab-neuroscience-hpc-workshop
June 20, 2014, Munich	3rd Bernstein Sparks Workshop "Modeling and Signal Processing for Auditory Implants"	B. Seeber, W. Hemmert (both BCCN München), Competence Center for Neuroengineering and Competence Center Bio-X at TU München, Bernstein Coordination Site (BCOS)	www.ci2014muc.info/Bernstein-Workshop.708.0.html
July 1–4, 2014, Reutlingen	9th International Meeting on Substrate-Integrated Microelectrode Arrays	A. Stett (BFNT Freiburg-Tübingen), G. Zeck, I. Digel, N. Gugeler, K. Bellack, NMI Reutlingen, Bernstein Center Freiburg, Multi Channel Systems MCS GmbH (industry partner of Bernstein Center Freiburg)	www.nmi.de/de/meameeting
July 11–24, 2014, Cold Spring Harbor Laboratory Banbury Conference Center, USA	Course "Computational Neuroscience: Vision"	G. Boynton, G. Horwitz, J. Pillow, S. Treue (BCCN and BFNT Göttingen)	http://meetings.cshl.edu/courses/2014/c-visi14.shtml
July 26 – 31, 2014, Québec City, Canada	23rd Annual Computational Neuroscience Meeting (CNS) with Bernstein Network Information Booth	M. Chacron, Y. de Koninck, A. Prinz	www.cnsorg.org/cns-2014-quebec-city
Aug 3–30, 2014, Frankfurt am Main	19th Advanced Course in Computational Neuroscience	E. Ahissar, D. Jaeger, M. Lengyel, C. Machens, Local Organizers: J. Triesch (BFNT Frankfurt), H. Cuntz (BPCN 2013)	http://fias.uni-frankfurt.de/accn
Aug 25–27, 2014, Leiden, The Netherlands	7th INCF Congress of Neuroinformatics	International Neuroinformatics Coordinating Facility (INCF)	www.neuroinformatics2014.org
Sept 2–5, 2014, Göttingen	Bernstein Conference 2014 Workshops: Sept 2–3, 2014 Main Conference: Sept 3–5, 2014	F. Wörgötter (BFNT and BCCN Göttingen, D-J Collaboration), K. Mosch and Y. Reimann (BCCN and BFNT Göttingen), Bernstein Coordination Site (BCOS)	www.bernstein-conference.de
Sept 8–13, 2014, Split, Croatia	G-Node Summer School Advanced Scientific Programming in Python	T. Zito (BCCN Berlin, G-Node), Z. Jedrzejewsky-Szmek (G-Node), L. Periša, I. Kajic (BCCN Berlin), I. Balaževic, F. Petkovski	http://python.g-node.org

Upcoming Events

Date	Title	Organizers	URL
Sept. 13, 2014, Yokohama, Japan	Symposium: Network of Attention in Human and Macaque within the framework of the 37th Annual Meeting of the Japan Neuroscience Society	Z. Hafed (D-J Collaboration), M. Yoshida	www.nncn.de/en/news/events/symposium-network-of-attention-in-human-and-macaque
Sept 15–19, 2014, Hamburg	International Conference on Artificial Neural Networks (ICANN)	S. Wermter, A. E. P. Villa, W. Duch, P. Koprinkova-Hristova, G. Palm, C. Weber (BFNT Frankfurt), T. Honkela, S. Magg, J. Bauer, J. Chacon, S. Heinrich, D. Jirak, K. Koesters, E. Strahl	http://icann2014.org
Oct. 5 – 10, 2014, Freiburg	BCF/NWG Course: Analysis and Models in Neurophysiology	S. Rotter, U. Egert, A. Aertsen, B. Ahrens (all Bernstein Center Freiburg)	www.bcf.uni-freiburg.de/events/conferences-workshops/20141005-nwgcourse
Nov. 15 – 19, 2014, Washington DC, USA	Neuroscience 2014 with Bernstein Network Information Booth	Society for Neuroscience (SfN)	www.sfn.org/annual-meeting/neuroscience-2014

The Bernstein Network

Chairman of the Bernstein Project Committee: Andreas Herz

The National Bernstein Network Computational Neuroscience (NNCN) is a funding initiative of the Federal Ministry of Education and Research (BMBF). Established in 2004, it has the aim of structurally interconnecting and developing German capacities in the new scientific discipline of computational neuroscience and, to date, consists of more than 200 research groups. The network is named after the German physiologist Julius Bernstein (1835–1917).

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