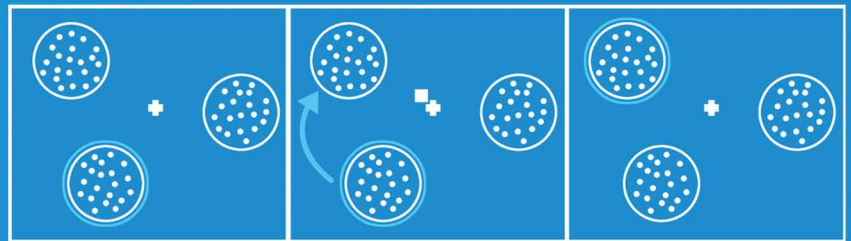


**Bernstein Network for Computational Neuroscience**

# Bernstein Newsletter



## **Recent Publications**

*Signal Processing – Electroencephalography – Visual Attention – Mouse Model for Eye Diseases*



## **News and Events**

*Bernstein Award – EU Grant – Bernstein Symposium – Personalia – Events – Job Opportunities – Alumni*



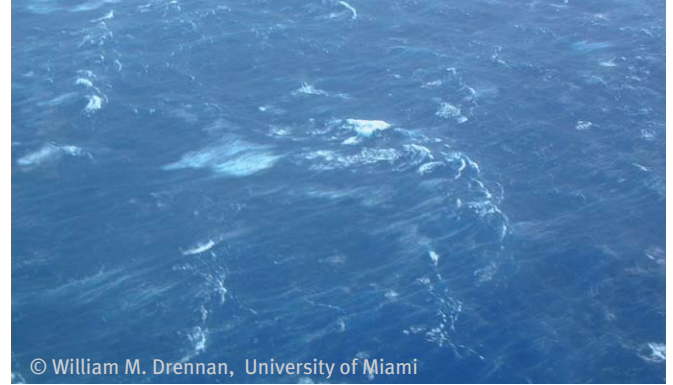
## RECENT PUBLICATIONS

# Signal processing against the background noise in the brain

The brain is continuously active. It doesn't matter whether we are awake or asleep, or whether we are thinking or relaxing, the nerve cells incessantly send signals. Scientists from the Bernstein Center for Computational Neuroscience and the University of Freiburg examined in a computer model how sensory stimuli or other information can be reliably processed and passed on in the face of such high background activity. Their work provides information on the specific form of neural information encoding which facilitates optimal information transfer.

When we see, hear or smell, the brain processes the received information step by step in progressively higher processing levels. Neurons at each level pass on signals to the next higher level in the form of electric impulses. The neural connections that form the basis of such a 'feed forward system' have already been studied in many ways. Usually, however, it has not been considered that this 'feed forward system' is embedded into the complex neural architecture of the brain, whose background activity provides feedback onto and, in turn, is influenced by this system. The question as to how signals can be passed on reliably in such a system has now been studied by Arvind Kumar, Stefan Rotter and Ad Aertsen. Using an elaborate computer model, the scientists simulated the function of a network of 50,000 neurons as realistically as possible.

Sensory information is translated in the brain into electric impulses in neurons. The principles determining the way in which information is encoded are not yet known in detail and differ from case to case. A sensory stimulus for example can increase the impulse rate in certain neurons. The stronger the stimulus, the more impulses the neuron sends per unit time. This is referred to as a 'rate code'. However, a sensory stimulus can also result in



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*Background activity in the cortex can be compared to the two-dimensional surface of the sea, fluctuating irregularly and incessantly. The propagation of individual waves depends on their individual size and on the roughness of the sea. When the sea is relatively calm, waves can travel long distances and interact with other travelling waves.*

several neurons sending out their signals simultaneously, such that synchronized 'impulse packets' are transported through the Feed Forward System. Also the background activity of the brain is not always the same: depending on the mental state, cells in the brain may send their signals more or less regularly and/or synchronously. In their model, the scientists now studied how these different forms of information transfer and background activity mutually influence each other.

As Kumar and his colleagues showed, not every form of information transfer is possible with every kind of background activity. Strongly synchronized neuronal background activity makes any targeted signal forwarding almost impossible. By contrast, an asynchronous background activity allows a reliable processing of sensory information and may even contribute constructively to a stable signal transmission. The researchers also showed that impulse packets of synchronized neuronal activity could be passed on far more reliably than increased impulse rates. Thus, their work provides indication how sensory information must be encoded in order to be processed effectively in the brain.

Source: Kumar, A., Rotter, S. & Aertsen, A. *J Neurosci.* 2008 May 14;28(20):5268-80.



# New facets of electroencephalography

Electroencephalography, or EEG for short, is a widely used measurement method in neurological diagnostics and neuroscientific research in humans. Up until now EEG has typically been used to record a certain bandwidth of neural signals emanating from the motor cortex. Researchers around Tonio Ball and Andreas Schulze-Bonhage from the Bernstein Center for Computational Neuroscience and the University of Freiburg have now broadened the scope of EEG. Ball commented, ‘more than 80 years after its discovery at the University of Jena, EEG still throws us new surprises’.

Using EEG, the summed activity of nerve cells in the brain can be recorded using electrodes attached temporarily to the scalp surface. Recordings can therefore be made both cost-effectively and in a way that is devoid of side effects. Only when many neurons synchronize their electrical activity they add up and can be detected in EEG recordings. Such ‘network-oscillations’ can appear within different frequency ranges that presumably reflect different functions of the brain. Up to now, studies have focused on oscillations within lower frequency ranges, since the high frequency ranges of neural activity are shielded more by the skull and can not be measured as effectively.

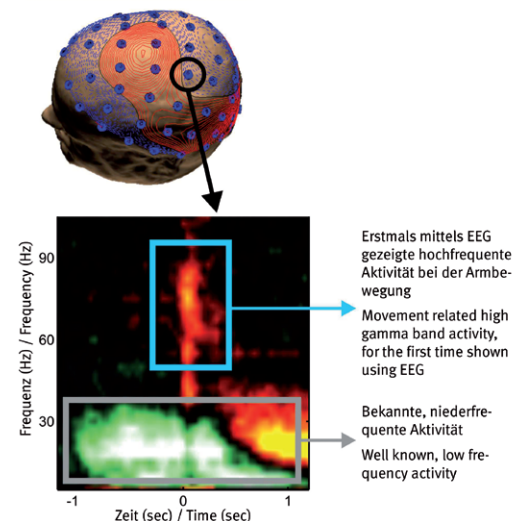
The Freiburg researchers have studied how the control of movements can be reconstructed from EEG signals. The long term goal is to develop neuronal motor prostheses for paralyzed patients allowing the patient to control external actuators through brain activity. The team around Ball has now been able to show

*Changes in the EEG signal during an arm movement. Movement onset occurs at time zero on the x-axis. Signal intensity increases in the higher frequency range (orange color, blue box) and decreases in the lower range (green, grey box).*

that movement-related brain activity can be recorded in the EEG over a much broader frequency spectrum than was previously assumed.

For this purpose, EEGs were recorded from subjects who were asked to perform goal directed arm movements. Using optimized procedures, high-frequency movement-related brain oscillations could be shown for the first time in the EEG data which changed within the range of a few milliseconds. Such high frequency brain activity might play a key role in the control of movement. The results of the Freiburg researchers have opened up new perspectives to investigate this form of brain activity in a cost-effective and side-effect free manner, whether it be in healthy subjects or in paralyzed patients, or also in patients with epilepsy or Parkinson’s disease where pathological changes in oscillatory brain activity are important to be studied.

Source: Ball, T., Demandt, E., Mutschler, I., Neitzel, E., Mehring, C., Vogt, K., Aertsen, A., Schulze-Bonhage, A. *Neuroimage*. 2008 Jun;41(2):302-310.





# Neuronal correlate of visual attention

Not all information that impinge on our eyes are processed equally by the brain. Attention crucially determines how visual stimuli are represented in the brain. If we are looking for an object, we ‘voluntarily’ direct our attention. We notice the object in question already in the visual periphery and ignore other items. On the other hand, prominent events in our surroundings, e.g. an approaching vehicle, can automatically attract our attention. Such ‘reflexive’ shifts of attention are typically not under voluntary control. Stefan Treue, Laura Busse and Steffen Katzner, scientists at the Bernstein Center for Computational Neuroscience and the German Primate Center in Göttingen, now showed that these two forms of visual attention are based on different neuronal mechanisms.

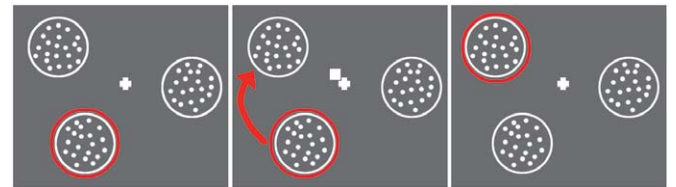
In their experiments, the scientists trained macaque monkeys to carry out visual tasks at a computer screen. The animals learned to direct their attention to a defined area of the visual field and to respond to changes in this area by pressing a button. Upon a cue signal outside of this focus – a short flashing dot – the monkeys had to shift their attention to a different area. Hence, both forms of visual attention take effect in this experimental setting: the short, salient cue will involuntarily – or reflexively – attract attention of the monkey. The subsequent shift of attention to another area of the visual field, in contrast, is a voluntary action.

While the animal was performing this task, the scientists measured the activity of single neurons in the cortex that are responsible for visual information processing. Cells covering the part of the visual field the monkey attends to are more active than those responsible for the processing of unattended regions. In this experiment, the exact time course of the attentional shift

could therefore be measured with high temporal precision. Since the salient signal, the cue, triggered both a reflexive shift of attention and, at the same time, initiates the voluntary change of attention, the response of single neurons to both forms of visual attention could be compared.

The researchers showed that neuronal modulations reflecting voluntary changes in attention occur significantly later than modulations elicited by the reflexive shifts of attention. After attention had briefly been distracted by the cue, it initially returned to the starting point. The voluntary attention shift to the newly cued area of the visual field only occurred with a temporal delay of about 150 milliseconds. This finding allows the conclusion that different neuronal mechanisms underlie the different forms of visual attentional control. Such investigations are of major clinical relevance: a better understanding of the neuronal processes underlying perception will allow for an adequate treatment of physiologically or psychologically induced attention deficits.

Source: Busse, L., Katzner, S. & Treue, S. *Proc Natl Acad Sci U S A*. 2008 Oct 21; 105(42):16380-5.



*Schematic representation of the experimental procedure. Macaques fixate the cross in the center of the screen with their eyes and pay attention to changes in the pattern at the bottom left. After appearance of the cue (small white square, middle image) they shift their focus of attention to a different area.*



# The mouse as model for eye diseases

If vision is impaired due to a cataract, adults can recover visual function after a surgery. In children, in contrast, a cataract can lead to permanent blindness. 'The plasticity of the visual cortex that still exists in children declines during the course of the years,' explains Siegrid Löwel of the Friedrich Schiller University Jena and Bernstein Collaboration Jena-Bochum-Göttingen. Plasticity of the visual cortex refers to the ability of neurons in this brain region to change their properties depending on their use. If, in children, no more visual inputs reach the brain due to a cataract, the nerve fibers originating from the eye permanently disconnect from the brain. Together with Konrad Lehmann, Löwel showed that also mouse nerve cells lose their plasticity in the course of a lifetime. 'This finding is an essential prerequisite for using the mouse as a model organism for human visual disorders or neurological diseases,' says Löwel.

To investigate cortical plasticity or disorders of the visual system, many researchers nowadays use mice as experimental

animals. In recent years, however, it has been frequently reported that in mice, in contrast to humans, visual cortical plasticity persists lifelong. "This previous, erroneous assumption was based on scientific experiments on mice no more than three months of age," says Löwel. Together with her team she studied mice at the age of up to eight months. To imitate a lens cataract, one eye of the animals was closed. 'Using a minimally invasive optical method (optical imaging of intrinsic signals), we have visualized the activity in the brain,' Löwel explains the relatively new method of optical imaging. In this technique, the brain of the mouse is illuminated with dark red light and observed with a camera. Increased neuronal activity leads to an increased concentration of deoxyhemoglobin, which absorbs the red illumination more strongly. Active brain areas thus appear darker than inactive areas. 'Thanks to a spatial resolution of 0.05 millimeters, which is approximately 20-fold better than that of an MRI scan, the processes in the brain can be observed very closely with the camera.'

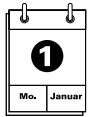
In parallel, the behavior of the same mice was tested in an optomotor apparatus to measure visual acuity. In an arena-like box, vertical stripes were projected onto the inner walls and moved either to the right or to the left. Since mice follow any movement they perceive with their head, a pursuit movement in the setup clearly indicated that the mouse perceived the stripes. The results showed that mice do not differ in their cortical plasticity from humans or from other usually studied experimental animals like cats or monkeys.

University Jena / BCOS

Source: Lehmann K. & Löwel, S. *PLoS ONE*. 2008 Sep 1; 3(9):e3120.

*A mouse at an eyesight test: If it sees the movement of the stripes, it will follow them with a head movement.*





# Bernstein Award 2008 to Susanne Schreiber

On October 8, 2008 the Bernstein Award of the Federal Ministry for Education and Research (BMBF), valued at 1.25 Million Euro, was presented to Susanne Schreiber. The Bernstein Award is allocated to excellent young researchers in the field of Computational Neuroscience and allows them to establish an independent research group. Susanne Schreiber, scientist at the Humboldt-Universität and the BCCN Berlin, will start her research group in Berlin. This year, the award is allocated for the third time.

Schreiber investigates how the characteristics of single neurons influence the function of larger networks in the brain. Every thought and every action is based on the neuronal activity of the brain and is ultimately affected by the molecular characteristics of the neurons.

In the brain, countless neurons are wired up in a complex network, influencing the activity of each other. Often, larger groups of neurons send out impulses in a common rhythm; they enter into a collective “oscillation” through mutual interaction. Such a rhythmic behavior is essential for many functions of the nervous system, such as the storage of memories. Schreiber investigates, which mechanisms are responsible for the synchronous oscillation of the network and how cells are enabled to keep the rhythm. Certain diseases, like epilepsy, are characterized by incidences of pathological synchronous oscillations. Schreiber’s work will contribute to a better understanding of how malfunctioning of the molecular setup of neurons can eventually lead to such diseases.

<http://www.nncn.de/Aktuelles-en/Portraits-en/schreiberz>



*Die drei Bernstein Preisträger, von links nach rechts / Jan Benda, Susanne Schreiber, Matthias Bethge*

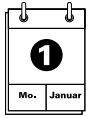
## Call for proposals: Bernstein Award 2009

Also in 2009, a research project will be funded within the initiative “Bernstein Award”. Funding is provided for research projects which have been designed by young, German or foreign postdocs who will conduct their work at a German university of research institution. Researchers are required to furnish evidence of extraordinary scientific achievements in the field of Computational Neuroscience. Application deadline for the ‘Bernstein Award 2009’ is May 25th, 2009.

<http://www.gesundheitsforschung-bmbf.de/en/1834.php>

## EU Grant for Michael Brecht

Michael Brecht, scientist at the Bernstein Center for Computational Neuroscience and the Humboldt-Universität zu Berlin has been awarded with the “ERC Advanced Investigators Grant” of the European Research Council. The funding measure, valued at 2.5 million Euros, aims at supporting risky, unconventional and ground-breaking research projects which provide a good outlook to have an impact on science beyond specific disciplines.



## NEWS AND EVENTS

Michael Brecht plans to answer fundamental questions by means of cutting edge technologies. How are neuronal activity and behavior related? Brecht will study this “language of the neurons” using the tactile perception of the rat as an example - a system well suited for this purpose, as the activity of one single neuron can already evoke a sensation or a movement of the vibrissae.

Another aim of Brecht’s research is to listen to the cells while an animal is freely moving around in an enclosure. Brecht increases the precision of such experiments by means of a miniaturized, highly complex experimental setup. Using the smallest mammal of the world, the Etruscan shrew, Brecht aims at an integral understanding of the brain. Due to its tiny dimensions, the animal is suited for modern microscopy methods that allow observing the activity of every single neuron in the living animal.

<http://www.nncn.de/nachrichten-en/eubrecht2008/>

## Bernstein Symposium 2008

More than 200 scientists of the Bernstein Network and renowned guest speakers participated at the ‘4th Bernstein Symposium’, which took place in Munich from October 8 – 10. To promote the international exchange also between younger scientists, 20 PhD students and postdocs from abroad were selected in a competitive procedure to attend the meeting. For the first time this year, all conference contributions are published in the scientific journal “Frontiers in Computational Neuroscience”.

A further novelty at this year’s symposium was the awarding of prizes for the best poster presentation. The first three prizes, valued at a total of 600 Euros, were sponsored by MED-EL Deutschland GmbH, went to Bartosz Telenczuk, Phillipp Hehr-



*Gewinner des Poster-Preises beim Bernstein Symposium 2008  
Winners of the poster award at the Bernstein Symposium 2008*

mann and Frank Hesse. MED-EL is a worldwide leading company in the area of implantable hearing systems and its German branch is a partner of the Bernstein Center and Technical University Munich. In addition, book prizes were awarded to Katharina Anton-Erxleben, Franziska Greifzu and Andreas Neef.

## Personalia

**Laura Busse**, former scientist at the BCCN Göttingen and the German Primate Center in the research group of Stefan Treue, has received the ‘Förderpreis’ of the **Berlin-Brandenburg Academy of Sciences**. The award supports highly talented women in science after completion of their PhD. Laura Busse’s research aims at understanding the neuronal basis of visual attention (see p. 7).

<http://www.bbaw.de/bbaw/Akademie/auszeichnungen/preise/foerderpreis/>



## NEWS AND EVENTS

**Anja Gundlfinger** has been awarded the ‘**Nachwuchswissenschaftlerinnen-Preis**’ of the ‘**Forschungsverbund Berlin e.V.**’. Her research in the group of Dietmar Schmitz (BCCN Berlin) focused on the mossy fiber synapse of the hippocampus. The hippocampus is a brain area that, amongst other tasks, deals with memory consolidation.

[http://www.fv-berlin.de/pm\\_archiv/2008/32-nachwuchspreis.html](http://www.fv-berlin.de/pm_archiv/2008/32-nachwuchspreis.html)

## Events

The first ‘**G-Node Winter Course in Neural Data Analysis**’ will take place from **January 26.-30, 2009** in **Munich**. ‘G-Node’ is the German node of the ‘International Neuroinformatics Coordinating Facility’ (INCF). This 1st course offers hands-on experience with neural data analysis for PhD students and young postdocs and is organized by **Martin Nawrot (BCCN Berlin)**.

<http://www.g-node.org/courses>

The ‘**Interdisciplinary College (IK) Guenne at Lake Moehne**’ is an annual, intense one-week spring school. In 2009, the course will take place from **March 3-6** and focuses on the topic ‘Rhythm and Timing’. **Gregor Schöner** from the **Bernstein Group Bochum** is one of the major organizers of the course.

<http://www.ik2009.de>

With about 30,000 participants, the **Annual Meeting of the Society for Neuroscience** is the largest conference in this field. In 2008, it took place from **November 15- 19** in Washington, D.C.. Numerous scientists from the Bernstein Network took part and presented talks and posters. In addition, the Bernstein Network informed the participants about its research, study programs and job opportunities at an information booth.

<http://www.sfn.org/am2008>

## Job opportunities

Since the four ‘Bernstein Foci: Neurotechnology’ have just started or are about to be launched, over 70 open positions are available in the Bernstein Network in this field.

<http://www.nncn.de/Aktuelles-en/Stellenausschreibungen-en>

## Alumni

... of the Bernstein Network are invited to stay in contact through the Alumni mailing list. The list informs alumni about:

- new editions of the Bernstein Newsletter
- news and events
- special alumni activities
- current job offers
- new calls for grant proposals

<http://www.nncn.de/alumni/bernstein-alumni-mailinglist>



*Booth of the Bernstein Network at the Annual Meeting of the Society for Neuroscience*

# Imprint

Published by:  
National Bernstein Network Computational Neuroscience  
<http://www.nncn.de>

Text, Editing:  
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Translation, English Language Editing:  
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Design: newmediamen, Berlin

Layout: Katrin Weigmann

Druck: Elch Graphics, Berlin

The Bernstein Network for Computational Neuroscience is funded  
by the Federal Ministry of Education and Research (BMBF).

*Title Image: Schematic representation of an  
experimental procedure to investigate visual attention*

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Rostock, Freiburg-Tübingen, Göttingen-Jena-Bochum, Göttingen-  
Kassel-Ilmenau, Munich-Göttingen, Munich-Stuttgart

Bernstein Award for Computational Neuroscience (BPCN)  
Dr. Matthias Bethge (Tübingen), Dr. Jan Benda (Munich), Dr.  
Susanne Schreiber (Berlin)

Chairman of the Bernstein Project Committee: Prof. Dr. Ad Aertsen  
Deputy Chairman of the Project Committee: Prof. Dr. Theo Geisel

GEFÖRDERT VOM



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