Bernstein Conference 2012

September 12-14

Munich, Germany

Bernstein Conference 2012

September 12 - 14, 2012

Klinikum rechts der Isar, Technische Universität München
Hörsaalgebäude, Einsteinstraße, 81675 München

Program and Abstracts

Organization

Simone Cardoso de Oliveira
Katharina Himmelstoß
Kathrin Koros
Kay Thurley
Ellen Schmidt
Monika Volk

Andreas Herz (Co-Chair)
Thomas Wachtler (Co-Chair)

Technical Support

Moritz Dittmeyer
Niklas Graf
Olivia Haas
Arne Hartz
Christian Kellner
Johanna Kipping
Fabian Kriesel
Ina Lackerbauer
Tatjana Meyer
Johannes Nagele
Sebastian Philipp
Martina Stadlmeier
Karen Stetter
Ming Zhao

Design

Hannes Lüling
Christine Meyer

Program Committee

Henning Bier (TU München)
Alexander Borst (MPI Martinsried)
Gordon Cheng (TU München)
Stefan Glasauer (LMU München)
Benedikt Grothe (LMU München)
Andreas Herz (LMU München)
Christian Leibold (LMU München)
Harald Luksch (TU München)
Thomas Wachtler (LMU München)

Neurovision Film Contest Organization

Henriette Walz

PhD Symposium Organization

Christian Garbers
Christian Kellner
Andrey Sobolev

[T 5] Integration of bottom-up and top-down signals in visual recognition

Julie Blumberg[1*], Jonas Bruder[1], Daniel Millman[2] and Andreas Schulze-Bonhage[1]

1. Epilepsy center, University hospital Freiburg, Germany
2. Children's Hospital, Harvard Medical School, USA
* julie.blumberg@uniklinik-freiburg.de

In a collaboration of Harvard Medical School and University hospital Freiburg we study visual perception and memory in the human brain with high spatial and temporal resolution. Subjects are epilepsy patients who are implanted with depth electrodes and/or intracranial surface electrodes to localize the seizure focus for potential surgical resection. In parallel with field potentials we record single neuron spiking activity using microwires inserted in depth electrodes. The goal of this collaborative effort is to understand the interaction and integration of bottom-up and top-down signals through the combination of neurophysiological recordings at high spatial and temporal resolution in the human brain, computational data analysis and modeling. The properties of hierarchical and feed-forward theories of visual recognition provide a quantitative framework to examine information processing in the feedforward path along the ventral stream to account for ultra-rapid complex object recognition. One of the main limitations of these models is that they do not take into account the massive back-projections that convey information from higher cortical areas back to the lower areas. In order to explain everyday visual perception, we need to incorporate a quantitative and computational description of top-down control of sensory processing derived from frontal and parietal cortex as well as medial temporal lobe memory structures.

In our study we examine progressively more complex tasks that include both bottom-up and top-down components in order to shed light on the dynamical integration of feed-forward and feed-back signals in the human ventral visual cortex. One type of information that can be fed back is the temporal relationships among visual events in an episodic memory. In order to investigate memory function involved in object recognition, we have subjects perform tasks that involve the learning of image sequences while we record from temporal lobe structures including hippocampus. These tasks offer the potential to reveal functions of the hippocampus in the learning of temporal relationships, such as prospective/anticipatory coding of upcoming images and/or learning of associations among temporally-linked images. In particular, we test the involvement of the hippocampus in learning the temporal component of episodic memories, beyond simple association of the events which are members of the episode. Here, we dissociate the learning of which images are members of a particular sequence from learning of temporal order by asking patients to memorize sequences, then testing either their memory of the sequence members or memory of the temporal relationships among sequence members. Finally, replaying of the order of activation of place cells that together constitute a trajectory to a reward location during and after training occurs in the rodent hippocampus, and is believed to play a role in memory consolidation. We test whether such replay occurs in non-spatial cognitive domains in the human hippocampus.

Acknowledgements
This work was supported by the NSF/BMBF Award for US-German Collaboration in Computational Neuroscience (Award ID 1010109/01GQ1010).

[T 19] Stimulus driven correlation gain modulation in neuronal networks

Alejandro F. Bujan*, Ad Aertsen and Arvind Kumar*

Bernstein Center Freiburg, University of Freiburg, Germany
* alejandro.bujan@bcf.uni-freiburg.de * arvind.kumar@biologie.uni-freiburg.de

In order to analyze the response of a neuronal network to an external source of correlated inputs it is useful to divide the input correlations into "between" and "within" correlations (Yim et al. 2011). The "between" correlations (B) are defined as the mean pairwise correlation between spike trains from the presynaptic pools of different neurons, whereas "within" correlations (W) refer to the mean pairwise correlation between spike trains belonging to the same presynaptic pool. In a random network the two types of correlations are same, however, in inhomogeneous networks W and B may differ strongly (Lindsay et al. 2012). From an abstract point of view, neurons in a recurrent network receive just two different sources of input, one coming from outside the network and the other coming from the network itself, each of these sources may have a different structure in terms W and B and the interplay between these two structures will define the correlation gain of the network. Correlation gain of a network can be adequately studied using a reduced two-neuron model. Here, we consider the case of two neurons receiving correlated inputs corresponding to the external and local network input. We show that the interplay between the correlation structure of local and external inputs provides a flexible mechanism to dynamically modulate (increase or decrease) network correlations. The correlations W and B are shaped by both the structure of the connectivity as well properties of the input. Thus, beyond proposing a mechanism to modulate correlations our findings clearly suggest that it is highly important to know the connectivity structure of the input projections as well that of the receiving network in order to correctly predict the impact of sensory and/or top-down inputs on the neural activity.

Acknowledgements
Work funded by the German Federal Ministry of Education and Research (BMBF 01GQ0420 to BCCN Freiburg and 01GQ0830 to BFNT Freiburg/Tuebingen) and the EU (Facets-ITN)

References

Yim M.Y., Aertsen A., Kumar A. (2011) Significance of input correlations in striatal function PLoS Computational Biology 7(11): e1002254. e1002254. doi: 10.1371/journal.pcbi.1002254
Lindsay G., Bujan A. F., Aertsen A., Kumar A. (2012) Membrane potential statistics reveal detailed correlation structure. Front. Comput. Neurosci. Conference Abstract: Bernstein Conference 2012.

[T 20] Site of spike initiation changes with functional context in coincidence detector neurons

Simon Lehnert[1*] and Christian Leibold[1,2]

1. Department of Biology II, Ludwig-Maximilians-Universität München, Germany
2. Bernstein Center for Computational Neuroscience Munich, Germany
* slehnert@bio.lmu.de

Principal cells of the medial superior olive (MSO) are very fast coincidence detectors in the auditory brainstem that encode interaural time differences by their firing rate. Their enormously low time constant of only a few hundred microseconds is caused by the very low input resistance of about 5MΩ at rest [1], which arises from the expression of low-voltage-activated potassium channels (KLVA) and hyperpolarization-activated unspecific cation channels (HCN). Spike initiation is generally assumed to occur in the axon's initial segment (AIS). However, in neurons with very low input resistance, as in the MSO, this may no longer hold true, because the soma constitutes an enormous current sink. Moreover, these cells receive a huge amount

The parameter types are scalable. For the choice of the parameter range we developed a heuristic based on spike rates and burst rates observed in experiments and the dependency between the parameters. The described brute force parameter fitting was applied within the intervals according to the derived parameter dependency. Results were shown in several isoline 3D plots depending on the value of f with the mean basic activity of all 1,000 neurons on the x-axis, the mean inhibitory weights on the y-axis and the mean excitatory weights on the z-axis.

The simulated spike trains show typical synchronous spike and burst patterns as known from MEA neurochip experiments with frontal cortex neurons. Calculated features adapted from spikes and bursts indicate that the presented model simulates neuronal activity similar to activity as observed on MEA neurochips.

Acknowledgements
We thank Matthias Reuter (Clausthal University of Technology, Germany), Lars Schwabe (University of Rostock, Germany) and last not least Olaf Schröder (NeuroProof GmbH, Rostock, Germany).

References

1. Lenk, K. (2011). "A simple phenomenological neuronal model with inhibitory and excitatory synapses" in Advances in Nonlinear Speech Processing, ed. C. Travieso-González and J Alonso-Hernández (Berlin/Heidelberg:Springer), 232-238.
2. Heeger, D. (2000). Poisson model of spike generation. http://www.cns.nyu.edu/~david/handouts/poisson.pdf. Accessed 31 Oct 2010.
3. Hertz, J., Roudi, Y. and Tyrcha, J. (2011). Ising Models for Inferring Network Structure From Spike Data. arXiv:1106.1752v1. Accessed 3 Jan 2012.
4. Glauber, R.J. (1963). Time-Dependent Statistics of the Ising Model. J. Math. Phys. 4, 294-307.

[T 26] How intrinsic neuronal heterogeneity shapes the cross-correlation functions between spike trains

Man Yi Yim*, Ad Aertsen and Stefan Rotter

Bernstein Center Freiburg & Faculty of Biology, University of Freiburg, Germany
* yim@bcf.uni-freiburg.de

Neurons of the same type are intrinsically heterogeneous, showing diverse output firing rates and imprecise spike timing in response to identical fluctuating input currents (Padmanabhan and Urban, 2010). These experimental observations can be reproduced in a population of leaky integrate-and-fire (LIF) model neurons. By rescaling the dynamic equations of the LIF neuron, mathematical relations between multiple neuronal parameters and input noise have been derived, and an identical input to heterogeneous neurons can be conceived as an identical noise with neuron-specific mean and variance (Yim et al., 2011). We further investigated the response relation of pairs of heterogeneous neurons receiving identical input by studying the cross-correlation function (CCF) between their spike trains. We find that the symmetry of the CCF is broken if the rescaled mean of the input to the two neurons is different. The neuron with the higher mean has a higher firing rate and tends to spike earlier than the other one. This is consistent with the previous theoretical finding that a pair of neurons with different firing statistics can exhibit an asymmetric CCF (Ostojic et al., 2009; Tchumatchenko et al., 2010). On the other hand, the symmetry of the CCF is preserved for neurons with different rescaled variances, even when their firing rates differ. This suggests, among other things, that more excitable neurons do not necessarily respond faster to common input.

Acknowledgements
Supported by the German Federal Ministry of Education and Research (BMBF 01GQ0420 "BCCN Freiburg" and BMBF 01GW0730 "Impulse Control").

References
Padmanabhan K, Urban NN (2010). Intrinsic biophysical diversity decorrelates neuronal firing while increasing information content. Nat Neurosci 13(10), 1276–1282.
Yim MY, Aertsen A, Rotter S (2011). Impact of intrinsic neuronal heterogeneity on firing rates and spike train correlations. Front Comput Neurosci Conference Abstract: BC11: Computational Neuroscience & Neurotechnology Bernstein Conference & Neurex Annual Meeting 2011. doi: 10.3389/conf.fncom.2011.53.00213.
Ostojic S, Brunel N, Hakim V (2009). How connectivity, background activity, and synaptic properties shape the cross-correlation between spike trains. J Neurosci 29(33): 10234-10253.
Tchumatchenko T, Malyshev A, Geisel T, Wolf F (2010). Correlations and synchrony in threshold neuron models. Phys Rev Lett 104(5): 058102.

[T 27] Reconstruction of connectivity in sparse neural networks from spike train covariances

Volker Pernice[1,2*] and Stefan Rotter[1,2]

1. Faculty of Biology, Albert-Ludwig University, Germany
2. Bernstein Center Freiburg, Germany
* pernice@bcf.uni-freiburg.de

The inference of causation from correlation is in general highly problematic. Similarly, it is difficult to infer the existence of physical synaptic connections between neurons from correlations in their activity. Covariances in neural spike trains have been the subject of intense research, both experimentally and theoretically. Linear models present a direct way to characterize the influence of recurrent connections on covariances in a resting state of asynchronous activity. The effect of direct connections is then described by a matrix of linear coupling kernels. However, as indirect connections also give rise to covariances, the inverse problem of inferring network structure from covariances can generally not be solved unambiguously.

Here we study to which degree this ambiguity can be resolved if the sparseness of neural networks is taken into account. To reconstruct a sparse network, we determine the minimal network of linear couplings consistent with measured covariances by minimizing the L1 -norm of the coupling matrix under appropriate constraints. Counterintuively, after stochastic optimization of the coupling matrix, the resulting estimate of the underlying network is directed, even if only a symmetric matrix of count covariances is known.

The performance of the method is best if connections are neither exceedingly sparse nor dense, and it is easily applicable for networks of a few hundred nodes. Time dependent coupling kernels can be obtained if the full matrix of covariance functions is known, as is demonstrated from simulated spike train data.

Acknowledgements
This work was supported by the German Research Foundation (CRC 780, subproject C4) and by the German Federal Ministry of Education and Research (BMBF grant 01GQ0420 to BCCN Freiburg).

[T 28] Firing rate mismatch can lead to inphase synchronization of neurons coupled by delayed excitatory synapses

Alireza Valizadeh* and Sadjad Sadeghi

physics, institute for advanced studies in basic sciences (IASBS), Iran
* valizade@iasbs.ac.ir

Synchronous firing of neurons has received much attention in relation to the generation of brain wave rhythms and information processing at various aspects in the neuronal systems [1]. It is shown that with inhibitory synapses, inphase firing of neurons is possible in presence of the finite time of transmission of signals between the neurons [2, 3]. Such time-delayed

[T 71] A single psychotomimetic dose of ketamine disrupts corticothalamic dynamics

Paul Anderson[1,2,3*], Terence O'Brien[1], Nigel C. Jones[1] and Didier Pinault[2,3]

1. Department of Medicine (Royal Melbourne Hospital), University of Melbourne, Australia
2. Faculté de Médecine, Université de Strasbourg, France
3. INSERM U, physiopathologie et psychopathologie cognitive de la schizophrénie, France
* p.anderson2@student.unimelb.edu.au

Sensory and cognitive deficits are common in schizophrenia. The underlying anatomo-functional mechanisms remain elusive. There is a growing body of literature indicating the involvement of dysfunctional thalamic networks in the pathophysiology of schizophrenia, including disturbances in function-related gamma frequency (30-80 Hz) oscillations. A postulated mechanism of these impairments is the reduced N-Methyl d-Aspartate receptor (NMDAr) activation at glutamatergic synapses on GABAergic interneurons.

Ketamine is a non-competitive NMDAr antagonist that when administered at sub-anaesthetic doses in humans and rodents produces symptoms reminiscent of psychosis and also induces aberrant gamma oscillations in cortical and sub-cortical structures, including the thalamus. Corticothalamic and thalamocortical pathways are glutamatergic and work together during brain operations, including during cognition and sensory information processing. Corticothalamic pathways originate from layer VI and innervate simultaneously GABAergic thalamic reticular nucleus neurons and thalamocortical neurons of the dorsal thalamus.

The goal of the present study was to explore the spatiotemporal dynamics of the corticothalamic and thalamocortical pathways in the rat somatosensory system under physiological (vehicle) and pathological (ketamine) conditions. We conducted under light anesthesia (4) multisite cell-to-network recordings in the rat somatosensory thalamus. Its background activity was challenged by stimulation of the vibrissae. Sensory stimulation evoked a short-latency (3.3 ± 0.1 ms, n=30 from 3 animals) prethalamic response and a longer latency (9.6 ± 0.1 ms, n = 30 from 3 animals) corticothalamic response. A single injection of ketamine (2.5 mg/kg, sc) significantly increased the power of gamma oscillations (~240 % of vehicle, $p < 0.001$) and decreased the amplitude of the sensory-evoked corticothalamic response (vehicle condition: -0.35 ± 0.02 mV; ketamine condition: -0.26 ± 0.05 mV, $p < 0.001$, n = 20).

In conclusion, the present results support the hypothesis that the psychotomimetic effects of ketamine are characterized by a reduction of the sensory signal-to-gamma noise ratio in corticothalamic systems.

Acknowledgements
Paul Anderson is supported by an Australian Rotary Health PhD scholarship

[T 72] Contrast invariant feature selectivity in balanced random networks

Sadra Sadeh*, Stefano Cardanobile and Stefan Rotter

Bernstein Center Freiburg & Faculty of Biology, University of Freiburg, Germany
* sadra.sadeh@bcf.uni-freiburg.de

Neurons in the primary visual cortex (V1) of mammals are highly selective for the orientation of a light bar [1, 2, 3], while they receive afferent connections from neurons in lateral geniculate nucleus (LGN) which are themselves not selective. The emergence of this property in cortex has been subject of debate since decades, and served as a paradigm to unravel the key mechanisms of information processing in the brain. We investigate the problem from a

network point of view, by focusing on random recurrent networks with no specific pattern of connectivity.

By exploring a large-scale network model of spiking neurons through simulations and theoretical analysis, we show how a purely random network operating in the inhibition dominated regime contributes to feature selectivity. In particular, we demonstrate how tuning amplification can happen in these networks as a consequence of 'selective attenuation', a general mechanism which selectively suppresses the common mode. By systematically investigating the relevant parameter space, we pinpoint different regimes of orientation selectivity, which yields testable predictions for the biological cortex.

The 'selective attenuation' mechanism also yields contrast invariance [4, 3] of feature selectivity, which ensures feature detection for a wide range of input scales. Therefore, we suggest that the basic mechanism of contrast invariance is a consequence of intracortical interactions, and neither a single cell property, nor a purely feedforward mechanism. We argue in favor of 'tuning amplification' as the key process of the recurrent processing stage, for which no specific structure is needed. This mechanism could, in principle, also work for other sensory features and other sensory modalities as well, since the neural hardware necessary to achieve it is readily available in the cortex.

Acknowledgements
Funding by the German Ministry of Education and Research (BCCN Freiburg, grant 01GQ0420 and BFNT Freiburg*Tubingen, grant 01GQ0830) is acknowledged.

References

[1] D H Hubel and T N Wiesel. Receptive fields, binocular interaction and functional architecture in the cat's visual cortex. The Journal of Physiology, 160:106–54, 1962.
[2] D H Hubel and T N Wiesel. Receptive fields and functional architecture of monkey striate cortex. The Journal of Physiology, 195(1):215–243, 1968.
[3] C M Niell and M P Stryker. Highly selective receptive fields in mouse visual cortex. The Journal of Neuroscience, 28(30):7520–36, 2008.
[4] G Sclar and R D Freeman. Orientation selectivity in the cat's striate cortex is invariant with stimulus contrast. Experimental Brain Research, 46(3):457–461, 1982.

[T 73] Temporal segregation of mitral and tufted cell activity – the role of glomerular and granule layer interneurons

Izumi Fukunaga[1], Manuel Berning[2], Jan T. Herb[1], Mihaly Köllö[1] and Andreas T. Schaefer[1,3*]

1. Max Planck Research Group Behavioural Neurophysiology, MPI for Medical Research, Germany
2. Max Planck Instutute of Neurobiology, Germany
3. Institute for Anatomy and Cell Biology, Ruprecht-Karls-University Heidelberg, Germany
* Andreas.Schaefer@mpimf-heidelberg.mpg.de

In olfaction, the sniff rhythm shapes activity across cell populations. We have previously shown that the two major types of output neurons of the mammalian olfactory bulb (OB), mitral and tufted cells (M / TC), lock to different phases of the sniff rhythm, and that this temporal segregation is caused by GABAergic inputs selectively delaying MC activation. Here we assess, using optogenetic manipulations of selective populations of OB interneurons, in combination with whole cell recordings from principal and interneurons in vivo, which inhibitory circuits underlie this separation.

We first tested the contribution from granule cells (GC). AAV carrying flexed ArchT and GFP were injected into the GC layer of mice that express cre under the control of Gad65 promoter. Intracellular recordings from GCs show that 42% (8/19 cells) of GCs were infected, hyperpolarizing by 10-30 mV in response to light presentations, at depth up to 0.8 mm. Despite the efficient silencing of GCs, there was no change in the physiology of MC or TC.

Figure 1: State trajectory (blue line) in 3D projection of the phase space.
Green surface - manifold of fast motion.
Red line - equilibrium states of fast subsystem..

Figure 1

References

Niedermeyer E (2005) Abnormal EEG patterns: epileptic and paroxysmal. In: Electroencephalography: Basic Principles, Clinical Applications, and Related Fields (Niedermeyer E, Lopes de Silva F, eds), pp 255-280. Philadelphia: Lippincott Williams & Wilkins.

Fröhlich F, Sejnowski TJ, Bazhenov M. Network bistability mediates spontaneous transitions between normal and pathological brain states. J Neurosci. 2010 Aug 11;30(32):10734-43.

Fröhlich F, Bazhenov M, Timofeev I, Steriade M, Sejnowski TJ. Slow state transitions of sustained neural oscillations by activity-dependent modulation of intrinsic excitability. J Neurosci. 2006 Jun 7;26(23):6153-62.

Krishnan GP, Bazhenov M. Ionic dynamics mediate spontaneous termination of seizures and postictal depression state. J Neurosci. 2011 Jun 15;31(24):8870-82.

Shilnikov A. Complete dynamical analysis of an interneuron model. Special issue: Dynamics in Biology and Medicine in J. Nonlinear Dynamics. Invited referred review, 2011. DOI 10.1007/s11071-011-0046-y.

[T 115] **Firing-phase coupling is preserved in the hippocampus of epileptic mice**

Antje Kilias[1,2,3*], Ulrich P. Froriep[1,2,3], Ute Häussler[4], Arvind Kumar[2,3], Carola A. Haas[3,4] and Ulrich Egert[1,3]

1. Department of Microsystems Engineering - IMTEK, Faculty of Engineering, University of Freiburg, Germany
2. Faculty of Biology, University of Freiburg, Germany
3. Bernstein Center Freiburg, University of Freiburg, Germany
4. Department of Neurosurgery, University of Freiburg, Germany
* kilias@bcf.uni-freiburg.de

Structural changes in the hippocampal network associated with mesial temporal lobe epilepsy (MTLE) very likely contribute to seizure susceptibility. These changes should not only be reflected in epileptic seizures but also affect ongoing brain activity.

Recent findings in mice suggest that the theta and gamma rhythms in ongoing activity are indeed altered in the epileptic hippocampus. In particular, the cross-structural coupling of theta activity between the dentate gyrus and the medial entorhinal cortex as well as the cross-frequency coupling between theta and gamma rhythms within the dentate gyrus has been shown to be shifted [1]. The mechanisms underlying these shifts, however, are unknown, as are their possible contributions to the generation of epileptic activity.

Importantly, theta and gamma band activity of the local field potentials (LFPs) are associated with preferential phase-coupled firing of single cells but it is unclear whether this coupling is preserved in epileptic animals.

To address this, we investigated the firing of hippocampal neurons with respect to theta and gamma rhythms using the intrahippocampal kainate mouse model, which reproduces key

features of MTLE. We implanted custom-made multi-site silicon probes [2] to record simultaneously single-unit activity and LFPs at several positions in the hippocampal formation.

We find that the phase-coupled firing of single cells to theta and gamma band activity is preserved in hippocampal and parahippocampal areas in epileptic mice. Since theta band activity is shifted between entorhinal cortex and hippocampus [1], these data indicate that this is associated with a shift of single cell firing.

Acknowledgements
This work was supported by the German Federal Ministry of Education and Research (FKZ 01GQ0420 and 01GQ0830) and by the Deutsche Forschungsgemeinschaft (SFB TR3 and SFB 780).

References

[1] Froriep UP, Kumar A, Cosandier-Rimélé D, Häussler U, Kilias A, Haas CA, Egert U (2012). Coupling changes across structures and frequencies in the hippocampus in epilepsy. FENS Forum Abstr. 2012
[2] Herwik S, Kisban S, Aarts AAA, Seidl K, Girardeau G, Benchenane K, Zugaro MB, Wiener SI, Paul O, Neves HP and Ruther P (2009). Fabrication technology for silicon-based microprobe arrays used in acute and subchronic neural recording, J. Micromech. Microeng. 19, 7, 074008-074019.

[T 116] **Impaired cross-frequency coupling in temporal lobe epilepsy**

Ulrich P. Froriep[1,2,3], Arvind Kumar[2,3], Antje Kilias[1,2,3], Ute Häussler[4], Carola A. Haas[2,4]and Ulrich Egert[1,2*]

1. Department of Microsystems Engineering - IMTEK, Faculty of Engineering, University of Freiburg, Germany
2. Bernstein Center Freiburg, University of Freiburg, Germany
3. Faculty of Biology, University of Freiburg, Germany
4. Faculty of Medicine, Department of Neurosurgery, University of Freiburg, Germany
* egert@imtek.uni-freiburg.de

The hippocampal formation is involved in mesial temporal lobe epilepsy. In many cases, this syndrome is accompanied by histological changes in different hippocampal subfields. While epileptiform activity (EA) is a transient phenomenon, these changes should be reflected in activity between EA because they are persistent. Moreover, investigation of this 'EA-free' ongoing activity could provide information on how seizures are generated in the first place.

We recently found that, in fact, during EA-free epochs, theta band activity is shifted between the medial entorhinal cortex and the dentate gyrus in the intrahippocampal kainate mouse model in vivo (Froriep et al., 2011).

Following these findings, we tested whether cross-frequency coupling between theta (4-8 Hz) and gamma (30-150 Hz) oscillations within these structures is shifted as well. While no phase shifts in theta-gamma coupling were found in the entorhinal cortex, we found an inversion of theta-gamma coupling in the dentate gyrus of epileptic mice. Because gamma activity is correlated with activity from single neurons, these findings suggest different spike timings with respect to the theta rhythm under epileptic as compared to healthy conditions.

Acknowledgements
This work was supported by the German Federal Ministry of Education and Research (BMBF, FKZ 01GQ0420 and 01GQ0830) and by the Deutsche Forschungsgemeinschaft (DFG, SFB TR3 and SFB 780).

References

Froriep UP, Kumar A, Cosandier-Rimélé D, Häussler U, Haas CA, Egert U (2011). Mismatch in network dynamics in a model of temporal lobe epilepsy. In: Proceedings of the Ninth Göttingen Meeting of the German Neuroscience Society (2011), p. 530

[F 5] Clustered connectivity promotes synchronous burst initiation in vitro

Samora Okujeni[1,2,3*], Nila Mönig[2,3], Steffen Kandler[1,2,3], Oliver Weihberger[1,2] and Ulrich Egert[1,2]

1. Bernstein Center Freiburg, Albert-Ludwigs University of Freiburg, Germany
2. Department of Microsystems Engineering, IMTEK, Albert-Ludwigs University of Freiburg, Germany
3. Department of Biology III, Albert-Ludwigs University of Freiburg, Germany
* okujeni@bcf.uni-freiburg.de

Synchronous bursting events (SBE) are widely observed in developing neuronal systems suggesting that the capability to spontaneously initiate these dynamics reflects a crucial intermediate feature of forming networks. Consistently, SBE dynamics similarly and robustly also emerge as the predominant type of activity in networks of cultured neurons in vitro. We speculate that this might hint towards general neuronal mechanisms guiding network self-organization with the aim to establish these dynamics. Interestingly, theoretical models have shown that hierarchical network structures embedding clusters of strongly inter-connected neurons are optimal for initiating and sustaining spontaneous activity (Kaiser 2010) and clustered network structure typically emerges in networks forming in vitro (Kriegstein 1983). We hypothesize that activity-dependent structural plasticity, being a principle driving force of network self-organization, establishes clustered network structures and thereby promotes spontaneous activity levels. Previous studies showed that protein kinase C (PKC) inhibition promotes dendritic outgrowth and arborization (Metzger 2000), and impairs pruning (Kano 1995), linking this protein closely to structural plasticity. To test our hypothesis we thus inhibited PKC in developing networks of cortical neurons in vitro.

We show that developmental inhibition of PKC in cortical cell cultures increased dendritic outgrowth, impaired neurite fasciculation and clustering, and abolished network pruning. This resulted in more homogeneous and potentially better connected networks. Consistently, SBEs propagated faster and in more regular wave fronts. Yet, following our hypothesis, SBEs were triggered from fewer sites and at lower rates suggesting that these homogeneous networks embedded fewer SBE initiation zones. We tested if the homogeneous networks were able to support higher SBE rates providing additional input by electrical stimulation. Interestingly, homogeneous networks achieved comparable rates when electrically stimulated compared to the more clustered control networks. This data suggests that activity-dependent structural plasticity promotes network clustering and thereby spontaneous SBE levels during development. Based on recent evidence for a reciprocal scaling between synaptic strength and number of neuronal partners in vitro (Wilson 2007), we propose that locally more confined synaptic targeting within neuronal clusters promotes stronger and more recurrent coupling of neurons. The resulting connectivity structure could thereby more easily amplify spontaneous excitation locally beyond a critical threshold necessary for SBE initiation. In summary, our results indicate that activity-dependent structural plasticity promotes neuronal clustering and thereby the ability of in vitro networks to spontaneously initiate SBEs. We propose that this might reflect a general strategy pursued by neuronal networks to establish this crucial activity pattern during development.

Acknowledgements
Supported by the German BMBF (FKZ 01GQ0420) and by the EC (NEURO, No. 12788).

[F 10] Spikelets in Hippocampal CA1 Pyramidal Neurons: Possible Origins and Functional Implications

Martina Michalikova[1]* and Richard Kempter[1,2]

1. Institute for Theoretical Biology, Department of Biology, Humboldt-Universität zu Berlin, Germany
2. Bernstein Center for Computational Neuroscience Berlin, Germany
* martina.michalikova@biologie.hu-berlin.de

Spikelets are brief spike-like depolarizations of small amplitude, measured in the soma of a neuron. Due to their all-or-none appearance, spikelets are considered to represent full action potentials (APs) generated in an electrotonically distinct compartment. Recently, prominent spikelet activity was demonstrated in hippocampal CA1 pyramidal neurons in awake behaving animals (Epsztein et al., 2010). However, the basic mechanisms underlying the generation of spikelets in these neurons are unknown.

In previous approaches, spikelets were described mainly in pairs of inhibitory neurons in the context of electrotonic coupling via dendritic or somatic gap junctions. However, these so-called coupling potentials exhibit substantially slower dynamics than the fast spikelets recorded from excitatory pyramidal neurons. In hippocampal pyramidal neurons, axo-axonic electrotonic coupling was instead suggested as a candidate mechanism for spikelet generation, although direct experimental evidence is rather scarce.

Analyzing computational models, we found that fast somatic spikelets can be generated in a single pyramidal neuron. Such spikelets are shaped by axial (longitudinal) currents from a spike elicited at the axon initial segment (AIS) that fails to backpropagate to the soma. The backpropagation failure might occur under conditions of increased electrotonic distance between the soma and the AIS and low input resistance of a neuron, as for example, during in-vivo bursting activity.

Therefore, somatic spikelets generated within a single neuron might represent APs that are only propagated forward, i.e., they are not backpropagated into dendrites and thus might not influence dendrites. As a result, this mechanism would enable pyramidal neurons in vivo to switch off dendritic plasticity without affecting the computations generating output spikes of the neuron. In this case, spikelets save energy since the large soma does not get (fully) activated during spikelet firing.

References

Epsztein, J., Lee, A.K., Chorev, E. and Brecht, M. (2010). Impact of spikelets on hippocampal CA1 pyramidal cell activity during spatial exploration. Science 327, 474-477.

[F 11] Membrane potential statistics reveal detailed correlation structure

Grace Lindsay*, Alejandro F. Bujan, Ad Aertsen and Arvind Kumar

Bernstein Center, University of Freiburg, Germany
* gracewlindsay@gmail.com

Much focus has been placed on determining the causes and functional roles of pairwise-correlations that are observed amongst neurons (Cohen and Kohn, 2011). In the pursuit of an understanding of the impact of correlations on network activity, an important division amongst them can be made, that of 'within' versus 'between'. These types of correlations are structurally defined, with 'within' (W) referring to the amount of correlated activity within the pre-synaptic pool of neurons projecting to a given neuron, and 'between' (B) referring to the amount of correlation between two pre-synaptic pools, each projecting to a different

post-synaptic cell. This distinction is important because these two types of correlations have different functional consequences: the later can serve to propagate existing correlations while the former influences firing rates (see Bujan et al. 2012).

Here we studied these two types of correlations in recurrent networks of excitatory and inhibitory spiking neurons. We find that in random homogeneous networks the W and B are comparable. Interestingly, in inhomogeneous random networks W and B greatly differ depending on the details of the network structure. Biological neural networks can be highly heterogeneous and thus we expect that even in vivo there will be difference in the values of W and B. Despite recent advances in the labeling of pre- or post-synaptic contacts of a neuron, it may not be possible to get enough details about network connectivity to reveal the differences between W and B experimentally.Fortunately, as our simulations show, statistics (variance and correlations) of the intracellular membrane potential could provide a good estimate of the W and B. Thus, in principle, the statistics of intracellular membrane potential could provide crucial information about the structure of the network.

Acknowledgements
Work funded by the German Federal Ministry of Education and Research (BMBF 01GQ0420 to BCCN Freiburg and 01GQ0830 to BFNT Freiburg/Tübingen), the EU (Facets-ITN), and DAAD Study Scholarship funding to Grace Lindsay

References

Cohen and Kohn (2011) Measuring and interpreting neuronal correlations. Nature Neurosci. 14(7) 811-819.
Bujan et al. (2012) Structure of stimulus induced correlations in random networks with distance dependent connectivity. COSYNE Abstract II-17

[F 12] **Adaptation enhances a population code for gaps**

Chun-Wei Yuan[1*] and Christian Leibold[1,2]

1. Bernstein Center for Computational Neuroscience, Germany
2. Biology II, University of Munich, Germany
* yuan@bio.lmu.de

It is believed that the inferior colliculus (IC) functions as a central processing unit that converts the temporal code of the upstream pathways into the rate code of the thalamus and the cortex. Yet how the IC is able to encode the rich array of temporal structures of our natural acoustic environment remains poorly understood. Here we present a computational study that investigates how a recurrent network discriminates amplitude-modulated sound stimuli through the diverse response behaviors of its constituent neurons.

In our model, amplitude-modulated Poisson inputs are fed into a recurrent network. The network consists of a mixture of excitatory and inhibitory integrate-and-fire neurons, and its output is feed-forwardly connected to a linear read-out unit to perform canonical classification tasks. The analysis is then conducted as a function of neuronal parameters (adaptation, parameter value variance, etc.) to investigate the functionality of experimentally observed heterogeneity.

It is found that adaptation enhances the network's ability in gap-detection. The effect is most pronounced when the adaptive hyperpolarization time constant is on the scale of the gap size to be detected. This implies that the IC should contain a wide range of adaptive behavior in response to the natural environment, as is experimentally found.

2003], however, it is not known how the interactions *between* brain areas are organized. Here we asked whether the interactions between brain areas are SOC.

We addressed these questions by characterizing neuronal avalanches – spatiotemporal waves of enhanced activity – from up to 61 local field potential (LFP) channels of intracranial depth recordings (5 human patients, 100 hours of recordings). The electrodes were distributed inside the entire brain. Neuronal avalanches were characterized for each sleep stage separately. Note that this number of electrodes is sufficient to avoid major subsampling effects: Subsampling in SOC models may lead to wrong classifications of the system [Priesemann etal. 2009].

We show that avalanche distributions closely follow a power law for each vigilance state, independent of the threshold and the temporal scale. For a temporal scale (bin size) which equals one average inter event interval, the slope of the power law is 1.5 (maximum likelihood estimation [Clauset et al. 2009]). This indicates first that the interaction between brain areas are SOC, and second that SOC governs all cognitive states, from wakefulness to deep sleep. Minor differences between cognitive states are, however, reflected in the avalanche distributions: Slow wave sleep is characterized by larger neuronal avalanches than REM sleep or wakefulness (difference in size: ds=19%, ds=12%; p<10-7, p<10-5, respectively). Differences between wakefulness and REM are also significant (p<10-3). Our SOC model predicts that these changes may be caused by tiny variations in the effective synaptic strength by less than 0.2%.

Acknowledgements
This work was supported by the Max Planck Society and the LOEWE Grant Neuronale Koordination Forschungsschwerpunkt Frankfurt (NeFF).

References

Beggs, J.M., and Plenz, D. (2003). Neuronal avalanches in neocortical circuits. J. Neurosci. 23, 11167–11177.
Clauset, A., Shalizi, C.R., and Newman, M.E.J. (2009). Power-Law Distributions in Empirical Data. SIAM Review 51, 661
Priesemann, V., Munk, M.H.J., and Wibral, M. (2009). Subsampling effects in neuronal avalanche distributions recorded in vivo. BMC Neurosci 10, 40.
Tononi, G., and Koch, C. (2008). The neural correlates of consciousness: an update. Ann. N. Y. Acad. Sci. 1124, 239–261.

[F 19] Lotka-Volterra Models Describe Large-Scale Activity of Balanced Random Networks

Fereshteh Lagzi[1,2*] and Stefan Rotter[1,2]

1. Bernstein Center Freiburg, Germany
2. Faculty of Biology, University of Freiburg, Germany
* fereshteh.lagzi@bcf.uni-freiburg.de

The large-scale dynamics of a balanced random network of excitatory and inhibitory integrate-and-fire neurons is the focus of our study. Based on the dynamical equations of the model, a mean field approach was employed to reduce the dimensionality of the network dynamics [1,2]. We analyzed the joint activity dynamics of excitatory and inhibitory populations using a pair of mutually interacting differential equations. In absence of a voltage leak for individual neurons, and for negligible synaptic transmission delay, these equations take the form of Lotka-Volterra equations. These are known for describing predator-prey systems, which correspond to excitatory and inhibitory populations in our case. We tried to find optimal parameters for the non-autonomous differential equations given a dataset from a numerical simulations of a network. Moreover, we attempted to analytically infer the parameters and compare it with the statistical estimates.

As a next step, we analyzed the stability of the network considering two bifurcation parameters: "g", the relative strength of recurrent inhibition, which controls the balance between excitation and inhibition in the network, and "eta", the intensity of external input to the network. We found out that for a value of "g" that keeps the exact balance between excitation and inhibition, a bifurcation from unstable to stable network dynamics takes place. This bifurcation separates Synchronous Regular (SR) from Asynchronous Irregular (AI) activity of the network, similar to what was found in a previous study on the same network using a Fokker-Planck approach [3].

It has been shown that Lotka-Volterra equations are capable of representing switching dynamics between different states of neural networks [4]. Our analysis represents a first step toward analyzing the dynamics of more complex "networks of networks" that are implicated in various cognitive abilities of the brain.

Acknowledgements
Support by the German Federal Ministry of Education and Research (BMBF; grant 01GQ0420 to BCCN Freiburg).

References

1. Cardanobile S, Rotter S. Multiplicatively interacting point processes and applications to neural modeling. Journal of Computational Neuroscience 28(2): 267-284, 2010
2. Cardanobile S, Rotter S. Emergent properties of interacting populations of spiking neurons. Frontiers in Computational Neuroscience 5: 59, 2011
3. Brunel N. Dynamics of sparsely connected networks of excitatory and inhibitory spiking neurons. Journal of Computational Neuroscience 8(3): 183-208, 2000Bick C, Rabinovich M. On the occurrence of stable heteroclinic channels in Lotka-Volterra models. Dynamical Systems 25: 97-110, 2010
4. Bick C, Rabinovich M. On the occurrence of stable heteroclinic channels in Lotka-Volterra models. Dynamical Systems 25: 97-110, 2010

[F 20] **Markov Models of Neuronal Populations: a Reduction of Integrate-and-Fire Dynamics**

Taskin Deniz[1,2*], Moritz Deger[1,2] and Stefan Rotter[1,2]

1. Bernstein Center Freiburg, Germany
2. Faculty of Biology, Freiburg University, Germany
* taskin.deniz@bcf.uni-freiburg.de

Neuronal populations are capable of responding to transient input much faster than single neurons can. Neuronal codes that exploit this fact are thought to be more robust than a code based on stationary firing rates. Here, we studied populations of unconnected leaky integrate-and-fire (LIF) neurons in the fluctuation driven regime, and compared them to ensembles of Markov Point processes (MPP). In particular, we were interested in characterising the transient responses to input mean modulation vs. input variance modulation, and finding the correspondence between the two models. Markov Point Processes are very attractive for neuronal modelling because many aspects of them are analytically tractable.

Acknowledgements
Funding by the German Ministry of Education and Research (BCCN Freiburg, grant 01GQ0420 and BFNT Freiburg*Tubingen, grant 01GQ0830) is acknowledged.

References

1. Tchumatchenko T., Wolf F. (2011) Representation of Dynamical Stimuli in Populations of Threshold Neurons. PLoS Comput Biol 7(10): e1002239. doi:10.1371/journal.pcbi.1002239
2. Buice M. A., Cowan J. D. (2009) Statistical mechanics of the neocortex. Progress in Biophysics and Molecular Biology, Volume 99, Issues 2–3, Pages 53-86, ISSN 0079-6107, 10.1016/j.pbiomolbio.2009.07.003.
3. Silberberg G., Bethge M., Markram H., Pawelzik K., Tsodyks M. (2004) Dynamics of population rate codes in ensembles of neocortical neurons. Journal of Neurophysiology 91(2):704–709
4. Deger M. , Helias M. , Cardanobile S. , Atay F. M. , Rotter S. (2010). Nonequilibrium dynamics of stochastic point processes with refractoriness. Phys. Rev. E 82, 021129
5. Muezzinoglu M.K., Tristan I., Huerta R., Afraimovich V.S., Rabinovich M.I. (2010) Transient versus attractors in complex networks. International Journal of Bifurcation and Chaos 20(6): 1-23.

[F 21] Scanning for relations of neuronal spiking activity and network structure across multifractal network ensembles

Moritz Deger*, Volker Pernice, Stefano Cardanobile and Stefan Rotter

Bernstein Center Freiburg & Faculty of Biology, University of Freiburg, Germany
* deger@bcf.uni-freiburg.de

Relations between structural features and spiking activity of neuronal networks have recently raised a lot of interest. Current studies typically focus on specific network models and attempt to discover relations between properties of the underlying graph and the signals generated by its neurons [1-4]. Structural parameters often considered in this context are degree distribution, degree correlations, and spectral radius of the adjacency matrix. Parameters typically used to characterize activity dynamics are firing rate, synchrony, spike train regularity, and spike count correlations.

Models of networks generally constrain the statistics of network properties due to their specific construction procedure. Results of the above type can hence be strongly biased by correlations between different features of the specific network model under consideration. Here we employ the multifractal network generator [5] to address network models with a broad distribution of properties and, consequently, generate realizations of networks with much higher variability than usual [4]. This approach can therefore be used to infer and systematically test the validity of structure-dynamics relations in a general context.

We present results based on a large set of simulations of networks comprised of excitatory and inhibitory integrate-and-fire neurons. Biophysical parameters and overall connectivity were arranged such that they would induce an asynchronous irregular activity state in the case of a random network with homogeneous coupling [6]. Firstly, our results indicate that different non-random structures can induce a large variety of activity regimes. Secondly, we find significant correlations between activity parameters and certain structural properties that have so far not received much attention. Thus our data mining approach might eventually lead to the discovery of network characteristics, the functional significance of which was previously unknown.

Acknowledgements
Supported by the German Federal Ministry of Education and Research (BMBF; grant 01GQ0420 BCCN Freiburg, grant 01GQ0830 BFNT Freiburg*Tübingen, grant 01GW0730 Impulse Control), and the German Research Foundation (DFG; CRC 780, subproject C4).

References

1. Riecke, H., Roxin, A., Madruga, S., and Solla, S.A. (2007). Multiple attractors, long chaotic transients, and failure in small-world networks of excitable neurons. Chaos 17:2, 026110. doi: 10.1063/1.2743611
2. Gaiteri, C., and Rubin, J.E. (2011). The interaction of intrinsic dynamics and network topology in determining network burst synchrony. Front. Comput. Neurosci. 5:10. doi: 10.3389/fncom.2011.00010
3. Mäki-Marttunen, T., Aćimović, J., Nykter, M., Kesseli, J., Ruohonen, K., Yli-Harja, O., and Linne, M.-L. (2011). Information diversity in structure and dynamics of simulated neuronal networks. Front. Comput. Neurosci. 5:26. doi: 10.3389/fncom.2011.00026
4. Cardanobile, S., Pernice, V., Deger, M., and Rotter, S. (2012). Inferring general relations between network characteristics from specific network ensembles. Accepted for PLoS ONE. doi: 10.1371/journal.pone.0037911
5. Palla, G., Lovász, L., and Vicsek, T. (2010). Multifractal network generator. P Natl Acad Sci USA 107, 7640-7645. doi: 10.1073/pnas.0912983107
6. Brunel, N. (2000). Dynamics of Sparsely Connected Networks of Excitatory and Inhibitory Spiking Neurons. J. Comput. Neurosci., 8:3, 183-208. doi: 10.1023/A:1008925309027

be differentiated electrophysiologically by means of event-related potentials (ERPs). In contrast to correctly rejected new items, items correctly classified as old yield a more positive ERP deflection which is termed old/new effect. One earlier frontally localized old/new effect emerging from about 300 ms after stimulus onset relates to familiarity processing whereas a functionally distinct later parietal effect is associated with recollection. Functional magnetic resonance imaging (fMRI) has revealed that within the medial temporal lobe, extrahippocampal cortical areas and the hippocampus proper support independently recognition based on familiarity or recollection, respectively. In order to examine the relation between hemodynamic changes and the modulation of ERP old/new effects during memory retrieval, we conducted a simultaneous EEG-fMRI study in 16 young healthy volunteers. Standard ERP analyses revealed an early mid-frontal and a later parietal old/new effect, presumably associated to the differential use of familiarity and recollection during recognition. FMRI old/new contrasts showed activity modulation in the hippocampus as well as in the precuneus, the retrosplenial cortex and the medial frontal gyrus. An EEG-informed fMRI analysis was performed to relate single-trial ERP amplitudes to hemodynamic signal changes, thus accounting for trial-to-trial fluctuations. By orthogonalisation to the standard stimulus-coding predictors the variance explained by the trial-to-trial modulation of the old/new effects was isolated. The results complement rare data from intracranial ERP recordings and patient studies. The results from this multimodal fusion analysis will be embedded into biophysically and anatomically detailed models of hippocampal-prefrontal interaction which will in turn generate predictors for the outcome of future imaging studies.

Acknowledgements
This study was supported by the Bundesministerium für Bildung und Forschung.

[F 94] Continuous variable models of voltage-based STDP

Yansong Chua* and Abigail Morrison

freiburg university, Germany
* james4424@gmail.com

Voltage-based spike-timing dependent plasticity (STDP) [2] can explain the results of many plasticity experiments that were previously not adequately accounted for by spike-pair based STDP models such as frequency dependence [6] and triplets dependence [3]. Recently, we have shown that anti-hebbian plasticity at distal dendrites of layer 5 pyramidal neurons [4] can be accounted for using a generalized form of the original voltage dependent plasticity model [1], where the pre-synaptic spike train in the long term depotentiation (LTD) component is replaced by its low pass filter. However, these models use a mixture of discrete (pre and post-synaptic spike trains) and continuous variables (low pass filter of membrane potential) to ensure spike-timing specificity. Here, we investigate whether models based purely on continuous variables can have the same explanatory power as the previously developed discrete-continuous models.

We test their ability to account for the sign and amplitude of synaptic plasticity in frequency, triplets and anti-hebbian protocols. A model inspired by Shouval's calcium concentration model provides a good account of all three experiments and is less complex than the original formulation [2] of voltage-based STDP.

References

[1] Chua, Y., & Morrison, A. (2012). Modified voltage STDP and calcium spikes can explain anti-hebbian plasticity at distal dendrites of pyramidal neurons. Proceedings of FENS forum 2012.
[2] Clopath, C., Büsing, L., Vasilaki, E., & Gerstner, W. (2010). Connectivity reflects coding: a model of voltage-based STDP with homeostasis. Nature neuroscience.
[3] Froemke, R. C., & Dan, Y. (2002). Spike-timing-dependent synaptic modification induced by natural spike trains. Nature.
[4] Letzkus, J. J., Kampa, B. M., & Stuart, G. J. (2006). Learning rules for spike timing-dependent plasticity depend on dendritic synapse location. The Journal of neuroscience.
[5] Shouval, H. Z., Bear, M. F., & Cooper, L. N. (2002). A unified model of NMDA receptor-dependent bidirectional synaptic plasticity. Proceedings of the National Academy of Sciences of the United States of America.
[6] Sjöström, P. J., Turrigiano, G. G., & Nelson, S. B. (2001). Rate, timing, and cooperativity jointly determine cortical synaptic plasticity. Neuron.

[F 95] **A spiking neuronal network model of fast associative learning in the honeybee**

Joachim Haenicke[1,2*], Evren Pamir[1,2] and Martin P. Nawrot[1,2]

1. Institute of Biology, Freie Universität Berlin, Germany
2. Bernstein Center for Computational Neuroscience Berlin, Germany
* joachim.haenicke@fu-berlin.de

Numerous experimental studies on classical conditioning in the honeybee (Apis mellifera) have provided insights into the physiological processes of olfactory learning and memory formation. On the basis of these findings, several theoretical studies have proposed different model hypotheses for sensory processing and learning in the insect brain. However, the actual dynamics of associative learning as evident from behavior in individual animals is typically neglected. For the honeybee, recent analyses suggest that individual animals learn to associate between odor and sugar reward within a single trial (Pamir et al. 2011).

Here we present a spiking neuronal network model which processes sensory stimuli defined by classical conditioning protocols of the proboscis extension response in the honeybee. We compare and implement different hypotheses on physiological mechanisms that support fast associative learning in their ability to reproduce both behavioral and physiological constraints as observed in experiments. The behavioral constraints of our model are defined by the learning performance of individual animals during absolute, differential, backward and trace conditioning. Physiological constraints comprise several recordings of neuronal activity from different processing stages along the sensory-to-motor pathway.

Acknowledgements
This work was supported by the BMBF through grant 01GQ0941 within the Bernstein Focus Neuronal Basis of Learning (BFNL). E.P was funded by the DFG within the Research Training Group Sensory Computation in Neural Systems (GRK 1589). Author contribution: J.H. and E.P. contributed equally to this study.

References

Pamir, E., Chakroborty, N. K., Stollhoff, N., Gehring, K. B., Antemann, V., Morgenstern, L.,Felsenberg, J., et al. (2011). Average group behavior does not represent individual behavior in classical conditioning of the honeybee. Learning & memory (Cold Spring Harbor, N.Y.), 18(11), 733-41.

Data analysis, machine learning, neuroinformatics

[F 110] Spectral Analysis of Local Field Potentials from Rat Primary Visual Cortex (V1)

Thomas Fucke[1,2,3,4], Katharina Heining[3], Anna I. Jasper[3,4], Clemens Boucsein[3,4] and Ad Aertsen[3,4]

1. Psychological Research, Central Institute for Mental Health, Germany
2. BCCN Heidelberg/Mannheim, Germany
3. Faculty of Biology, Albert Ludwig University of Freiburg, Germany
4. Bernstein Center Freiburg, Germany

In primary visual cortex (V1) of rats, orientation selective neurons do not show topographic organization on a larger scale (Ohki et al., 2005), in contrast to the columnar organization of orientation selective cells in V1 of cat and monkey. Accordingly, while orientation tuning in mass signals like the local field potential (LFP) has been described in recordings from cat V1, it can be assumed to be weak or absent in rodent V1. However, in monkey motor cortex, which also shows no clear columnar organization, information about the direction of the monkey's hand movement could be extracted from LFP power spectra with high predictive power (Rickert et al., 2005).

To reveal in how far global network tuning properties could be extracted from mass signals of primary sensory areas which do not show clear topographic organization, we performed in vivo multi-electrode recordings in V1 of anesthetized rats while presenting visual stimuli with clear direction information (moving edges and gratings). Spectral analysis of LFP signals from multiple channels was performed using adaptive multivariate auto-regression (AMVAR; Ding et al., 2000) after removing the first two statistical moments (mean and standard deviation across trials) from the signal. This method allows high spectral estimation accuracy with high temporal resolution superior to other methods of time-dependent spectral analysis like multi-tapering (Nalatore & Rangarajan, 2009). Direction tuning was assessed using circular statistical measures.

For moving edges, significant directional tuning in the LFP power spectrum can be found during the onset transient up to 500 ms after stimulus onset. Tuning strength was not distributed evenly across the whole observed spectrum (<200 Hz), however, but limited to mainly two distinct frequency bands centered around ~30 Hz and ~70 Hz. Preliminary analysis of moving grating stimuli did not reveal significant tuning either in the onset transient or the steady state during stimulus presentation. These results suggest that, even in the absence of coarse scale organization of cortical networks with respect to tuning properties, information about the stimulus properties can be inferred with appropriate methods.

Acknowledgements
This project received funding from the German Federal Ministry of Education and Research (Grants 01GQ0420 to BCCN Freiburg and 01GQ0830 to BFNT Freiburg-Tübingen)

References

Ding M, Bressler SL, Yang W, Liang H (2000) Short-window Spectral Analysis of Cortical Event-related Potentials by Adaptive Multivariate Autoregressive Modeling: Data Preprocessing, Model Validation, and Variability Assessment. Biol. Cybern. 83, 35-45

Nalatore H, Rangarajan G (2009) Short-window Spectral Analysis Using AMVAR and Multitaper Methods: a Comparison. Biol Cybern. 101:71–80

Ohki K, Chung S, Ch'ng YH, Kara P, Reid RC (2005) Functional Imaging with Cellular Resolution Reveals Precise Microarchitecture in Visual Cortex. Nature 433:597-603

Rickert J, Cardoso de Oliveira S, Vaadia E, Aertsen A, Rotter S, Mehring C (2005) Encoding of Movement Direction in Different Frequency Ranges of Motor Cortical Local Field Potentials. J Neuroscience 25:8815– 8824

The **Bernstein Conference** is organized by the Bernstein Network Computational Neuroscience. The network represents about 200 research groups from over 20 locations in Germany, covering all areas of modern neuroscience. It is one of the largest research initiatives in Germany and the only network in neuroscience of its kind in the world.

The **Bernstein Conference** is a single track conference that covers all aspects of Computational Neuroscience and Neurotechnology.

www.bccn2012.de