The Free State of Bavaria is a first-rate location for science and research, where life sciences play an eminent role. They find one of their strongest bases in Munich. The Bavarian capital is home to two great research universities – both winners of the Germany-wide Initiative for Excellence – as well as numerous highly-specialized and well-known non-university research institutions. It is no wonder that Munich is the ideal place for committed scientists to deliver prime scientific results at the highest international level.

Today, top science demands close cooperation – beyond the limits of institutes and disciplines. The “Munich Center for Neurosciences” provides the integrative platform to take the strong interdisciplinary approach the complexity of the different fields of neurosciences asks for. Its being open to integrating perspectives and findings from neighbouring fields of research even allows a holistic reflection of burning neuroscientific questions.

Through various teaching programmes – above all, the Graduate School for Systemic Neurosciences – young scientists are integrated in this excellent research environment and can fully develop their potential. The fact that the Graduate School for Systemic Neurosciences was successful in the first round of the Initiative for Excellence emphasizes that it can serve as a superb role model.

Its brilliant concept has established the “Munich Center for Neurosciences” as a beacon of science in Munich’s research environment. The list of its distinguished members, the great amount of third-party funding as well as the high demand for its teaching programmes clearly prove the centre’s great success.

All these results are both promising and encouraging. With innovative projects like the “Munich Center for Neurosciences”, we can successfully advance the further development of our research landscape and maintain our leading position in the life sciences.

I am sure that the great work of the scientists at the “Munich Center for Neurosciences” will continue its success and wish the centre all the best for the future.

Munich, August 2011

Dr. Wolfgang Heubisch
Bavarian State Minister of Sciences, Research and the Arts
Ludwig-Maximilians-Universität München is one of the leading research-intensive universities worldwide, with a more than 500-year-long tradition. It is LMU’s mission to combine excellent research with outstanding teaching, to conduct basic research and tackle the grand challenges of our time. The extraordinary research output of the university is based on the exceptional achievements of our researchers and scientists. This is proved by our success in the first round of the Excellence Initiative in 2006. In addition to that, LMU also offers the best possible education for its 46,000 students with degree programs in 150 subjects and thus ideally preparing young people for a career in academia or outside university.

One of LMU’s very successful institutions is the “Munich Center for Neurosciences – Brain and Mind (MCNLMU)”, which contributes essentially to LMU’s top position within the life sciences. MCNLMU aims towards building up a network of groups and disciplines with interest in questions of neurobiology, cognition, and “brain and mind”. With its interdisciplinary approach, MCNLMU combines various research fields at LMU ranging from the natural sciences to the humanities. Scientists from the field of experimental and theoretical neurosciences, philosophy and psychology do research and teach in the numerous projects and programs within the MCNLMU. The Center is an excellent example for transferring new and broad knowledge in an emerging field of science to the new student generations. The two specialized Master programs in Neurosciences and Neuro-Cognitive Psychology, funded by the Elite Network of Bavaria, are the successful teaching institutions at MCNLMU. The Graduate School of Systemic Neurosciences which is funded within the German Excellence Initiative promotes young scientists by offering them the best possible framework for doing their first independent research.

One essential requirement for the success of the MCNLMU is the intense cooperation with its partners, the Technische Universität München, different Max Planck Institutes, the Helmholtz Zentrum München and the Bernstein Center for Computational Neuroscience. It also maintains close ties to renowned international partners in Europe, the United States and Australia and thus creates an important global network for the exchange of knowledge. This brochure offers interesting insights into the Munich Center for Neurosciences – Brain and Mind, its research projects and teaching programs as well as an overview on the excellent researchers who are working at the MCNLMU. The multiplicity, interdisciplinarity and internationality of this top-class institution strongly contributes to LMU’s vision to address the key areas of research and innovation of the 21st century.

Prof. Dr. Bernd Huber
President
Ludwig-Maximilians-Universität München

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Prof. Dr. Bernd Huber
President
Ludwig-Maximilians-Universität München
Dear Reader,

Modern sciences increasingly depend on the ability of crossing disciplinary boarders as well as collaborations that allow sharing expertise and infrastructure. This holds particularly true for an area like the neurosciences. The structure and function of the human brain and the question of how its activity relates to our concepts of the mind cannot be studied in isolation, but only through extensive networking. The “Munich Center for Neurosciences – Brain and Mind (MCNLMU)” was founded in 2005 to create a local network in and around Munich that connects all groups and disciplines with interests related to questions of neurobiology, cognition, and “brain and mind”. It provides a platform for interdisciplinary interactions, supports the establishment of new collaborative research programs and has developed a teaching concept that attracts excellent students at all levels of training. The program M.Sc. Neurosciences, generously funded by the Elite Network of Bavaria and the Ph.D. program of the Graduate School of Systemic Neurosciences GSNLMU, funded by the German Excellence Initiative, are offspring of the MCNLMU Teaching Concept (see page 88). The SFB 870: Assembly and Function of Neuronal Circuits in Sensory Processing is a new collaborative research center that resulted from scientific interactions of many members of the MCNLMU, and several other research and training networks such as the Bernstein Center for Computational Neuroscience (BCCN) Munich or the Research Training Group 1091 Orientation and Motion in Space have profited greatly from established networks within MCNLMU and also from its teaching concept. This only begins to exemplify how MCNLMU fosters Munich as an internationally attractive site for training and research in the neurosciences.

In Munich, research related to the neurosciences spans a wide spectrum of current areas of investigation, ranging from neural stem cells and the molecular mechanisms of early brain development, via cellular and systems neurobiology (including neurology), neuropsychology, and behavior (including “theory of mind”), to epistemology, philosophy of science, logic, and ethics. It involves numerous research groups working in various institutes and departments of the LMU (in particular, biology, medicine, philosophy, psychology), most of them in close collaboration with the Max Planck Institutes of Neurobiology, Psychiatry, and Ophthalmology, the institutes of the HelmholtzCenter Munich (HMGU), several institutes at the Technische University of Munich (TUM; electrical engineering, medicine, physics, life sciences) as well as with the computer industry.

MCNLMU was implemented to make Munich, with its multitude of expertise, not only one of the real “hot spots” in the neurosciences, but also one of the few neuroscience hubs where the bridge from experimental neurobiology to the philosophy of brain and mind can be competently spanned.

Prof. Dr. Benedikt Grothe
Chair of the Board of Directors

Prof. Dr. Benedikt Grothe
MCNLMU Chair of the Board
of Directors
Managing Director
Prof. Dr. Oliver Behrend
MCNLMU Managing Director

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With kind regards,

Prof. Dr. Oliver Behrend
MCNLMU- Managing Director

Dear Members and Friends of the Munich Center for Neurosciences,

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Prof. Dr. Oliver Behrend
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This compendium of the Center’s activities is meant to reach out to the wider neuroscience community, both nationally and internationally, and also to make individual research interests of the Center’s members visible to each other. Furthermore, this publication was designed to communicate some of the richness and sophistication of the neurosciences in the greater Munich area to non-scientists. The LMU-wide Ringvorlesung (Theme Lecture Series) "Der Mensch und sein Gehirn" was already an important step in that direction. Beyond presenting the Center’s scientific wealth, this document attempts to clarify the aims of the Center, and the advantages that arise from bringing together such a vast variety of neuroscientific expertise. The university’s initiative LMUinnovativ led to the formation of the MCNLMU, which is on an efficient communication structure to promote scientific interaction within the Center and associated entities. Significant amounts of research funding were drawn from federal sources (Bundesministerium für Bildung und Forschung, Deutsche Forschungsgemeinschaft), Bavarian-wide initiatives (Elite Network of Bavaria), as well as private organisations and industry (AMGEN). Successful research initiatives that were substantially supported by the Center range from fundamental research on neuronal circuits (Collaborative Research Center 870 to theoretical and computational neurosciences (Bernstein Center for Computational Neuroscience Munich). Beyond the circuit level, the Center’s focus is also set on research on cognitive processes. The huge potential for translating results from research into tangible applications becomes evident by successful initiatives applying research to technical systems (Excellence Cluster Cognition for Technical Systems). These initiatives also have substantial influence on the society’s perception of neurosciences and help in forging a general consensus that neuroscience research is critical for a healthy development of our society in the future. A number of initiatives keep Munich as a Center for neurosciences on the screen of local, national, and international neuroscientists. For instance, more than 40 well-recognised researchers were brought to the Center by invitation to participate in the prestigious MCNLMU Monday Lecture Series since 2007. Other events, like the envisaged Christmas Lecture in collaboration with the Bavarian Ministry of Science, Research and the Arts will further strengthen the Centers public outreach. In the future, also the online presence of the Centers public outreach. In the future, also the online presence of the Center’s focus is also set on research on cognitive processes. The huge potential for translating results from research into tangible applications becomes evident by successful initiatives applying research to technical systems (Excellence Cluster Cognition for Technical Systems). This holds especially true for those initiatives applying top-notch scientific results directly to the benefit of patients, i.e. within centers that integrate research and treatment in neurology, as well as the exchange of young scientists with other excellent neuroscience institutions around the world. To effectively secure a straightforward curriculum with the multitude of options available to students within the MCNLMU / GSNLMU a teaching coordinator has been appointed, and a student relations coordinator helps students to adjust their path towards graduation on an individual basis. The sound education of future neuroscientists within the Center will help to further develop the Munich area as an outstanding neuroscience hub in the world. On a personal note – enjoy the read!

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MCNLMU- Managing Director
The network
Neuronal representations of space and time are of fundamental importance for cognition and behavior – from localizing prey by auditory cues and visually detecting moving objects to the planning and neuronal control of future movements. Goal-directed self-motion relies on continually evaluating changing sensory inputs in real time and taking previously stored information into account to generate spatially coordinated and appropriately timed motor actions. Our brain solves these challenging computational tasks with apparent ease, using intricate feedback circuits in distributed neural circuits whose functional architecture adapts in time. Pathologies of visuomotor control and age-related navigation deficits reveal that the underlying processes hang in a delicate balance; limitations and failures of current technical applications demonstrate that we have only rather restricted insight into some of the most basic functions of nervous systems. Yet, in recent years, there have been numerous exciting new discoveries about neuronal representations of space-time, as also shown by many publications from BCCN Munich.

Research projects at Bernstein Center Munich cover and connect:
- experiment, data analysis, modeling and theoretical approaches
- neurobiology, clinical neuroscience, bioinformatics, physics, computer science, and engineering
- computational modeling on various levels; compartmental models of dendritic trees, simplified single neuron models, networks of spiking neurons, and models at the systems level
- investigations on auditory, electrosensory, vestibular, and visual information processing
- in-vitro recordings, in-vivo recordings as well as psychophysics and fMRI
- studies in different neuronal structures: brain stem, cortex, as well as insect receptor neurons and interneurons
- scientists from Ludwig-Maximilians-Universität München (LMU), Technische Universität München (TUM), Max-Planck-Institute of Neurobiology (MPI), MED-EL Deutschland, and NPI – Electronic Instruments for the Life Sciences

Together with five other Bernstein Centers, the BCCN Munich forms the core of the National Network Computational Neuroscience (www.nncn.de). Supported by highly competitive start-up funds from the Federal Ministry of Education and Research, more than 20 faculty positions have been newly created within the Network, five of which are located at BCCN Munich.
The need to write computer programmes for all possible events that may occur. Be it servicerobots or industrial robots – the scientists in CoTeSys work devotedly on the realization of robots as assistants for many aspects of life. Cognition technology poses all kinds of questions in brain research, psychology and biophysics, computer science, mechanical engineering, control engineering and mechatronics, solutions that are found only in close, interdisciplinary teams. The practical implementation of the theoretical findings is of high importance to CoTeSys. Therefore, all theoretical results have to be demonstrated in technical demonstration scenarios, to verify and validate the superiority of cognitive approaches. These scenarios provide means for applying, integrating, validating and analyzing new research methods in the context of real-world scenarios that are of critical importance economically and to society.

Since 2006, CoTeSys has pooled the expertise of around 100 scientists of the Technische Universität München, the Max Planck Institute of Neurobiology, the Ludwig-Maximilians-Universität München, Universität der Bundeswehr, the German Federal Armed Forces University of Munich and the German Aerospace Center DLR in Oberpfaffenhofen. CoTeSys, therefore, belongs to the largest interdisciplinary research clusters in the field of cognition. CoTeSys can report numerous success stories giving examples on how to bridge the gap between fundamental research in neurocognition, psychology and informatics, and engineering. CoTeSys attracts top international scientists as new junior and tenured professors and has a significant impact on academia, industry, future societies and the general public. CoTeSys is highly successful in establishing Independent Junior Research Groups and is involved in several educational gender projects, attracting young girls and boys to scientific and technical professions. It is an explicit goal of CoTeSys to promote more women into senior positions. CoTeSys has successfully established two Central Robotics Laboratories CCRL-I in Barerstraße and CCRL-II in Karlstraße, both located in downtown Munich. CoTeSys is one of the strategic projects supported with federal and state funds through the German Excellence Initiative.

CoTeSys – Cognition for Technical Systems

CoTeSys is one of the largest projects in providing machines and robots with biology-inspired cognitive capabilities.

Cognitive technologies are the crux. They differ from other technical systems as they have cognitive capabilities and hence perform cognitive control. Cognitive control orchestrates reflexive and habitual behaviour towards long term autonomy and intentions. Cognitive capabilities include perception, reasoning, learning, goal-oriented planning, and result in systems of higher autonomy, flexibility, adaptivity, reliability, robustness featuring better interaction with humans and improved collaboration capabilities.

In order for machines and humans to work together, machines must learn to accomplish tasks the way humans do. Only if robots are able to recognize their environment, react flexibly, intuitively, and, to a certain extent autonomously, are they able to assist human beings in an overall manner and spare them the need to write computer programmes for all possible events that may occur.

CoTeSys has the expertise of around 100 scientists of the Technische Universität München, the Max Planck Institute of Neurobiology, the Ludwig Maximilians Universität München, Universität der Bundeswehr, the German Federal Armed Forces University of Munich and the German Aerospace Center DLR in Oberpfaffenhofen. CoTeSys, therefore, belongs to the largest interdisciplinary research clusters in the field of cognition.

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Integrated Center for Research and Treatment of Vertigo, Balance and Ocular Motor Disorders (IFBLMU)

The Integrated Center for Research and Treatment of Vertigo, Balance and Ocular Motor Disorders (IFBLMU), established in Munich in 2010, brings a novel approach towards integrating basic research and clinical treatment. During the last decades, Munich has become the site of a unique concentration of leading experts on vertigo, balance and ocular motor disorders, both in the clinical and basic sciences.

Using this unique expertise, the IFBLMU seeks (1) to create an independent patient-oriented clinical research centre; (2) to overcome existing clinical and academic barriers separating the traditional specialisations; (3) to establish a standardised interdisciplinary longitudinal and transversal network at one site for the management of patients; (4) to organise the study infrastructure for prospective multicentre clinical studies as well as to free clinical scientists from administrative tasks; (5) to promote translational research with a focus on the innovative topics of molecular, functional and structural imaging, experimental and clinical pharmacotherapy, clinical research of vertigo and balance disorders, mathematical modelling, interaction between biological and technical systems (robotics), and research on functionality and the quality of life; (6) to offer new attractive educational paths and career images for medical doctors, students of the natural sciences, and engineers in clinical research in order to overcome traditional hierarchical structures. This should also be seen as an incentive that will attract the best young scientists; (7) to incorporate IFBLMU competence into the existing medical and biological graduate schools. Translational research within the IFBLMU is supported by up to eight young scientist groups, working independently and self-reliantly within the IFBLMU and up to eight (tenure-track) professors. The access to patients and methods is ensured by cooperation contracts among the clinics and institutes involved in the IFBLMU.

Training within the IFBLMU builds on existing scientific training programmes such as the M.Sc. programmes in Clinical Epidemiology and Human Functioning Sciences and the Ph.D. program in Neuroscience through the Graduate School of Systemic Neurosciences (GSNLMU). The IFBLMU, furthermore, plans to establish a "Clinical Scientist IFBLMU" curriculum which shall be integrated in the degree awarding process for M.Sc. (Epidemiology, Public Health) and M.D./Ph.D. programmes focussed on clinical research.
Along with major success in molecular and cellular neurosciences, over the last decades, brain imaging techniques like fMRI and EEG provided fascinating data. However, the understanding of the brain’s complex functions, compartments and interrelations still needs conjoined research efforts. Fundamental, but yet open questions – like the translation of cellular mechanisms into higher brain functions as well as processing of behaviourally relevant information on intermediate levels of brain organisation by specific neuronal circuits and neuronal populations within – remain largely unanswered.

In order to address such questions, the Collaborative Research Center (CRC) 870 ‘Assembly and Function of Neuronal Circuits in Sensory Processing’ comprising 23 scientific projects, aims at elucidating structure-function relationships of neuronal circuits, their dynamics and computations and intends to gain a deeper understanding of the molecular basis of the development, plasticity and regeneration of sensory circuits as well as processing mechanisms for behaviourally relevant information.

For various reasons, neuronal circuits serve as ideal model systems to study the principles of neuronal information processing. First, these circuits process highly specific physical cues, which are present in sensory stimuli and can be tightly controlled in physiological and/or behavioural experiments. Efficient analysis of the information processing in neuronal circuits is facilitated by parallel, anatomically distinguishable pathways specialized for certain sensory stimuli. Moreover, sensory circuits show specific adaptations to structure and functions related to behavioural needs, which help to determine biologically relevant experimental approaches. In addition, advanced model driven hypotheses about sensory processing combined with new experimental techniques enhance the development of new and more powerful experimental approaches vital for advancing systemic neuroscience. Therefore, several projects in the CRC 870 are investigating new approaches for the manipulation of neuronal activity in specific subpopulations of neurons within neuronal circuits. These include genetic alterations targeting specific subpopulations as well as the use of optically controlled, photo-switchable molecules that can be used to accentuate the activity of single neurons. Such methods will allow for more efficient and conclusive testing of hypotheses about the flow of information within neuronal circuits.
The people

- **Biomedical Neuroscience**
- **Behavioral & Cognitive Neuroscience**
- **Neurophilosophy**
- **Molecular & Developmental Neuroscience**
- **Cellular & Systems Neuroscience**
- **Theoretical Neuroscience & Technical Applications**

Selection of MCNLMU members. See page 120 for list of all MCNLMU members.
Promoting axonal growth, pathfinding and synapse formation following spinal cord injury

We are studying the neuronal response to traumatic and inflammatory lesions of the spinal cord. In initial studies we have investigated how therapeutic strategies can limit neuronal cell death following CNS injury (Bareyre et al., 1997; 1999; 2000; 2001). We are currently trying to understand how we can promote axonal repair of surviving neurons by focusing on the molecular and anatomical mechanisms underlying axonal plasticity after traumatic and inflammatory spinal cord lesions (Bareyre et al., 2002; 2004; Kerschensteiner et al., 2004). By microarray analysis, we have identified a number of candidate molecules that might impact axonal outgrowth and pathfinding during post-traumatic recovery (Bareyre et al., 2002). To further understand how spontaneous recovery of function is achieved we study the reorganization of the corticospinal tract after traumatic or inflammatory lesions of the spinal cord. We have shown that the recovery of corticospinal function is achieved by the formation of new intraspinal detour circuits involving propriospinal relay neurons (Bareyre et al., 2004; Kerschensteiner et al., 2004). We are now trying to address the following important questions: (i) how do growing axons find the appropriate path to their intraspinal targets and (ii) how do they form and stabilize synapses onto these targets?

In order to gain first insight into the principles that can regulate axonal pathfinding and synapse formation, we engineered methods to visualize synapses via tagged peptides (McCann, Bareyre et al., 2005) and generated transgenic mice in which the corticospinal tract is selectively and specifically labelled with a fluorescent protein (Bareyre et al., 2005). Using these mice we have demonstrated that when the main CST tract is lesioned, minor CST components remodel to compensate the lesion. We now combine our expertise on axonal remodeling with emerging imaging techniques that allow the direct visualization of regrowing axons and their path to the target cells in vivo (Misgeld et al. 2007; Nikic et al., 2011). We use this approach in combination with viral gene therapy to dissect the molecular regulation of the neuronal growth response in vivo (Bareyre et al., 2005) and generated transgenic mice in which the corticospinal tract is selectively and specifically labelled with a fluorescent protein (Bareyre et al., 2005). Using
The main goal of our research on sensory systems is to identify common principles of signal processing in various neural systems and to investigate their implementation on the cellular level. Our experimental approaches are strongly influenced by theories on neural function as dynamical systems and on information theoretical considerations. Vice versa, we develop new theoretical concepts that are inspired by our experimental findings. In particular, we perform electrophysiological recordings on the active and the passive electrosensory systems of wave-type weakly-electric fish and on the auditory system of grasshopper and crickets. Both systems have the advantage to allow for comparative studies between related species. We contrast our data with well known properties of canonical integrate-and-fire type models in order to identify non-trivial features of recorded neural responses. Currently, we focus on potentially advantageous roles of intrinsic noise source in sensory processing.

In addition, we characterize the statistics of natural stimuli for the electrosensory systems of weakly electric fish both in well controlled experiments in the lab and in natural habitats in South-America. For the latter we are developing a grid of electrodes that continuously record the electric fields of the fish. From the data we reconstruct the position as well as the communication signals for each fish individually. This novel method eventually allows us to record natural signals in natural habitats on unprecedented spatial and temporal scales. The resulting data will be very important for discussing our findings from the comparative electrophysiological experiments on neural tuning properties.
Ion channels in the CNS: from genes to disease

Our laboratory aims at achieving insights into the role of ion channels in normal physiology and disease. Ion channels are protein complexes that confer the flux of ions through cellular membranes. These proteins are vital for virtually every cell in the body. In neurons, ion channels provide the basis for action potential generation and information processing. Dysfunction of ion channels causes acquired or inherited diseases ("channelopathies") including numerous diseases of the nervous system (e.g. epilepsy, migraine, pain disorders, depression).

One class of ion channels we are interested in are the cyclic nucleotide-regulated cation channels (CNG and HCN channels). CNG channels are crucial for olfactory and visual transduction. We have characterized several members of this ion channel class and have investigated their physiological relevance using genetic mouse lines produced in our laboratory. We are particularly interested in retinal CNG channels since dysfunction of these channels can lead to visual impairment and even blindness. We recently developed advanced gene therapy approaches to restore vision in a genetic mouse model of a special kind of blindness (achromatopsia).

Another focus of our work is on HCN channels. Our group discovered these ion channels in 1998. HCN channels are activated by membrane hyperpolarization (H) and cyclic nucleotides (CN) and play a crucial role in controlling basic excitability and rhythmic firing of neurons. HCN channels are also involved in other neuronal functions including memory formation, sleep control and dendritic integration. Dysfunction of HCN channels has been associated with epilepsy, ataxia and other neurological diseases. As for CNG channels, we examine the role of HCN channel on the molecular and systemic level using biophysical tools and genetic mouse models.

The third group of ion channels we are studying are calcium channels. Recently our laboratory discovered a novel class of calcium channels (TPCNs, "two-pore channels") that are strictly localized in lysosomes which represent the smallest organelles of cells. We found that TPCNs are specifically activated by the novel second messenger NAADP (nicotinic acid adenine dinucleotide phosphate). Our long-term goal is to achieve a complete understanding of the specific physiological roles of TPCNs. To this end we are developing a variety of tools (including planar patch-clamp approaches) to characterize TPCNs in native lysosomes.
Structural correlates of synaptic plasticity

The department is investigating the fundamental principles of synaptic plasticity at a number of different levels, ranging from molecular approaches to studies of the intact nervous system. Recent results from the lab have shown that synaptic plasticity is accompanied by structural changes of dendritic spines, they have demonstrated the importance of neurotrophins in synaptic plasticity, and they have revealed the detailed structure of functional maps in the visual cortex.

Advanced Professional Degrees
- Professor
- Director at the Max-Planck-Institute of Neurobiology

Awards and Professional Affiliations
- Member of the German Academy of Sciences Leopoldina
- Ernst-Jung Prize for Medicine
- Associate, Neuroscience Research Program (NRP), The Neurosciences Institute, San Diego, USA

Publications

Lab members
- Cvetalina Coneva, Driz Gökce, Susanne Gallner, Rosa Garcia Verdugo, Mark Hübener, Claudia Huber, Julian Jortner, Georg Kohle, Marcus Knopp, Arne Krift, Marcus Limenander, Sabine Lützher, Daniel Meyer, Piaas Mühler, Tobias Rose, Alexander Ferrao Santos, Volker Scheuss, Arne Schlimmer, Max Sperling, Volker Stasper, Frank Voss, Corinna Warneke, Pawel Zmarz

Contact information on page 120
Motion processing in the fly visual system

Our department is interested in how motion information from the changing retinal images is computed in the fly visual system and how this information is decoded for flight control. In general, this processing is done in two steps: In the first step, local motion vectors are calculated from local changes in retinal brightness. This calculation is done according to the Reichardt model of local motion detection, most likely in the fly’s medulla. From the resulting vector fields (the ‘neural optic flow’), important course control parameters are extracted in a second step. This is realized in the fly visual system at the level of the lobula plate. Here, tangential cells integrate, by their large dendrites, the output signals of retinotopically arranged local motion-sensitive neurons and, in addition, interact amongst each other. Postsynaptic to these tangential cells, descending neurons become further selective for specific optic flow fields and transmit this information to the neck motor neurons or, via the cervical connective, to motor centers for legs and wings in the thorax.

Our work combines experimental and theoretical analyses ranging from visual responses, membrane properties and pharmacology of individual neurons up to network responses to natural image sequences created by the fly’s own flight maneuvers. Our experimental animals are the blow fly Calliphora vicina (‘BigFly’) and the fruitfly Drosophila melanogaster (‘LittleFly’). While the first species allows for intracellular and optical recording from individual neurons, the latter provides in addition a wealth of genetic techniques including tissue specific expression of genetically encoded indicators and blockers of nervous activity. In collaboration with Winfried Denk (MPI for Medical Research, Heidelberg), we also try to fully reconstruct important parts of the optic lobes of both species at the ultrastructural level using his recently developed Serial Block Face Scanning Electron Microscope (‘BlueFly’). Biophysically realistic compartmental models of individual neurons obtained from 2P-image stacks allow us to reconstitute the network of motion processing neurons in computer simulations (‘ModelFly’). As a joint project with Martin Buss and Kolja Kuehnlenz (TUM, Munich, sponsored by the BMBF within the excellence cluster CoTeSys), our knowledge about the fly motion vision system goes into the development of miniature airborne vehicles (‘RoboFly’).
Humanoid robotics and neuroscience: science, engineering and society

Our research interests fall in line with the notion of “Understanding through Creating”, three essential aspects motivate our approach in the area of Humanoid Robotics and Neuroscience: Science, Engineering and Society:

In Engineering – Engineers can gain a great deal of understanding through the studies of biological systems, which can provide guiding principles for developing sophisticated and robust artificial systems.

Scientifically – Building of a human-like machine and the reproduction of human-like behaviours can in turn teach us more about how humans deal with the world, and the plausible mechanisms involved.

For society – In turn we will gain genuine knowledge toward the development of systems that can better serve our society.

Advanced Professional Degrees:
2001  Ph.D. (Systems Engineering), The Australian National University, Australia
1993  Master of Computer Science, University of Wollongong, Australia
1991  Bachelor of Computer Science, University of Wollongong, Australia

Awards and Professional Affiliations:
• IEEE Gennai Medal (2007)
• Center of Excellence (CEO) Fellow (2000)
• Japan Science and Technology Agency (JST) Fellow (1998)

Publications:

Lab members:
Takaaki Kuratate, Samer Alfayad, Andreas Holzbach, Brennand Pierce, Marcus Riey, David Latchner, Philipp Mitterdörffer, John Naveer, Erhard Weiser, Rong Li
The research in our laboratory studies the interplay between mechanisms related to visual perception and mechanisms related to the generation of simple actions such as eye movements, manual reaching, and grasping.

On the one hand, we are interested in precisely how visual information is processed in order to finally allow for a goal-directed movement – in other words, how the visual input projected on the retina is ultimately transformed into an appropriate motor response such as an accurate saccade. On the other hand, our research (along with recent findings from other laboratories) has indicated that the way how visual information is processed depends strongly on the actually planned motor action – that is, what we “see” at each moment in time depends on which actions we currently plan to perform.

One striking example for such a strong relationship between perception and action relates to the role of spatial attention and movement preparation. In a series of recent studies we demonstrated that before the execution of movements such as sequential reaching movements, bimanual movements, and manual grasps, all those regions and objects in the visual field are selectively processed that are relevant for the planned action. This results in an “attentional landscape” that closely reflects the requirements of the motor task (Baldauf & Deubel, 2010).

The world is perceived as stable, despite the notorious shifts of the retinal image due to continuous eye and body movements (e.g., Rolfs et al., 2011). Methods used in our research include various psychophysical procedures, eye and hand tracking, EEG, and transcranial magnetic stimulation (TMS).

Advanced Professional Degrees
- 2005 Professor (apl), Department of Psychology, LMU
- 2007 Academic Director, Department of Psychology, LMU

Publications

Lab members
Donatas Jonikaitis, Rene Gröster, Saurabh Dhawan, Anna Klapetek, Giulia Manca

Prof. Dr. Heiner Deubel
Experimental Psychology, Department of Psychology
http://www.paed.uni-muenchen.de/~deubel/

Contact information on page 120
Most of our current knowledge of multisensory vestibular brain structures and their functions in humans derive from brain activation studies with PET and fMRI conducted over the past decade [review: Dieterich & Brandt 2008]. The patterns of activations and deactivations during caloric and galvanic vestibular stimulations in healthy subjects have been compared with those in patients with acute and chronic peripheral and central vestibular disorders. These findings have provided a better insight into the complex cortical interactions between the vestibular system and other sensory systems. Among the most notable findings, it was shown that the central vestibular system exhibits a spontaneous visual-vestibular activation-deactivation pattern in patients with an acute peripheral vestibular disorder (such as vestibular neuritis). This pathological pattern was similar to that described in healthy volunteers during unilateral vestibular stimulation. In the acute stage of vestibular neuritis, the regional cerebral metabolic rate glucose (rCMRglc) increases in the multisensory vestibular cortical and subcortical areas, while decreasing in the visual and somatosensory cortex areas [Bense et al., 2004]. Although we can now begin to attribute particular patterns of cerebral activation and deactivation to the particular functional deficits in distinct peripheral vestibular disorders, the complex puzzle of the various multisensory and sensorimotor functions of the phylogenetically ancient vestibular system is still imperfectly understood. The current project will concentrate on the differential effects of acute ischemic cortical lesions with vestibular signs on multi-modal sensory interactions. Particular emphasis will be placed on functional imaging studies of visual-vestibular interactions e.g., in patients with lesions within the peripheral or central vestibular system, the visual and somatosensory systems.

References:

Publications

Lab members
Iva Stefanova, Sandra Bense, Caroline Cyran, Regina Feuerecker, Thomas Stephan, Rainer Böegle, Matthias Bügle.
Sensory processing in the olfactory bulb

While odours appear to be rather simple sensory stimuli, it is, as of yet, unknown how the olfactory code operates: how is an olfactory image synthesized from the structural groups of the odour molecule that are recognized by the odorant receptors? Our lab is interested in the microcircuitry of the olfactory bulb that processes olfactory sensory information, in particular the role of granule cells. Granule cells are axonless local inhibitory interneurons that represent the largest fraction of the neuronal population of the olfactory bulb and interact exclusively with mitral and tufted cells via dendrodendritic reciprocal synapses.

Methods:
- We use two photon laser scan microscopy in conjunction with whole-cell patch clamp recordings from individual neurons in acute brain slices to study calcium signals and correlated electrical activity in response to sensory-like input from mitral cells. These techniques allow us to optically detect synaptic activity at the level of individual synapses, that are located in large granule cell spines. To be able to investigate release from the reciprocal synapse, we are currently establishing two-photon uncaging of glutamate.

Our lab is interested in the microcircuity of the olfactory bulb that processes olfactory sensory information, in particular the role of granule cells. Granule cells are axonless local inhibitory interneurons that represent the largest fraction of the neuronal population of the olfactory bulb and interact exclusively with mitral and tufted cells via dendrodendritic reciprocal synapses.

Main current projects:
- Reciprocal action between granule cells and mitral cells: Role of TRPC channels
- Long-term plasticity at the mitral cell – granule cell synapse
- Role of newborn interneurons
- Conditions for release from the granule cell spine
Sounds arriving at the ear contain only information about intensity and frequency, yet our auditory system enables us to build an auditory environment that contains features from detected sound source localizations up to complex speech recognition.

To achieve such a representation of auditory space our auditory system is specialized in extracting all possible features of incoming sounds and computing their correlations for example between left and right ear. These computational features dominate the information processing in subcortical circuits starting already in the cochlear and continue throughout the auditory brainstem circuits up to the midbrain. To achieve such computational tasks, neurons that form auditory brainstem circuits have specialized in many ways. To quantitatively understand these morphological and functional specializations will be key to understand how these circuits process sound information.

Our focus is hereby on cellular specializations that allow for the exquisite temporal precision that is maintained even at high firing rates of many neurons in the auditory brainstem. Common features of these neurons are for example a very low input resistance to increase the speed of postsynaptic integration or the presence of large synapses that allow synaptic information transfer with little temporal jitter. Using in vitro patch-clamp recordings combined with imaging and light activation techniques we aim to quantitatively understand the strength and time course of synaptic transmission and of postsynaptic integration mechanisms shaped by voltage gated ion channels in auditory brainstem circuits.
Assessment and modification of attentional functions and dysfunctions

Visual attention enables us to select a limited amount of relevant objects from our environment in order to effectively control behaviour. In our research group, we assess attention by psychophysical experiments, which are analyzed using a mathematically formalized theory. We describe the attentional functions of a given participant by independent, quantifiable parameters: the speed of visual information uptake and the capacity of visual short-term memory are relevant for fast and parallel uptake of information in a given instant. Selection parameters describe how effectively we can filter specific information on the basis of e.g. colour or location and ignore other, irrelevant information.

Some of these functions are prone to changes across the lifespan. One line of our research focuses on the characterisation of the relative decline of some attentional functions and the relative stability of others in healthy elderly (such as the participant shown in the picture). Having established “normal” attentional parameters, we can use these sensitive parameters for the identification of impairments induced by pathological neural processes. We have shown e.g. a systematic decline of attention in early Alzheimer’s disease and even in Mild Cognitive Impairment, a high-risk stage for the development of this disease. Furthermore, we showed that attentional parameters differentiate normal participants from patients with attention-deficit-hyperactivity disorder (ADHD). In these groups of interest, we also analyse how the attentional parameters and their changes are related to genetics and to underlying brain structures and activity patterns.

We have identified correlations to genetic abnormalities and to metabolic activity (Positron Emission Tomography, PET) in neurodegenerative diseases. Similarly, in ADHD patients, we aim at characterizing their attentional deficits and identifying anatomical deviations in critical brain regions by magnetic resonance imaging (MRI). Using electroencephalography (EEG), we look for specific electrophysiological correlates which reflect the different attentional parameters and EEG-biomarkers of age-related changes. Recently, we have started to assess whether and how the attentional parameters might be modifiable by changes of the general arousal state of the brain, using e.g. neuropharmacological and electrical stimulation. The aim is to analyze the degree of cognitive plasticity of these attentional functions in healthy and disordered brain systems.
Mechanisms of vocal learning and its sex-specific implementation

In most bird species, male singing behavior functions for direct or indirect competition for females, and female mate choice involve vocal performances of the males. In songbirds, songs consist of genetically determined and learned components. Further, learning is changing female preferences for male songs. Thus, learning is crucial for both, the production of sexual signals and the response to sexual signals, i.e. learning is central for vocalization-based sexual selection in songbirds. The acquisition of auditory memories, the transformation of auditory memories into, and the use of motor memories is influenced by the physiological conditions and/or the socio-sexual experience of an individual. This suggests that vocalization-based sexual selection in songbirds is anchored on the life-history of males and females.

In order to produce learned sounds, birds need a "songbird" genetic background and sex steroids (androgens and estrogens) to develop the neural vocal control system into a male or female configuration, which differs between species. Song production in adulthood is sensitive to sex steroid hormones (androgens and estrogens) and other endocrine systems (e.g. melatonin) that signal environmental changes (ecological and socio-sexual) to the vocal control.

The anatomical and functional distinctness of the vocal system of songbirds as well as the large data base on natural behavior of songbirds makes the vocal system very attractive to study the genetic and environmental causes of neural sex differences and its consequences for sexual behavior (sex specific functions). The projects are multidisciplinary and integrate works on the level of behavior, of endocrinology, of neuroanatomy, of gene-expression, and of electrophysiology in constrained, semi-natural, and natural conditions.

Projects:
• The molecular mechanisms that determine the differentiation of the song control system
• Sex hormones and cellular mechanisms of song learning
• Hormone-dependent development and importance of gender-specific brain structures
• Electrophysiological studies of hormone dependent song learning and production
• Song development under semi-natural conditions
• Evolutionary and environmental physiology

Advanced Professional Degrees
• Director at Max Planck Institute for Ornithology

Awards and Professional Affiliations
• Scientific member of the Max Planck Society

Publications

Lab members
Andries ter Maat, Falk Dittrich, Caroline Franki-Vilches, Wolfgang Geymann, Gabriel Beckers, Moritz Hertel, Albertine Lietas, Vincent van Mar

Prof. Dr. Manfred Gaier
http://www.orn.mpg.de/2525/Abteilung_Gaier
Contact information on page 121
Neurogenesis in the developing and adult brain; neuronal repair after brain injury

Our research aims to elucidate the key mechanisms of neurogenesis in the developing and adult brain. In contrast to organs such as the skin, the small intestine or the hematopoietic system, most cells in the adult mammalian nervous system are permanently postmitotic, such as the neurons and the oligodendrocytes, and are not turned over nor regenerated once they die. Neurogenesis persists only in very few regions of the adult mammalian forebrain, and neurons degenerated after acute or chronic injury are not replaced in the adult mammalian brain. To overcome this, we study neurogenesis when and where it works with the aim to re-activate these mechanisms and re-instruct neurogenesis after brain injury.

Our key questions are:

• What are the intrinsic determinants of neurogenesis and how can they be re-activated again in the adult brain to reconstitute neurons in adult brains?
• What are the intrinsic and extrinsic differences between radial glial cells endowed with stem cell properties and the majority of ependymal cells and astroglial cells, the closest relatives of radial glia, in the remainder of the brain?
• Why do most astrocytes in the adult mammalian brain fail to generate neurons after injury in vivo?
• What are the key mechanisms specifying neuronal subtypes?

We tackle these questions at three levels: during development, at early postnatal stages when neurogenesis comes to an end and gliogenesis peaks in the mammalian forebrain, and in the adult brain, where neurogenesis is restricted to two specific regions, the subependymal zone of the lateral ventricle and the dentate gyrus of the hippocampus. In order to better understand the physiology after injury and the mechanisms of neurogenesis, we implement a broad range of genetic, genomic, cell biological, molecular and physiological techniques.

Advanced Professional Degrees
2001 Habilitation in Zoology
2004 Director Institute of Stem Cell Research
2004 Full Professor for Physiological Genomics

Awards and Professional Affiliations
• Gottfried Wilhelm Leibniz Award 2007
• Longlistee Memma 2008
• Bisser Prize 2008

Publications

Lab members
Becker-Merendino, Cappello, Dimou, Fichter, Gascon, Haupt, Heinrich, Johannas, Nikovic, Silbo, Barone, Barbeito, Berendt, Deshpande, Lerch, Manero, Petrica, Petrinec, Pilz, Simon, Skaal, Wolker

Ludwig-Maximilians-Universität München and Helmholtz Center Munich

Prof. Dr. Magdalena Götz
LMU – Physiological Genomics
Helmholtz Center Munich, Institute Stem Cell Research
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http://www.helmholtz-muenchen.de/en/isf/members/index.html
Contact information on page 121

Our research aims to elucidate the key mechanisms of neurogenesis in the developing and adult brain. In contrast to organs such as the skin, the small intestine or the hematopoietic system, most cells in the adult mammalian nervous system are permanently postmitotic, such as the neurons and the oligodendrocytes, and are not turned over nor regenerated once they die. Neurogenesis persists only in very few regions of the adult mammalian forebrain, and neurons degenerated after acute or chronic injury are not replaced in the adult mammalian brain. To overcome this, we study neurogenesis when and where it works with the aim to re-activate these mechanisms and re-instruct neurogenesis after brain injury.

Our key questions are:

• What are the intrinsic determinants of neurogenesis and how can they be re-activated again in the adult brain to reconstitute neurons in adult brains?
• What are the intrinsic and extrinsic differences between radial glial cells endowed with stem cell properties and the majority of ependymal cells and astroglial cells, the closest relatives of radial glia, in the remainder of the brain?
• Why do most astrocytes in the adult mammalian brain fail to generate neurons after injury in vivo?
• What are the key mechanisms specifying neuronal subtypes?

We tackle these questions at three levels: during development, at early postnatal stages when neurogenesis comes to an end and gliogenesis peaks in the mammalian forebrain, and in the adult brain, where neurogenesis is restricted to two specific regions, the subependymal zone of the lateral ventricle and the dentate gyrus of the hippocampus. In order to better understand the physiology after injury and the mechanisms of neurogenesis, we implement a broad range of genetic, genomic, cell biological, molecular and physiological techniques.
One of the greatest challenges in neuroscience has been to monitor activity and biochemistry in populations of identified neurons in vivo and to relate their activity patterns to behavior. Previous work on new microscopy techniques has moved the field considerably further in that direction. In particular the combination of modern imaging technology and genetic labeling methods heralds a bright future for neuronal circuit analysis. Our work complements these efforts on the “indicator side” by providing probes for key events crucial for an understanding of neuronal function and plasticity and aims at overcoming long-standing limitations in the ability to monitor neuronal activity and biochemistry in intact tissues.

The fluorophore we use is the Green Fluorescent Protein (GFP) and its related variants from other organisms. Our preferred approach is the design and engineering of genetically encoded biosensors, from the cuvette via imaging of single cells in culture to the generation of whole transgenic indicator organisms which harbor the biosensor of choice in the cells and tissues that one wishes to study. This opens up new avenues for the study of structure-function relationships of intact neuronal circuits.
Auditory neurons concerned with temporal processing are the most precise time analyzing units in the mammalian brain. Some auditory neurons exhibit time resolutions of only a few µs. We are interested in the neuronal mechanisms of temporal auditory processing and their evolution in mammals. In particular, our studies are concerned with the role of neural inhibition in temporal processing. Inhibition has been more or less neglected as a possible player in neuronal filtering of temporal cues. However, recent results from several groups indicate a link of age-related hearing deficits in temporal processing, age-related down-regulation of the inhibitory transmitters GABA and glycine, and the role of inhibition in temporal filtering as found in the bat and gerbil auditory brainstem. The analysis of temporal cues of sounds is important for the two basic tasks of sound localization and sound recognition.

Auditory Processing Structure and Function of Neuronal Circuits Spatial Orientation

Approaches and Techniques
We use a comparative approach investigating animals living in different ‘auditory worlds’ (high frequency specialists like bats; models for ancient mammalian hearing like short tailed opossums; low frequency specialists like gerbils; mice and rats as “standard” models for hearing in modern placental mammals. Additionally, we are using transgenic mice to study developmental mechanisms.

 Approaches include
• extracellular recording single unit techniques in vivo combined with acoustic stimulation (binaural and free-field)
• manipulation of early auditory experience (combined with anatomical and/or physiological investigations)
• multi-electrode recordings
• patch-clamp recording techniques in vitro (acute brain slices and in vivo)
• immunohistochemistry (confocal microscopy)
• classical anatomical techniques (e.g. tracing studies)
• transgenic mouse collaboration with Wolfgang Wurst, HelmholtzZentrum München
• modeling of spatial and temporal auditory processing
• human and animal psychoacoustics
• behavioral approaches

Advanced Professional Degrees
1996 Dr. rer. nat. habil (LMU)
1991 Dr. rer. nat. (LMU Munich)
1988 Diploma in Biology (LMU Munich)

Awards and Professional Affiliations
• Chair of Neurobiology (LMU Munich) since 2003
• Head of Graduate School of Systemic Neurosciences (LMU Munich) since 2007
• Dean, Faculty of Biology (LMU Munich) 2009-2011

Publications

Lab members
Felix Feing, Todd Jennings, Alexander Kaiser, Lai Kunz, Ursula Koch, Mike Myoga, Michael Pecka, Susanne Ruder-Schneider, Ida Svave, Lutz Wegener, Mario Wullimann

Prof. Dr. Benedikt Grothe
Division of Neurobiology, Department Biology II
http://neuro.bio.lmu.de/
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Ludwig-Maximilians-Universität München

Advanced Professional Degrees
1996 Dr. rer. nat. habil (LMU)
1991 Dr. rer. nat. (LMU Munich)
1988 Diploma in Biology (LMU Munich)

Awards and Professional Affiliations
• Chair of Neurobiology (LMU Munich) since 2003
• Head of Graduate School of Systemic Neurosciences (LMU Munich) since 2007
• Dean, Faculty of Biology (LMU Munich) 2009-2011

Publications

Lab members
Felix Feing, Todd Jennings, Alexander Kaiser, Lai Kunz, Ursula Koch, Mike Myoga, Michael Pecka, Susanne Ruder-Schneider, Ida Svave, Lutz Wegener, Mario Wullimann

Prof. Dr. Benedikt Grothe
Division of Neurobiology, Department Biology II
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Ludwig-Maximilians-Universität München
Cellular mechanisms of neurodegeneration

In my laboratory we focus on the generation of Alzheimer’s disease (AD) Amyloid β-peptide (Aβ), which accumulates during aging in our brains and becomes deposited as insoluble aggregates called amyloid plaques.

Back in 1992 I made the very surprising observation that Aβ is produced constantly throughout life. These observations changed the concept of AD pathogenesis, and it is now clear that AD constitutes a major part of normal aging. Since Aβ has a central role in AD pathology, we investigate the cellular mechanisms behind its generation. Aβ is generated by proteolytic processing involving two types of proteases, β-, and γ-secretase.

Our work on γ-secretase focuses on its identification, function, assembly, and reconstitution. It turned out that γ-secretase cleaves its substrates multiple times within the membrane. Moreover, by identifying the active site motifs of the γ-secretase activity in presenilins, we were able to define a completely novel class of aspartyl proteases of the GxGD type. By using C. elegans and zebrafish as a model system in combination with biochemical and cell biological technologies, we could demonstrate that presenilins are directly involved in the Notch signaling pathway. However, PS alone could not perform proteolysis and we could demonstrate that a complex composed of four different proteins is required to reconstitute γ-secretase activity in yeast. Currently we are investigating the assembly of the γ-secretase complex and the interaction sites of the individual components. In parallel we are studying the function and regulation of β-secretase (BACE1). Here we are specifically interested in regulative mechanisms, which may be responsible for the increased β-secretase activity during aging. First evidence suggests a posttranscriptional mechanism via the 5’ untranslated region of the β-secretase mRNA. The function of β-secretase and its homologues is investigated in zebrafish and mice. We could demonstrate that β-secretase is required for myelination via neuregulin signaling. More recently we also started to investigate the cellular mechanisms of frontotemporal lobar dementia with ubiquitin positive deposits as well as amyotrophic lateral sclerosis. Here we are again interested how genetically inherited mutations in the genes encoding for example TDP-43, FUS and Progranulin cause neurodegeneration.
Computational neuroscience: Cellular biophysics, network dynamics, and neural information processing

The brain is, without any doubt, one of the most complex biological systems. Thoroughly understanding its fascinating dynamics and information processing strategies remains a great challenge. The theory of non-linear dynamics, complex systems, and stochastic processes, together with methods from theoretical biophysics, computer science, and statistical physics offers a broad spectrum of concepts and techniques to answer the question of how living organisms have learnt to solve hard computational problems. Vice versa, we can use the results of these investigations to further our basic understanding of computational problems.

Examples for the two main experimental paradigms: (1) a fly is recorded while it navigates in a simulated environment, and (2) scorpions and bees are exposed to a natural environment. Both paradigms led to major scientific advances and have a large impact on the future development of theoretical biophysics, neuroscience, computer science and various technical application domains. Using grasshopper communication as a model system, we have addressed a wide range of biophysical and neurobiological questions: How do sensory systems integrate information over multiple time scales to solve complex pattern recognition tasks? How are external signals analyzed in real time despite the constant influx of large quantities of new sensory inputs? Is firing rate adaptation a spurious byproduct of neural dynamics or does it serve a computational purpose? How do neural systems handle the dilemma of “insulation versus interaction” inherent to any distributed information processing? Which biophysical mechanisms allow robust computations in an animal whose temperature may fluctuate by more than ten degrees within an experiment? From a conceptual point of view, our approach extends traditional concepts to describe neural response patterns, such as “tuning curve” or “optimal stimulus”, into the information theoretic domain, and introduces concepts well known in physics to neurophysiology, such as the notion of iso-response manifolds in stimulus space.

The cell's inside and outside are separated by a capacitance and ionic conductances in series with batteries describing ionic reversal potentials. IV: Linear-nonlinear cascade. Stimuli $S(t)$ are convolved with a filter and then fed through a nonlinearity to generate responses $R(t)$, typically time-dependent firing rates. V: Black-box model. Neglecting biophysical mechanisms, conditional probabilities $p(R|S)$ describe responses $R$ for given stimuli $S$.

Examples for five levels of single-cell modeling. (Herz et al., Science 314:80-85 (2006))
During development, specific connections among neurons within the visual cortex as well as its in- and outputs are formed, ultimately leading to a functional network enabling fine grain analysis of the visual world. While the basic circuitry is set up early in life, the visual cortex of adult animals displays some degree of plasticity, too. We study the cellular and synaptic mechanisms underlying circuit formation and plasticity in the visual cortex during development and in adult animals. To address these questions at the functional as well as the structural level, we make use of imaging techniques, such as two-photon microscopy and intrinsic signal imaging.

In mouse visual cortex, plasticity can be readily induced by closing one eye for a few days. This intervention, termed monocular deprivation (MD), shifts the balance between the representation of the two eyes in the visual cortex, such that inputs from the deprived eye are weakened, while open eye inputs gain influence. We could recently show that the visual cortex retains a lasting memory of this experience: If an animal undergoes a second episode of MD many weeks later, the shift in eye balance is induced much faster and lasts longer than in naïve mice. Thus, the animal has learned to learn, reminding us of our own experience that exposure to an altered sensory environment, a new sensorimotor task, or a foreign language makes for easier learning of the similar information later in life.

In order to unravel the cellular mechanisms underlying this enhanced plasticity by prior experience, we studied the fine structure of neurons in the visual cortex. Repeated two-photon imaging of neurons expressing green fluorescent protein demonstrated that MD increased the number of dendritic spines, tiny protrusions that correspond to synaptic inputs. We believe that these newly formed synapses mediate the strengthening of open eye inputs seen after MD. Importantly, the added spines did not disappear after reopening of the temporary closed eye, suggesting that they might form a lasting structural trace which mediates the enhanced plasticity seen after a second MD. Indeed, a second closure of the eye did not result in the further addition of spines, despite the fact that the shift in eye representation occurred even faster than in inexperienced mice. These experiments indicate that specific structural modifications serve to store information about past experiences, thereby endowing the cortex with an improved ability to adapt to similar experiences in the future.
Development and function of neural circuits in the olfactory system

The sense of smell allows discrimination of a large number of odorants using precisely wired projections from neurons in the periphery expressing specific olfactory receptors to neurons in higher brain centers that process the information. The ability to recognize a particular odor and to activate the appropriate neurons in the brain is instrumental in driving important behaviors.

We are interested in the genetic program that controls the formation and function of olfactory neuronal circuits. One aim is to identify the genes that specify neuronal identity, link them to the connectivity of a neuron, and ultimately to its integration into functional nervous systems. The neural networks that control olfactory behavior responses and other innate behaviors remain largely unknown in any animal or human. Therefore, another important goal of our research is the identification of neural processing centers and eventually single neurons that underpin different innate behaviors. Ultimately, we aim to understand how neural circuits and genetic programs have changed during evolution to give rise to nervous systems that are perfectly adapted to the specific biological niches of different species.

To this aim, we mainly use the fruitfly Drosophila with its rich, unmatched repertoire of genetic tools and robust innate behaviors. We combine genetics with behavioral testing, state of the art anatomy, in vivo electrophysiology, and imaging.

Different insects feed on different kinds of food, aim at attracting only mating partners of their species, and face very specific dangers in their environment. Therefore, olfactory systems of different insect species were subject to evolutionary pressure and change. The detection of CO2 plays a specific role in the life of many insect species. The malaria vector mosquito is attracted to CO2, and uses it to find human hosts. In contrast, Drosophila melanogaster flies detect CO2 as part of the so-called stress odor, and thus are strongly repelled by it. We are addressing how genes and gene networks have changed to give rise to the olfactory system of different insects. We look at behavioral and structural divergence between species, and by using Drosophila genetics, we aim at finding the responsible genes that were critical for development and evolution of these differences.
Finding their way – Axon guidance in the spinal cord

Our neurons are cells highly specialized in processing and transmitting information. To establish networks of communication, they extend long, fine processes – also called axons – which establish physical contact with their targets, such as other neurons or muscle cells. Finding the correct target is essential for the development of neuronal networks – but how do neurons achieve that? This is not only the founding question of the axon guidance field, but also a major research topic of our group.

We focus on the Eph/ephrin signal transduction pathway, a receptor-ligand system essential for correct guidance of neuronal processes. Ephs and ephrins sit in the plasma membrane of axons and their target cells, respectively. If an axon comes along and contacts a potential target, Ephs bind to ephrins; this initiates a signal transduction cascade, followed by negative, repulsive cellular response: Eph-containing axons turn away from ephrin-expressing cells, and continue searching for another, potentially correct target. Now, what happens if the Eph/ephrin system is not functioning properly? Let’s take a look at the spinal cord, a part of the nervous system we are especially interested in. There, two neuronal circuits control the locomotor, or walking behavior of the mouse, our favorite model system. During development, these two circuits are kept separate by the Eph/ephrin system, so they can finally function independently from each other and control the movement of the left and right hindleg, respectively. This is why a healthy mouse walks by moving its hindlegs in an alternate manner: First the left hindleg, then the right, then again the left, and so on. However, if the Eph/ephrin system is not functioning properly, these circuits contact each other by mistake, and lose their autonomy. Can you guess what this means for the walking behavior of the mouse? Indeed, an Eph or ephrin deficient animal moves both hindlegs in a synchronous manner, thereby hopping like a little rabbit. This is a beautiful example for the fundamental role the Eph/ephrin signaling system plays during development of neuronal networks.
Cellular and molecular mechanisms of cortical circuit function

We use in vivo two-photon calcium imaging in different areas of the mouse cortex (visual, auditory, sensory-motor) combined with targeted patch-clamp recordings and optogenetics to study electrical signaling and plasticity of specific types of neurons in behaviorally-defined conditions. Molecular mechanisms of cortical circuit function are determined by analyzing various genetically-modified mouse lines.

Cerebellar function and plasticity

We are interested in synaptic mechanisms, including the roles of mGlu receptors, TRPC channels, calcium signaling as well as in cerebellar sensory integration. We use various mutant mouse lines, in which specific types of cerebellar neurons (e.g., Purkinje cells) are genetically modified.

Dendritic signaling and integration in vivo

Our major aim is the visualization and mapping of sensory-evoked signals on the level of individual synaptic inputs in defined neurons of the mouse cortex. We investigate the dendritic mechanisms that determine the neurons’ output signals.

Development of imaging technology

We develop and implement two-photon imaging devices with a high spatial and temporal resolution for the functional analysis of networks, cells and subcellular compartments in vitro and in vivo. Recent developments include the implementation of a new two-photon imaging variant, named LOTOS (low power temporal oversampling), that is highly sensitive and minimizes phototoxic damage, allowing functional imaging of individual spines in vivo.
Models of learning and memory in recurrent neuronal networks

Recurrent neuronal networks are thought to serve as a physical basis for learning and memory. For example, the recurrent networks in the hippocampus exhibit the replay of stored sequences of previously experienced events. This replay is accompanied with field potential–phenomenon of sharp wave–ripple complexes. We study the mechanistic basis of this phenomenon on the cellular and population level. This includes the development of data analysis methods for electro-physiological recordings and for local connectivity measurements in brain slices. We also develop a behavioral virtual reality setup for rodents that allows recordings of memory-related brain activity in vivo. The goal of the research group is to use dynamical, structural, and functional constraints to build computational models of recurrent networks and in particular to gain understanding of the computations that are performed by the recurrent connections.

Current projects include:
- Analysis of postsynaptic currents in an in-vitro model of sharp wave ripples and their relation to models of replay and preplay of hippocampal memory sequences;
- Modelling readout of spatial representations in the hippocampal formation;
- Formation of grid fields in the entorhinal cortex;
- Assessment of the computational performance of recurrent networks.

Ludwig-Maximilians-Universität München
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Contact information on page 123

Advanced Professional Degrees
- Dr. rer. nat. (theoretical physics, TU Munich)
- Diploma in Physics (TU Munich)

Awards and Professional Affiliations
- Editor-in-Chief: Network: Computation in Neural Systems
- Coordinator: Bernstein Focus Neural Basis of Learning

Publications

Lab members
- Simon Lehnert, Li Liu, Hannes Lüling, Axel Kammerner, Sven Schörnich, Akaroa Tejero Cantero, Kay Thurley, Chun-Wei Yuan
"Mathematical philosophy" means the application of logical and mathematical methods to various questions and problems in philosophy and cognitive science. Amongst others, I use such methods in order to shed new light on
• formal theories of truth that avoid notorious semantical paradoxes
• the logic, semantics, and pragmatics of conditionals (if-then statements)
• the representation of logical inference with conditionals in artificial neural networks
• formal systems of inductive logic, belief revision, and metacognition
• justifications for the probability calculus
• structuralist foundations of mathematics.
Mechanisms of attention in perception, cognition, and action

From the vast amount of information reaching the senses at any point in time, only a small fraction becomes available for conscious report and the control of voluntary actions. Attention refers to a set of principles and mechanisms that realize this function of perceptual 'selection' in the pursuit of behavioral goals. One principle is that attention biases processing by enhancing representations that are goal-relevant, and/or suppressing representations that are irrelevant. Attention may be biased either by stimuli encountered in the environment or by our action intentions. Intentional, or 'top-down' control relies on a set of executive functions that coordinate perceptual with action systems in what is referred to as 'task set'.

Over the years, my group has made major contributions to this field. Regarding perceptual selection, we have contributed to elucidate the principles governing selection as space-, object-, and feature -based. One highlight of this work has been the clarification of the links between spatial selection and the planning of sequential motor actions, e.g., target-directed hand and eye movements. Another highlight is the theory of 'dimension weighting', which describes how encountering particular perceptual events (e.g., a particular target in a visual scene) biases the perceptual system to 'expect' similar events in the next instant of time, leading to facilitated processing of similar events or compromised processing of changed events. We have shown that these biases operate at early, preattentive levels of visuo-cortical processing (though they are top-down modulable), but influence also post-selective levels of attentional stimulus analysis and translation of stimuli into choice responses. Further, we have shown that the weight sets for performing particular tasks are buffered across task switches, and that the sets are task-component specific, i.e., separate sets sharing the same components share the same weight sets. On this basis, we have proposed a multiple-weighting-systems framework, with independent weight systems operating at all levels of the cognitive hierarchy. We have shown how the weighting principle operates at the behavioral and brain levels, and we have started to develop computational accounts of its operation. One further highlight has been our work on the simultaneous performance of dual or, more generally, multiple tasks, the limitations in multi-tasking, and the executive-coordinative processes that may be optimized as a result of multi-tasking practice.

Prof. Dr. Hermann J. Müller
General & Experimental Psychology / Neuro-cognitive Psychology, LMU
http://www.psy.lmu.de/exp/index.html
Contact information on page 123

Advanced Professional Degrees
• Ph.D., Dipl. Psych.

Awards and Professional Affiliations
• Wilhelm Wundt Prize 2010 of the Wilhelm Wundt Society, awarded "for excellent achievements in fundamental psychological research" (2010)
• Member of the CAS/LMU Center for Advanced Studies (2007 –)
• LIE venium Award for Excellence in Psychology (2007 –)
• Elected "DFG-Exzellenzprofessor" (DFG Special Reviewer) for experimental and physiological psychology (1999 – 2003)

Lab members
Markus Conci, Heiner Deubel, Kathrin Freile, Thomas Geyer, Dragom Ranjelovic, Torsten Schlaer, Zhanghui Shi, Paul Taylor, Thomas Töller, Agnieszka Wyłomuska, Michael Zehetleitner, etc.
Rational Choice Theory
What role do reasons play in decision making and which is the importance of rational choice theory for practical philosophy in general?

Metaethics
Can we conceive of a metaethical realism without controversial ontological implications?

Ethics
Research interests in animal, environmental and bioethics as well as the ethics of science and risk-management.

Political Theory and Philosophy
What are the normative assumptions of democracy and the modern theory of political authority?

Anthropological Implications of the Lifesciences
Can reasons be naturalized and is there such thing as free will?
Epilepsy represents one of the most common chronic neurological disorders. Pharmacological treatment concepts are currently limited to symptomatic approaches with suppression of seizure activity by chronic administration of antiepileptic drugs. Unfortunately, multidrug resistance remains a major problem in clinical epileptology with more than thirty percent of patients not adequately responding to pharmacotherapy.

Research of the group aims to identify mechanisms of drug resistance. In this context, recent experimental data substantiated the ‘transporter hypothesis’ indicating enhanced active efflux of several antiepileptic drugs at the blood-brain barrier. Currently, we develop innovative therapeutic approaches to overcome transporter-associated drug resistance. These approaches are validated using in vitro and in vivo testing procedures including chronic rodent models with selection of drug-resistant animals. Translational development is based on functional studies using patient tissue dissected during epilepsy surgery. In collaboration with positron emission tomography experts imaging tools are developed for the prediction of drug sensitivity in patients rendering guidance for personalized therapeutic concepts. Considering that transporter-associated drug resistance seems to play a role in various central nervous system diseases the imaging tools as well as the novel therapeutic approaches are of interest for different neurological conditions.

Another focus of the group is the prevention of symptomatic epilepsies which can occur following brain insults such as traumatic brain injury, hypoxia, ischemia, tumors or infection. Mechanisms of epilepsy development (epileptogenesis) are elucidated in chronic rodent models. Preventive approaches target neuronal plasticity, neuronal cell loss, inflammatory reactions and blood-brain barrier alterations. For instance we currently assess the potential of novel peptide mimetics which mimic selected effects of complex ‘parent’ molecules such as erythropoietin, adhesion molecules, or neurotrophic factors. In collaboration we analyze whether targeting of the endocannabinoid system can interfere with the development of a hyperexcitable epileptic network. Considering that psychiatric comorbidities and cognitive impairment might increase the burden in a subgroup of epilepsy patients, it is also tested whether respective approaches interfere with the development of behavioral alterations and cognitive deficits in experimental models.
Multi-Modal Human-Machine Interaction

The research activities of Gerhard Rigoll are in the area of multi-modal human-machine communication, covering areas such as speech and handwriting recognition, gesture recognition, face detection & identification, action & emotion recognition and interactive computer graphics.

The most important scientific basis for these activities is the area of pattern recognition, where a signal that shall be recognized (e.g. a speech signal or a handwritten letter) is first transformed into a suitable feature representation using methods from signal processing and then classified to one of a large variety of possible classes (e.g. words or letters in speech or handwriting recognition) by methods from statistical pattern recognition. In most cases, the classifier parameters are automatically trained from collected samples with machine learning techniques, such as e.g. Neural Networks, Hidden Markov Models or Probabilistic Graphical Models. Statistical machine learning techniques are also mostly used for the fusion of different modalities. A popular example for information fusion is the combination of speech and gestures for interaction in smart environments, such as e.g. intelligent houses or smart meeting rooms. In this case, the user might control a device such as a TV by voice commands and typical hand gestures, for instance to point to one of several devices while speaking a command to switch a TV channel. In this case, the acoustic modality is augmented by the visual communication channel and the problem is to fuse the combined information coming from both channels. These information streams will be asynchronous in time, since hand gestures will be most likely performed not exactly at the starting or ending points of voice commands.

Learning the asynchronous relation between the streams and resolving the semantic meaning resulting from decoding both streams simultaneously is typically a very complex problem in machine learning. Other typical application scenarios for this recognition and fusion problem can be e.g. found in human-driver dialogues for infotainment applications in the car or interaction of a user within virtual environments.

Advanced Professional Degrees
2002 – present Professor (C4) for Human-Machine Communication, TUM
1993 – 2002 Professor (C4) of Technical Informatics, Uni Duisburg

Awards and Professional Affiliations
• Member of the Overview Editorial Board of the IEEE Signal Processing Society since 2009
• Heisenberg-Stipendium, DFG (1993)

Publications

Technical University Munich
Prof. Dr. Gerhard Rigoll
TUM, Institute for Human-Machine Communication
www.mmk.ei.tum.de
Contact information on page 124
Functional organization and plasticity of sensory-motor transformation for gaze and posture control

All vertebrates, whether running, swimming or flying, are confronted with the effects of their locomotor actions on the ability to perceive their surrounding environment. Potential consequences of self-generated body motion include head movements that cause retinal image displacements with a resultant degradation of visual information processing. In order to maintain visual acuity during locomotion, retinal image drift must be counteracted by dynamic compensatory eye and/or head-adjustments that derive from vestibulo-ocular, optokinetic and proprioceptive reflexes. In addition, efference copies of rhythmic neural signals produced by locomotor CPG circuitry within the spinal cord of larval Xenopus are conveyed to the brainstem extraocular motor nuclei and potentially contribute to gaze stabilization during locomotion.

The use of inherent feed-forward and sensory feedback signals to counteract the visual consequences of self-motion has major implications for understanding gaze control in general. Our central project concerns the interaction and developmental plasticity of CPG-derived intrinsic signals and visuo-vestibular sensory feedback in the amphibian model Xenopus laevis. This requires understanding of how individual network components are ontogenetically assembled and how spatial and dynamic specificity is established. The delayed developmental onset of semicircular canal-evoked vestibulo-ocular reflexes compared to otolith-evoked responses renders differentiation between tilt and translational acceleration impossible and opens the question of how an appropriate intrinsic reference frame for body-motion in space is centrally formed. The transition from larval to adult frogs involves a drastic restructuring of central circuitry that correlates with the switch from an undulatory swimming to tadpole's a limb-based propulsion in adult frogs along with corresponding changes in gaze-stabilizing eye movements. This raises general neurobiological questions on adaptive plasticity of cellular properties and network connectivity. These questions are studied by a variety of morpho-physiological approaches that mostly employ isolated, semi-intact brain preparations with intact sensory organs and motor components of Xenopus laevis. Intracellular and extracellular recordings, Calcium imaging together with morphological reconstructions allow determining the functional organization and plasticity of sensory-motor circuit formation and reconfiguration during ontogeny.

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When the world goes round: diagnosis and treatment of vertigo, eye movement disorders and nystagmus

Pharmacotherapy of vertigo, dizziness, ocular motor disorders and nystagmus

One of my major interests is developing and evaluating new therapeutic principles. We are, therefore, currently performing prospective randomized trials a) on the treatment of Menière’s disease with high dosages of betahistine, b) on how to improve central vestibular compensation in acute vestibular neuritis, and c) on central disorders such as vestibular migraine, downbeat nystagmus, episodic ataxia type 2 and cerebellar gait disorders.

Role of viral infections in acute unilateral vestibular failure

There is some evidence that vestibular neuritis is caused by the reactivation of a latent herpes simplex virus 1 infection. The underlying pathophysiology and mechanisms leading to the damage are not clear and are therefore evaluated by virological techniques.

Interaction between the vestibular system and the hippocampus

We demonstrated an atrophy of the hippocampus and impaired spatial navigation and memory in patients with a bilateral loss of vestibular function. The cause and the consequences are now further evaluated by multimodal imaging techniques.

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Advanced Professional Degrees
1988 MD, RWTH Aachen
2003 Professor of Neurology and Clinical Neurophysiology, LMU Munich

Awards and Professional Affiliations
2003 Robert-Wartenberg Lecture and Award
2005 Hans-Jörg-Weitbrecht Award for clinical neuroscience
2010 Award of the German Neurological Society, belonging to the five best teachers of the last five years of the Academy

Publications

Lab members
Roger Kalla, Jens Claassen, Katharina Hüfner, Olympia Kremmyda, Roman Schnepp, Caroline Fischer, Stefan Teufel, Katharina Feil, Oliver Bayer

When the world goes round: diagnosis and treatment of vertigo, eye movement disorders and nystagmus
Optochemical Genetics

Transmembrane receptors allow a cell to communicate with its environment in response to a variety of input signals. These can be changes in the concentration of ligands (e.g., hormones or neurotransmitters), temperature, pressure (e.g., via acoustic waves or touch), transmembrane potential, or light intensity. Many important receptors have now been characterized in atomic detail and our understanding of their functional properties has markedly increased in recent years. As a consequence, these sophisticated molecular machines can be reprogrammed to respond to unnatural input signals. Arguably, the most useful of these signals is light. Both ligand-gated ion channels, and G-protein coupled receptors, as well as voltage-gated ion channels, can be manipulated with synthetic photoswitches to become light-sensitive. The resulting hybrid photoreceptors can be used to optically control neurons with very high precision. They have been used to dissect neural networks and might find applications in the restoration of vision and the control of other sensations (such as pain). This combination of synthetic photoswitches and receptor proteins augments the field of Optogenetics and adds a new functional dimension to Chemical Genetics. As such, we propose to call it “Optochemical Genetics”.

Advanced Professional Degrees
2008 – present Professor (Chair) for Chemical Biology and Genetics, Dept. of Chemistry, LMU
2006 – 2010 Associate Professor (Tenure), Dept. of Chemistry, UC Berkeley
2000 – 2006 Assistant Professor, Dept. of Chemistry, UC Berkeley

Awards and Professional Affiliations
• Japanese Society for the Promotion of Science (JSPS) (2010)
• European Research Council Advanced Investigator Grant (2011)
• From 2011 on: Member ÖAW (Österreichische Akademie der Wissenschaften)

Publications

Lab members
Johannes Brücklberger, Timm Fehrentz, Elena Herrero-Gómez, Florian Huber, Holger Moroder, Alwin Reiter, Matthias Schindlberger, Philipp Stawski, Marco Steim, Martin Sumser
In view of a steadily increasing life expectancy, the amount of older people within the society becomes greater than ever. As a consequence the prevalence of chronic age-related diseases of the nervous system such as degenerative diseases (i.e. Parkinson’s Disease, Alzheimer’s Disease as well as chronic depression and other psychiatric diseases) will be gradually rising with serious personal but also societal and economical impacts. Thus, our vision is to help improving the quality of life for patients suffering from psychiatric (depression) and neurological diseases (Parkinson’s Disease, dementia) by contributing to the development of new therapies and preventive measures. Since it is apparent that these neurological and psychiatric diseases are multifactorial disorders, an integrative research approach is needed to understand the etiopathogenesis of the diseases—a prerequisite to develop novel preventive and/or therapeutic strategies. Therefore, our goal is to unravel the molecular basis of the pathoetiology of psychiatric and neurological diseases by generating and comprehensively analysing genetic animal models. In doing so, we specifically take into account the role of environmental factors on the etiology and progress of the diseases. As a consequence the IDG is structurally divided into two research areas. Within the IDG different groups in the Research Area “Disease Modelling” are approaching the central question of the pathoetiology of neuropsychiatric diseases from different angles using systemic, cellular and molecular approaches. In this context the IDG is focusing specifically on synaptic, mitochondrial, and neuroendocrine dysfunction and its consequence on behaviour. The IDG also integrates groups which are dedicated to the understanding of the mechanisms underlying plasticity and regeneration in the central nervous system. Here the focus is put on developmental signalling pathways and mechanisms which potentially are neuroprotective and/or support neurogenesis in the adult brain. The Mouse Genetics Teams generate targeted mouse mutants for internal scientific projects and external collaborations. The Large Scale Mutagenesis Team participates in the international EUCOMM large scale mutagenesis program to create a genome-wide resource of conditional targeted ES cells and mice. Within the national DIGTOP (disease genes to proteins) project the proteomic interactions of disease-related genes in stem cells and mice are analysed. The Technology Development and Animal Model Generation teams develop new mutagenesis tools and provide infrastructure for the generation of mouse mutants.

Generation and analysis of animal models for neuropsychiatric diseases

Prof. Dr. Wolfgang Wurst
Institute of Developmental Genetics
http://www.helmholtz-muenchen.de/en/idg/
Contact information on page 125
Teaching
The School's Objective

Under the umbrella of the MCN/LSU, the GSN/LSU links research groups from cellular and systems neuroscience, computational neuroscience, neurocognitive psychology and neurophilosophy, thus providing a stimulating environment for novel formulations and concepts. A special PI lecture series introduces the various key topics and methods to all students in the GSN/LSU. Thus, students keep a broad scope even though their own research is getting more and more focussed.

A special stipend program was initiated by GSN/LSU to promote especially those PhD research projects which go along the boundaries between subdivisions, bearing a higher risk but also high potential. The field of neurophilosophy for example is still developing in Germany. While the MCN/LSU promotes this development by inviting very renowned visiting professors to support the local teaching, the GSN/LSU declares special stipends for up to five new neurophilosophy PhD projects each year.

From the beginning, the GSN/LSU set out to become the hub for neuroscience education in Munich. After five years ~100 students are enrolled in the program, numbers rising. This is possible as the GSN/LSU is a distinct institution of LMU governed independently and independently awarding the doctoral degree, thus making GSN/LSU not only on a working basis, but also from a formal point of view, truly interdisciplinary. Implementing GSN/LSU as an independent, degree awarding institution was the key innovation in the original concept.

Another key feature is the fact that the doctoral degree the GSNLMU awards is the internationally compatible PhD. For international students this is a very important issue when choosing the location for their education. A proportion of currently almost 40% international students (aiming for 50%) GSNLMU demonstrates its attractiveness.

What makes the GSN/LSU so attractive? First of all, the scientific environment in which the GSN/LSU operates is one of the neuroscience hot-spots worldwide. Besides the excellent research opportunities the structure of the degree program at GSN/LSU has many advantages to a traditional doctorate. All GSN/LSU students have thesis advisory committees (TACs) rather than single supervisors. These TACs comprise 3 or more researchers from different fields and may include junior faculty as well as external members. In regular meetings with student and TAC, individual research plans are developed and documented (Training Objectives). At least once a year the Training Objectives have to be evaluated and updated. This leads to maximal transparency in the process and to maximal security of “staying on track”. What has proven to be best practice in educating and supervising doctoral students in the past years, has found implementation in the PhD regulations for the GSN/LSU. Next to the TAC supervision, students need to earn credit.
point by acquiring a variety of competencies required for scientific working next to methodological expertise: participating in regular lab meetings and progress reports, going to conferences to present their work, visiting summer school, gain own teaching and supervision experience. The GSNLMU defines the minimum amount of credit points to be earned with qualification measures. The content is individually defined for each student together with the TAC and also recorded in the training objectives. All this leads not only to close supervision for the research project, but automatically extends to very individual career advice. Of course science is not all in life. The GSNLMU has vivid interactions between members. Regularly GSNLMU organizes informal get-togethers like a summer barbeque or an annual dinner when the new cohort arrives. Also events like hiking, theatre, museum and movie nights regularly take place. Being a part of GSNLMU is being part of a community.

Fast-track education
While still many students especially from Germany and other European countries enter the program with a MSc or equivalent degree, the GSNLMU offers the opportunity to enter the program with a BSc degree in neuroscience related areas. During the first two semesters students go through a preparatory year receiving basic training in neuroscience in close collaboration with the master programs Neurosciences and Neurocognitive Psychology. A special advisory commission with permanent members closely watches the achievements of the fast-track students. Personal mentors from the GSNLMU faculty give additional individualized advice to the students. After the preparatory year, the advisory committee, together with the student, a decision is made to continue in the MSc or PhD track.

Next to the awarded degree, the structure of the program is highly compatible to other programs worldwide. Especially the different entry points to the program and flexibility to change the course as students go along. Whether suitable candidates come with a BSc degree a MSc or Diploma in related field or come as career changers with a MSc or Diploma from more distant fields, the GSNLMU can offer an individually tuned program, making sure that in the end all students leave GSNLMU with profound knowledge in different areas of neuroscience.

As neuroscience is a rapidly developing field bringing up new topics and methods, GSNLMU will respond by integrating these new developments into the teaching concept. To structure this large variety of participating researchers, methods and topics, the GSNLMU defined scientific sections and each faculty member is assigned to a section. These sections are Behavioural and Cognitive Neurosciences, Cellular and Circuit Neurosciences, Clinical Neuroscience, Computational Neuroscience, Developmental Neuroscience, Molecular Neuroscience and Neurophilosophy.
In order to implement the standardization of European university education according to the Bologna process, the strong neuroscience community of the LMU immediately developed and implemented a program in neurosciences, which Nowadays serves as an educational role model. Right from the beginning, the LMU master program in neurosciences was supported within the exclusive Elite Network by the government of Bavaria and was launched in the winter term of 2007. After the end of the first funding period the program was re-evaluated in June 2011, with excellent statements of scientific reviewers and the government of Bavaria. Initiated by the Bavarian State Government, the Elite Network of Bavaria contributes to excellent education for highly qualified students at top facilities. Selected students receive intensive individual tutoring and get the chance to study in a challenging scientific environment.

1. General education: The educational program is based on four main scientific topics: systems neurobiology, molecular and cellular neurobiology, computational neuroscience and neurophilosophy. Our curriculum takes the students on a “round trip” providing a profound understanding of the biological principles in brain structure and neuron-neuron communication before broadening the scope towards cognition and higher brain functions, computational methods and philosophical aspects in neurosciences. The main part of the general education takes place in the first two semesters and includes also GSNLMU Fast Track Students and students from the GSN™ PhD program with unrelated backgrounds.

2. Individual research training: In each semester, the student has to complete an individual research project. This will guarantee hands-on research training from the very beginning and gives students the opportunity to become acquainted with participating laboratories and researchers. In addition, besides the mandatory general courses, the students can choose from a broad spectrum of methods and interdisciplinary courses. Finally, of course, the students complement their education in neuroscience with their master thesis.

3. Complementary Skills: Our training concept would not be complete without the airing of complementary skills, which supplement our core curriculum and help to optimally prepare students for their future career goals. In their second year our students obtain first practice (and credits) in teaching by tutoring their younger fellows. In addition to the scientific education, the Master Program includes modular workshops on general working techniques in science such as communication training, presentation skills, scientific writing, and time management.

4. Mentoring: Each student has his or her own mentor from the GSN™. This mentor serves as academic advisor, helping the students plan their educational career and facilitate contacts to collaborating institutions. In mainly informal meetings the students have an excellent opportunity to discuss problems, receive guidance or have an informative scientific chat.
Teaching | Amgen Scholars Undergraduate Summer Research Program

Amgen Scholars European Undergraduate Summer Research Program

Amgen Scholars at LMU Munich engage in 8 weeks of intensive laboratory research. Each summer up to 25 undergraduate students gain exposure to cutting edge science in laboratories at LMU’s HighTechCampus offering a unique academic and scientific life science environment with numerous renowned life science research institutions and world leading scientists.

Participants conduct mentor-guided, hands-on research in the fields of biochemistry, structural, molecular, cell, and developmental biology, neurobiology, computational neuroscience, cancer research and physiological sciences. The research program includes:

• Participation at the European Amgen Scholars Summer Symposium at the University of Cambridge
• Networking events with local graduate students and extra-curricular excursions
• Concluding local symposium with poster presentations

The Amgen Scholars Program aims to create balanced top-level educational opportunities across Europe by supporting the mobility and networking of academics at a very early stage, thus enhancing the interest of the participants in a scientific career.

Target Group
Selected undergraduate students from relevant fields, only European countries (according to the European Higher Education Area (EHEA))

In Europe the program is conducted in partnership with the University of Cambridge (UK) and the Karolinska Institutet (Sweden). The program is financed through the generosity of the Amgen Foundation.

Faculty Director: Prof. Dr. Benedikt Grothe
Program Director: Lena Bittl
Program Administrator: Liz Atwood

www.amgenscholars.uni-muenchen.de
www.amgenscholars.eu

Teaching | Amgen Scholars Undergraduate Summer Research Program

Amgen Scholars – From Molecules to Behavior

Amgen Scholars at LMU Munich engage in 8 weeks of intensive laboratory research. Each summer up to 25 undergraduate students gain exposure to cutting edge science in laboratories at LMU’s HighTechCampus offering a unique academic and scientific life science environment with numerous renowned life science research institutions and world leading scientists.

Participants conduct mentor-guided, hands-on research in the fields of biochemistry, structural, molecular, cell, and developmental biology, neurobiology, computational neuroscience, cancer research and physiological sciences. The research program includes:

• 4 day orientation retreat in the Bavarian countryside
• Weekly lectures and workshops on state-of-the-art research topics and methods, bioethics, poster presentation, abstract writing and scientific career paths
• 8 weeks of hands-on research in a host laboratory under the supervision of an assigned faculty mentor

Target Group
Selected undergraduate students from relevant fields, only European countries (according to the European Higher Education Area (EHEA))

In Europe the program is conducted in partnership with the University of Cambridge (UK) and the Karolinska Institutet (Sweden). The program is financed through the generosity of the Amgen Foundation.

Faculty Director: Prof. Dr. Benedikt Grothe
Program Director: Lena Bittl
Program Administrator: Liz Atwood

www.amgenscholars.uni-muenchen.de
www.amgenscholars.eu

Teaching | Amgen Scholars Undergraduate Summer Research Program

Amgen Scholars European Undergraduate Summer Research Program

The Amgen Scholars Program aims to create balanced top-level educational opportunities across Europe by supporting the mobility and networking of academics at a very early stage, thus enhancing the interest of the participants in a scientific career.

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In Europe the program is conducted in partnership with the University of Cambridge (UK) and the Karolinska Institutet (Sweden). The program is financed through the generosity of the Amgen Foundation.
The mission of FUN is:
• Enhancing undergraduate participation in research and the presentation of research at the SFN meeting (Society for Neuroscience, U.S.A.)
• Disseminating innovations in undergraduate neuroscience education
• Recognizing excellence in undergraduate neuroscience education
• Developing national and regional networks that enhance undergraduate neuroscience education and research and faculty development

In order to further develop and enhance the international neuroscience network, in June 2011 undergraduate students and faculty members of FUN visited Munich and Berlin each for a 2-week summer school on Neuroscience. The courses included lectures, practical course work and lab visits throughout the faculty of the Graduate School of Neurosciences in Munich and the Graduate School of Mind and Brain in Berlin. In addition to the scientific education, the students had many opportunities to socialize with local students and faculty members and visit local and regional attractions, like alpine excursions, city tours and, of course, beer gardens. The summer school was a great success for students and faculty and will be continued on an annual basis.
The DFG Research Training Group Orientation and Motion in Space is supported by scientific groups from different disciplines and faculties of the Ludwig Maximilians University Munich (biology, clinical neurology, psychology), together with neurobiological groups from the Max Planck Institute for Neurobiology in Martinsried.

The participating senior scientists, together with their cooperating group members, provide optimal training, education and support for doctoral students from various fields (Biology, Computer science, Engineering, Medicine, Physics and Psychology).

We cooperate closely with the Graduate School of Systemic Neuroscience (GSNLMU), the International Max Planck Research School RTG 1091 Orientation and Motion in Space.

“From Biology to Medicine” and the Bernstein Center for Computational Neuroscience (BCCN). We offer challenging research topics of high biological relevance and permit the detailed investigation of complex central nervous processes. These also include the essential sensory inputs (acoustic, vestibular, visual), as well as the psychophysical and motor reactions in regard to the control of movements and balance in space.

The latter are investigated in normal subjects and patients, whereas animal experiments with optical and extracellular single unit recordings are planned in order to study information processing within the central nervous system. Attention and memory are also decisive factors for adequate orientation and movement in space. These topics are specifically addressed by projects in the program. We also investigate the effect of lesions on orientation and motion analysis in patients and animal experiments. Thus, with the different scientific backgrounds the participants are working on a common theme, using different approaches and problem-solving strategies.

Furthermore, a wide spectrum of methods is available. These include extra cellular recordings from individual neurons, optical recordings to establish maps in central nervous structures, as well as eye movement recordings and psychophysics.

The common scientific theme, combined with different backgrounds and the wide range of methods, gives the graduate students a unique opportunity to apply interdisciplinary approaches and broaden their scientific view. A major goal of the training group is to look beyond the narrow topic of the individual project. These are the best preconditions for better problem solving strategies and new approaches. There is a tight link to clinical problems such as Ataxia and dizziness.

Last but not least, the students can choose from a whole range of specially organised soft skill courses, lectures and workshops we organise for them.
The scientific aim of this Research Training Group is to elucidate the cellular and molecular signaling underlying brain function in health and disease. A special focus is to relate physiological processes to disturbances of signaling in neurological disease conditions. For this purpose, members of the Research Training Group analyze animal models utilizing high-resolution in vivo imaging techniques and electrophysiological methods. Complementary efforts of other groups focus on the analysis of molecular mechanisms of brain function, including the development of new mouse models. Finally, imaging and electrophysiology approaches that can be applied to small animal models as well as human patients form a technological bridge towards clinical translation.

The educational concept of our Research Training Group will specialize in providing in-depth scientific training to students with a medical background, as well as offering disease-related research opportunities to young scientists from natural science disciplines. Training will be conducted in the form of a study program directly inspired by the successful M.D./Ph.D. programs that present the gold standard for training of clinician-scientists. Over the past years, this program has proven a sounding success with exceptionally talented students applying in large numbers. Renewal of this Research Training Group will provide us the opportunity to consolidate the pioneering efforts of our first funding period and expand our research program aimed at elucidating brain signaling in health and disease. Thus, multi-disciplinary training in disease-related neuroscience will be firmly established at our partnering universities.

The inaugural symposium on Systems Neuroscience between the Queensland Brain Institute (QBI) and the Munich Center for Neurosciences (MCNLMU) took place at the University of Queensland, Brisbane, QLD, Australia in September 2011. The symposium brings together leading researchers from both universities in sensory, cognitive, cellular and molecular neuroscience to share their recent findings with the Australian neuroscience community including student participants from LMU Munich. Further joint efforts will include a second symposium in 2012, a Summer School in 2013, long term student exchange (1-2 years) and on-going short-term exchange (2-3 weeks) between faculty members and advanced researchers from both institutions.

Speakers at the 2011 QBI-MCNLMU Symposium included:

**From MCNLMU:**
- Prof. Benedikt Grothe, Director MCN
- Prof. Heiner Deubel
- Prof. Magdalena Götz
- Prof. Mark Hübener
- Prof. Rüdiger Klein
- Prof. Christian Leibold
- Prof. Lutz Wiegrebe

**From QBI:**
- Prof. Perry Bartlett, Director QBI
- Prof. Geoff Goodhill
- Prof. Ottmar Lipp
- Prof. Justin Marshall
- Prof. Linda Richards
- Prof. Pankaj Sah

The LMU Harvard Young Scientists’ Forum (YSF) seeks to unite Ph.D. students and postdoctoral fellows from Harvard University and the Ludwig-Maximilians-Universität (LMU) with core faculty from the two universities to create a framework for an interdisciplinary exchange of ideas. The first conference of the series was held at LMU Munich in June 2009, followed by a conference at Harvard University in 2010. LMU-Harvard YSF was held in 2011 at the Center for Advanced Studies (CAS) of the LMU Munich.

Speakers in 2011:

**LMU Munich:**
- Prof. Tobias Bonhoeffer
- Prof. Thomas Carel
- Prof. Christian Haass
- Prof. Matthias Mann

**Harvard:**
- Prof. Catherine Dulac
- Prof. Venkatesh Murthy
- Prof. Eric Ruben
- Prof. William Shih

The LMU-Harvard Young Scientists’ Forum (YSF) Teaching | Young Forum & QBI-MCNLMU Symposium

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Community outreach
Awards
- Young Scientist Award
- LMU/Scopus Neuroscience Award
- Scopus Young Neuroscientist Award
- Brain Navigator Award

Lectures & Events
- LMU Lecture Series ("Ringvorlesung")
- MCNLMU Monday Lecture Series
- MCNLMU Christmas Lecture
- Neurohistory Workshop
The ultimate goal of the "Munich Center for Neurosciences – Brain and Mind" is to create a network bringing together all groups and disciplines with interests related to questions of neurobiology, cognition, and "brain and mind". In addition to direct support of teaching initiatives and research collaborations, the center also strives to bring publically relevant issues and topics within neuroscience to the greater community by organizing lectures open to both the neuroscience community and the general public:

During the 2010/2011 academic year, a university-wide, interdisciplinary series of 15 lectures titled "Der Mensch und sein Gehirn" was co-organized by MCNLMU. Topics included the evolutionary basis of the human brain, brain development and regeneration, epilepsy, the vestibular system which controls balance, learning and plasticity, logic, Alzheimer’s Disease, and ethics. For more details see www.lmu.de/ringvorlesung

The Monday Lecture Series, open to the neuroscience community, features high-profile local and international experts covering an interdisciplinary spectrum of current research. Lectures take place monthly during both academic semesters on Munich’s high-tech Campus in Martinsried. See the MCNLMU website for more information.

Upon invitation by the Bavarian State Ministry of Science, Research and the Arts, the MCNLMU has coorganized the upcoming inaugural lecture of the Munich Christmas Lecture Series to be held yearly at the Residenz in Munich. The Christmas Lecture Series is inspired by the traditional Christmas Lecture of the British Royal Institution. The first lecture will be held on December 19th, 2011 by Wolfgang Klein from the Max Planck Institute for Psycholinguistics in Nijmegen (Netherlands) on beauty and aesthetics.
Neurohistory Workshop

Neurohistory: How Can Neuroscience Help Us Understand the Past?

This question was addressed at a workshop held 6-7 June 2011 at the Rachel Carson Center in Munich, Germany. The interdisciplinary workshop focused on ways that neuroscience might help us to understand history (and, ideally, vice versa).

Four main questions were addressed:

1. What ideas and methods have neuroscientists developed that historians can use to shed new light on the past (and vice versa)?
2. What new research questions can neuroscience suggest for historians (and vice versa)?
3. What are the biggest challenges to developing neurohistory as a field, and how can they be overcome?
4. How might neurohistory shed light on the interaction between people and their environment in the past and present?
In 2010, the Graduate Center LMU, the Munich Center for Neurosciences and Elsevier assigned four awards between 1500 and 5000 Euros for excellent publications in the life sciences/neurosciences to young scientists from Munich. The “LMU Young Life Scientist Award” is dedicated to doctoral candidates of LMU Munich from the life sciences (including biology, biochemistry, bioinformatics and medicine), while the remaining three awards (“LMU/Scopus Neuroscience Award”, “Scopus Young Neuroscientist Award” and “Brain Navigator Award”) are restricted to young researchers from the neurosciences.

**Awardees in 2010**

**LMU/Scopus Neuroscience Award:**
Dr. Jovica Ninkovic, Helmholtz Zentrum Munich, for his publication “The transcription factor Pdx1 regulates survival of dopaminergic olfactory bulb neurons via crystallin aA.”

**Scopus Young Neuroscientist Award:**
Hongbo Jia, Technische Universität München for his publication “Dendritic organization of sensory input to cortical neurons in vivo.”

**The Brain Navigator Award:**
Dr. Tobias Bittner, LMU Munich, for the publication “Microglial CX3CR1 knockout prevents neuron loss in an Alzheimer’s disease mouse model”

**The LMU Young Life Scientist Award:**
Dorota Zielinska, Max Planck Institute for Biochemistry / LMU Munich for her publication “Precision Mapping of an In Vivo N-Glycoproteome Reveals Rigid Topological and Sequence Constraints”
(Zielinska DF*, Gnad F*, Wisniewski JR and Mann M (2010), Cell 141(5)).

The Brain Navigator Award:
Appendix
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<th>MCN Management &amp; Administration</th>
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<th>MCN Kuratorium (Board of Trustees)</th>
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<td>Prof. Dr. Benedikt Grethe</td>
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<td>Prof. Dr. Oliver Behrend</td>
<td>LMU, Division of Neurobiology</td>
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<td>Managing Director</td>
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<td>Prof. Dr. Godfried Lenski</td>
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<td>LMU, Medical Faculty</td>
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<td>Lena Bitt</td>
<td>LMU, Faculty of Philosophy</td>
<td>Konstanzer Wissenschaftsforum</td>
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<td>Program Director &amp; Public Relations Manager</td>
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<td>Prof. Dr. Wolfgang Prinz</td>
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<td>Morgan Scholars Program &amp; MCNLMU</td>
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<td>MPI for Human Cognitive and Brain Sciences</td>
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<td>Prof. Dr. Heidrun Potschka</td>
<td>LMU, Faculty of Philosophy</td>
<td>Gent Scobel</td>
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<td>Office Management</td>
<td>Prof. Dr. Wolfgang Prinz</td>
<td>Nat. Science Journalist, Presenter and Managing Editor</td>
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<td>Sylvia Zehner</td>
<td>LMU, Faculty of Veterinary Medicine</td>
<td>Prof. Dr. Wolf Singer</td>
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