Dr. Gordon Pipa

Full Professor
Chair of the Neuroinformatics Department

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Personal Data

Date of birth	September 20th 1974
Marital status	married, three children

Education

12/2010	**Habilitation**, Biology, University of Technology Darmstadt, Germany, 'Self-Organized Information Processing in the Brain'
4/2002–8/2006	**PhD**, with Prof. Klaus Obermayer, Department of Neural Information Processing, Berlin University of Technology, Germany, 'The Neuronal Code: Development of tools and hypotheses for understanding the role of synchronization of neuronal activity', *Grade very good*,
5/2001–3/2002	**Diploma**, Max Planck Institute for Brain Research and the Faculty of Physics, J. W. Goethe University, Frankfurt am Main, Germany, *Grade very good*
9/1995–5/2001	**Diploma-Studies in Physics**, specialized on theoretical physics, stochastic processes and image processing, RWTH-Aachen University, Germany

Positions

since 2/2011	**Full professor (W3) and chair of the Neuroinformatics department**, Institute of Cognitive Science, University of Osnabrueck, Germany
10/2009-2/2011	**Substitute professor for Neuroinformatics (W3)**, Institute of Cognitive Science, University of Osnabrueck, Germany
01/2005-9/2010	**Group leader** with Prof. Wolf Singer, Department of Neurophysiology, Max Planck Institute for Brain Research, Frankfurt am Main, Germany
08/2003-9/2010	**Junior fellow** (≈Junior Professor), Frankfurt Institute for Advanced Studies (FIAS), Frankfurt am Main, Germany
10/2007–1/2009	**Research fellow** with Prof. Emery Brown, joint appointment: Department of Brain and Cognitive Sciences, Massachusetts Institute of Technology, Cambridge, MA, USA, and Department of Anesthesia and Critical Care, Massachusetts General Hospital, Boston, MA, USA
4/2002–7/2003	**Research assistant** with PD Dr. Sonja Grün, Department of Neurophysiology, Max Planck Institute for Brain Research, Frankfurt am Main, Germany

Grants

- 2010–2013 • **European Grant**, 'Photonic liquid state machine based on delay-coupled systems', *294k€*
- 2008 • **PENS Grant** for running the FIAS Summer School 2008, *40k€*

2007–2010 • **European Grant**, 'Global Approach to Brain Activity', *272k€*

2006 • **Volkswagen Grant** for running the FIAS Summer School 2006, *70k€*

Professional Activities

Director **Osnabrück Computational Cognition Alliance Meeting** - International Workshop on Natural Computation in Hierarchies, 2011, Osnabrück, Germany

Organizer **Multi-scale complex dynamics in the brain** - International Workshop Multiscale Complex information processing in the Brain, 2011, Palma, Spain

Organizer **Workshop on multi-scale complex dynamics in the brain** (Cosyne), 2010, Snow Bird, Utah, US

Scientific advisor **International Neuroinformatics Coordinating Facility** (INCF), 2009, School of Informatics, Edinburgh, Scotland

Program Chair **Bernstein Conference for Computational Neuroscience** (BCCN), 2009, Frankfurt am Main, Germany

Organizer **Trends in Complex Systems** - International Workshop on Synchronization and Multiscale Complex Dynamics in the Brain (BSYNC09), 2009, Dresden, Germany

Course Director **FIAS Summer School** on Theoretical Neuroscience and Complex Systems in 2006, 2007 and 2008, Frankfurt Institute for Advanced Studies, Frankfurt am Main, Germany

Guest scientist 10-11/2006, **Group of Prof. Claudio R. Mirasso**, Institute for Cross-Disciplinary Physics and Complex Systems, Palma de Mallorca, Spain

Jury member since 2005, **German contest for young scientists** (Jugend Forscht)

Visiting student 11-12/2003, **Group of Prof. Larry Abbott**, Brandeis University, Waltham, MA, USA

Reviewer for Journals Neuron, Journal of Neural Computation, Journal of Neuroscience, Physical Review E, PLoS Computational Biology, Journal of Computational Neuroscience, Journal of Neurophysiology, Journal of Neuroscience Methods, European Journal of Physics, Nonlinear Biomedical Physics, Journal of Complexity, Neurocomputing, Journal Frontiers in Neuroscience, The European Physical Journal B, Frontiers in Neuroscience

Patents

German **DE9701454***

European **EP0993657***

United States **US6231185***

International **PCT/DE1997/001454*** and **WO/1999/003066*** for Canada, Japan, United States and European states: AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE)

German patent applications **DE10008251A1**, **DE19601024A1**, **DE19800845A1**

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Awards and Honors

2008–2010 • MainCampus Educator, for young faculty

1995–2001 • Scholarship of the German National Academic Foundation, state scholarship

1997 • Awarded as a young talent with outstanding creativity, International Zermatt Symposium for 'Creativity and Leadership'

1995–1996 • Triple prize winner in the German contest for young scientists (Jugend Forscht)
i.e. federal 3rd: 'Realtime Eyetracking: a new microprocessor for ultra fast image processing'

- Reception by the German President Prof. Dr. Roman Herzog and Chancellor Helmut Kohl
- Honorary medal of the Friedrich-Bläse-Foundation
- Reception at The Nobel Laureate Meeting at Lindau hosted by Count L. Bernadotte of Wisborg

Collaborators

- **Prof. Emery N. Brown**, Department of Brain and Cognitive Sciences, MIT, Cambridge, USA
- **Prof. Ingo Fischer**, Nonlinear Photonics Group, Heriot-Watt University, Edinburgh, U.K.
- **Prof. Ralf Galuske**, Department of Biology, Technical University Darmstadt, Germany
- **PD Dr. Sonja Grün**, Riken Brain Science Institute, Tokyo, Japan
- **Prof. Claudio R. Mirasso**, Institute for Complex Systems, Palma de Mallorca, Spain
- **PD Dr. Matthias Munk**, Max Planck Institute for Biological Cybernetics, Tübingen, Germany
- **Dr. Sergio Neuenschwander**, Max Planck Institute for Brain Research, Frankfurt, Germany
- **Dr. Bertram Scheller**, Clinic for Anaesthesiology, Goethe University, Frankfurt, Germany
- **Prof. Jochen Triesch**, Frankfurt Institute for Advanced Studies, Frankfurt am Main, Germany
- **Prof. Jordi Garcia Ojalvo**, Universitat Politècnica de Catalunya, Barcelona, Spain
- **Prof. Carl van Vreeswijk**, Centre national de la recherche scientifique, Paris, France

Invited Talks

2011
- Workshop on Reservoir Computing, Ruhr University Bochum, Germany
- École polytechnique fédérale de Lausanne (EPFL), Lausanne, Switzerland

2010
- Workshop on Cognitive and Neural Models for Automated Processing of Speech and Text, Ghent, Belgium
- Department for Neural Coding and Computation, National Institute of Mental Health and National Institutes of Health, Bethesda, Maryland, USA, Group of Prof. Berry J. Richmond
- Redwood Center for Theoretical Neuroscience, University of California, Berkeley, USA, Group of Prof. Fritz Sommer

2009
- Trends in Complex Systems - International Workshop on Synchronization and Multiscale Complex Dynamics in the Brain (BSYNC09), Dresden, Germany
- Computational and Systems Neuroscience Meeting (COSYNE), plenary talk and workshop, Salt Lake City, UT, USA
- Department of Brain and Cognitive Sciences, Massachusetts Institute of Technology, Cambridge, MA, USA, Group of Prof. Ann Graybiel

2008
- German-American Frontiers of Science Symposium (GAFOS), Potsdam, Germany
- Center for BioDynamics, Boston University, Boston, MA, USA, Group of Prof. Nancy Kopell
- International Conference on Cognitive and Neural Systems (ICCNS), Boston, MA, USA
- Computational Neuroscience Meeting (CNS), Portland, OR, USA
- International Conference on Artificial Neural Networks (ICANN), Prague, Czech Republic

2007
- Center for Neurobiology and Behavior, Columbia University, New York, USA, Group of Prof. Larry Abbott
- University of Potsdam, Germany, Nonlinear Dynamics Group of Prof. Jürgen Kurths
- International Workshop on Stochastic Dynamics in the Neurosciences, Dresden, Germany
- University of California, San Francisco, CA, USA, Group of Prof. Loren Frank

2006
- The dynamical brain, International Titisee Conference, Titisee, Germany
- Institute for Cross-Disciplinary Physics and Complex Systems, Palma de Mallorca, Spain

- Faculty of Biology, Freie Universität Berlin, Germany, Neuroinformatics and Theoretical Neuroscience Group of PD Dr. Sonja Grün

2005
- Brazilian Conference for Biology (FeSBE), Sao Paulo, Brazil
- Summer school on Nonlinear Dynamics and Chaos at the Max Planck Institute for Complex Systems, Dresden, Germany
- Workshop on Data Analysis in Neuroscience, Trinity College, Dublin, Ireland

2003
- Computational Neuroscience Meeting (CNS), Alicante, Spain
- Woods Hole Course for Neuroinformatics, Woods Hole, MA, USA
- Society for Neuroscience Meeting (SFN), New Orleans, LA, USA

2002
- Center for Neurodynamics, University of Missouri, St. Louis, MO, USA, Group of Prof. Frank Moss
- Computational Neuroscience Meeting (CNS), plenary talk, Chicago, IL, USA

Supervision

PhD
- finished 2009, *Andreea Lazar,* Informatics
- finished 2008, *Wei Wu*, Physics
- started 2008, *Katharina Schmitz*, Mathematics
- started 2010, *Johannes Schumacher*, Cognitive Science
- started 2010, *Hazem Toutounji*, Cognitive Science
- started 2010, *Marta Castellano*, Cognitive Science

Diploma
- finished 2008, *Katharina Schmitz*, Mathematics

Master
- finished 2009, *Felipe Gerhard*, Computational Sciences
- finished 2009, *Marta Castellano*, Computational Sciences
- finished 2010, *Johannes Schumacher*, Cognitive Science
- started 2010, *Mina Shahi*, Cognitive Science
- started 2010, *Vikash Peesapati*, Cognitive Science
- started 2011, *Eduardo Aponte*, Cognitive Science

Bachelor
- finished 2008, *Alexandra Wellner*, Biology
- finished 2010, *Benedict Küster*, Cognitive Science
- finished 2010, *Jan Herding*, Cognitive Science
- started 2010, *Stefan Depeweg*, Cognitive Science
- started 2010, *Patrick Putzky*, Cognitive Science
- started 2011, *Jacob Huth*, Cognitive Science
- started 2011, *Anna-Birga Ostendorf*, Cognitive Science

Teaching (G: Graduate, U: Undergraduate courses)

teaching concept
To account for a typical attention span I partition a lecture into 20 min. segments. After each segment the students work for 5 min. on a questionnaire followed by 5 min. of discussion.

2010
- (U+G) **'Spike decoding competition'** Quest 5 days, Univ. Osnabrueck
- (U+G) **'NeuroInformatics I'** Lecture & Tutorial, 42x 90 min., Univ. Osnabrueck
- (U+G) **'Advanced NeuroInformatics II'** Lecture & Tutorial, 28x 90 min., Univ. Osnabrueck
- (U+G) **'Advanced NeuroInformatics II'** Seminar, 14x 90 min., Univ. Osnabrueck

2009
- (U+G) **'Advanced NeuroInformatics I'** Lecture & Tutorial, 28x 90 min., Univ. Osnabrueck
- (U+G) **'Advanced NeuroInformatics I'** Seminar, 14x 90 min., Univ. Osnabrueck

- (G) **'Neurobiology II'**, 10x 60 min., Technical Univ. Darmstadt, Institute for Biology
- (G) **'Synchronization and Emergent Properties in Complex Systems'**, 3x 90 min., Max Planck Institute for Brain Research, Frankfurt
- (G) **'Linear Time Series Analysis and Spectral Analysis Techniques'**, 3x 90 min., Max Planck Institute for Brain Research, Frankfurt
- (U) **'Seminar on The Visual System, Visual Information Processing and Psychophysics'**, 8x 4h, Technical Univ. Darmstadt, Institute for Biology
- (G) **'Time Series Analysis of Point Processes'**, 3x 90 min., Max Planck Institute for Brain Research, Frankfurt

2008 • (G) **'Spectral Analysis Techniques: Fourier, Wavelet and Multitaper Method'**, 2x 90 min., Max Planck Institute for Brain Research, Frankfurt

2007 • (G) **'Analysis of Synchronous Neuronal Spiking Activity'**, 2x 90 min., Max Planck Institute for Brain Research, Frankfurt

2006 • (G) **'Statistical Inference'**, 1x 90 min., team teaching with Prof. Jochen Triesch, FIAS graduate school, Frankfurt

2006-2008 (G) **'Statistical Inference and Time Series Analysis'**, 5x 90 min., FIAS Summer School, Frankfurt

Software and toolbox development

- **NeuroXidence:** Matlab toolbox for analyzing synchronous spiking activity based on surrogate data (www.neuroxidence.com)
- **Field trip transfer entropy module:** Matlab module for the field trip toolbox for analyzing information flow from time series from complex dynamical systems such as MEG, EEG, ECoG and LFP. The toolbox offers automatic optimization of embedding dimension and rigorous assessment of statistical importance based on resampling and boostraaping.
- **SpkeCoh:** C++ toolbox for analyzing synchronous spiking activity based on a color-based visualization technique (http://www.ovidiu.jurjut.ro/sources/visualization/)

Book chapters

- R. Vicente, L. L. Gollo, C. R. Mirasso, I. Fischer, and G. Pipa. *'Far in space and yet in synchrony: neuronal mechanisms for zero-lag long-range synchronization. Coherent Behavior in Neuronal Networks.'* Springer Series in Computational Neuroscience, Vol. 3, *2009.*
- S. Boccaletti, J. L. Cantero, M. Chávez, K. Egiazarian, I. Fischer, G. Gómez-Herrero, C. Mirasso, G. Pipa, W. Singer, A. E. P. Villa, and J. García-Ojalvo. *'Global Approach to Brain Activity: from Cognition to Disease.'*, Success Stories of the Advances and Applications of Complex Systems Science, Springer Series
- E. Balaban, S. Edelman, S. Grillner, U. Grodzinski, E. D. Jarvis, J. H. Kaas, G. Laurent, and G. Pipa, *'Dynamic Coordination in the Brain - Evolution of Dynamic Coordination'*, Ernst Strüngmann Forum, MIT press

Publications

2011 • F. Gerhard, G. Pipa, B. Lima, S. Neuenschwander, and W. Gerstner. *'Extraction of network topology from multi-electrode recordings : Is there a small-world effect ?'* Frontiers in Neuroscience, *accepted*.

- P. Ulhaas, G.Pipa, S. Neuenschwander,and W. Singer. *'A new look at gamma? High- (>60 Hz) γ-band activity in cortical networks: Function, mechanisms and impairment'* Progress in Biophysics and Molecular Biology, 105:1-2 *2011*.

2010
- F. Gerhard, R. Haslinger, and G. Pipa. *'Applying the multivariate time-rescaling theorem to neural population models.'* Journal of Neural Computation, *accepted*.
- R. Haslinger, G. Pipa, and E.N. Brown. *'Discrete Time Rescaling Theorem: Determining Goodness of Fit for Discrete Time Statistical Models of Neural Spiking.'* Journal of Neural Computation, 22:2477-2506 *2010*.
- B. Scheller, G. Pipa, H. Kertscho, P. Lauscher, J. Ehrlich, O. Habler, K. Zacharowski, and J. Meier, *'Normovolemic anemia induces QT-prolongation and T-wave depression in a pig model'*, Shock, 1073-2322, *2010*.
- R. Vicente, M. Wibral, M. Lindner, and G. Pipa *'Transfer Entropy - A model-free measure of effective connectivity for the neurosciences.'* Journal of Computational Neuroscience.,0929-5313:1-23 *2010*.

2009
- P. Ulhaas, G.Pipa, B. Lima, L. Melloni, S. Neuenschwander, and W. Singer. *'Neural synchrony in cortical networks: History, concept and current status.'* Review. Frontiers in Integrative Neuroscience, 3:17, *2009*
- G. Pipa, E. S. Städtler, E. F. Rodriguez, J. A. Waltz, L. F. Muckli, W. Singer, Rainer Goebel, and M. H. J. Munk. *'Performance- and coding-dependent oscillations in monkey prefrontal cortex during short-term memory.'* Frontiers in Integrative Neuroscience, 3, *2009*
- O. F. Jurjut, D. Nikolic, G. Pipa, W. Singer, D. Metzler, and R. C. Muresan. *'A color-based visualization technique for multi-electrode spike trains.'* J. Neurophysiology, *2009*
- B.C.A. Scheller, M. Daunderer, and G. Pipa. *'General anesthesia increases temporal precision and decreases power of the brainstem auditory evoked response.'* Journal of Anesthesiology, 111(2):340–355, *2009*
- A. Lazar, G. Pipa and J. Triesch. *SORN: a self-organizing recurrent neural network* Frontiers Computational Neuroscience 3:23. *2009*
- V. Moca, B.C.A. Scheller, M. Daunderer, and G. Pipa. *'EEG under anesthesia - feature extraction with tespar.'* Jorunal Computer Methods and Programs in Biomedicine, 95(3):191–202, *2009*

2008
- R. Vicente, L.L. Gollo, C.R. Mirasso, I. Fischer, and G. Pipa. *'Dynamical relaying can yield zero time lag neuronal synchrony despite long conduction delays.'* Proceedings of the National Academy of Sciences of the United States of America (PNAS), 105(44):17157–17162, *2008.*
- W. Wu, D.W. Wheeler, E.S. Städtler, M.H.J. Munk, and G. Pipa. *'Behavioral performance modulates spike field coherence in monkey prefrontal cortex.'* Neuroreport, 19(2):235–238, *2008.*
- E.Ullner, R.Vicente, G.Pipa, and J.Garcia-Ojalvo. *'Contour integration and synchronization in neuronal networks of the visual cortex.'* Springer Lecture Notes in Computer Science - Artificial Neural Networks, 5164:703–712, *2008.*
- A. Lazar, G. Pipa, and J. Triesch. *'Predictive coding in cortical microcircuits.'* Springer Lecture Notes in Computer Science - Artificial Neural Networks, 5164:386–395, *2008.*
- G. Pipa, R. Vicente, and A. Tikhonov. *'Auto-structure of presynaptic activity defines postsynaptic firing statistics and can modulate STDP-based structure formation and learning.'* Springer Lecture Notes in Computer Science - Artificial Neural Networks, 5164:413–422, *2008.*
- G. Pipa, D. W. Wheeler, W. Singer, and D. Nikolic. *'Neuroxidence: reliable and efficient analysis of an excess or deficiency of joint-spike events.'* Journal of Computational Neuroscience. 25(1):64–88, *2008.*

2007
- D. Huang and G. Pipa. *'Achieving synchronization of networks by an auxiliary hub.'* Europhysics Letters, 77(5), *2007.*
- A. Lazar, R. Muresan, E. Städtler, M.H.J. Munk, and G. Pipa. *'Importance of electrophysiological signal features assessed by classification trees.'* Neurocomputing, 70(10–12):2017–2021, *2007*.

- A. Lazar, G. Pipa, and J. Triesch. *'Fading memory and time series prediction in recurrent networks with different forms of plasticity.'* Neural Networks, 20(3):312–322, *2007.*
- G. Pipa, A. Riehle, and S. Grün. *'Validation of task-related excess of spike coincidences based on NeuroXidence.'* Neurocomputing, 70(10–12):2064–2068, *2007.*
- R. Vicente, G. Pipa, I. Fischer, and C. Mirasso. *'Zero-lag long range synchronization of neurons is enhanced by dynamical relaying.'* Springer Lecture Notes in Computer Science - Artificial Neural Networks, 4668, *2007.*

2006
- A. Lazar, G. Pipa , and J. Triesch. *'The combination of STDP and intrinsic plasticity yields complex dynamics in recurrent spiking networks.'* European Symposium on Artificial Neuronal Networks, ISBN 2–930307–06–4, Springer. Bruges, Belgium, *April 2006.*

2005
- R.C. Muresan, G. Pipa, R.V. Florian, and D.W. Wheeler. *'Coherence, memory and conditioning. A modern viewpoint.'* Neural Information Processing - Letters and Reviews, 7(2):19–28, *2005.*
- R.C. Muresan, G. Pipa, and D.W. Wheeler. *'Single-unit recordings revisited: Activity in recurrent microcircuits.'* Springer Lecture Notes in Computer Science - Artificial Neural Networks, 3696:153–159, *2005.*

2003
- G. Pipa and S. Grün. *'Non-parametric significance estimation of joint-spike events by shuffling and resampling.'* Neurocomputing, 52–4:31–37, *2003.*

Research Interests

multi-scale collective behavior

My research is focused on understanding how realtime information processing and cognition can arise from the collective self-organization of elements interacting across many spatial and temporal scales. In particular I study, first synchronization of neuronal activity in delay coupled systems, second information processing in self-organized complex systems in different dynamical states, i.e. self-organized criticality, and third, the use of time series analysis to estimate information flow between neural activity occurring at different spatial and temporal scales. The long term goal of my research is to identify principles that shape neuronal activity and are used to process information in a multi-scale system like the brain. I firmly believe that understanding the principles of neuronal information processing requires the combination of experimental, computational and theoretical approaches. Therefore my research is multidisciplinary and is composed of two tracks.

modeling

The first research track develops and uses analytical and computational models to identify and understand principles. My modeling activities have three main thrusts: first modeling networks and emergent properties, second rhythms and synchronization, and third neuronal computations based on self-organizing systems. In the first thrust I model networks of neurons assuming that emergent phenomena are inherently important for understanding neuronal dynamics and information processing. Second, rhythms and synchronization seem to be an omnipresent feature of neuronal activity. I model rhythm generation and synchronization. A key element is the use of the network topology to stabilize subsets of synchronization solutions, i.e. zero time lag or near zero time lag. Third, the neuronal system comprises a large diversity of elements that define various temporal and spatial scales. The self-organization of the system and the resultant dynamics have to cope with or even take advantage of the multi-scale nature and diversity. While in a traditional view such complexity is often seen as noise or an unwanted feature I am interested in principles of neuronal information processing that can take advantage of these properties. Towards this end I identified reservoir computing, originally introduced in the context of echo state or liquid state machines, as a promising concept. I extended the reservoir computing concept by adding delay coupling and neuronal plasticity to allow for self-organization.

networks

rhythms and synchronization

network topology

reservoir computing

time series analysis

The second track is data driven and concerns first the understanding of realtime information processing and cognition, and second the development and use of new tools for analyzing time series of neuronal data, including spiking activity, local field potentials (LFP), EEG and MEG. To investigate information processing and cognition I have setup with my group over the past years an experimental laboratory for behaving monkeys and realtime recording of eCOG, LFP and spiking activity from up to 256 channels, based on semi-chronical and chronical implants. The setup allows for realtime interaction between all technical components that are, a high speed eyetracker (Eyelink), a stimulus generation (VISAGE) and a recordings system from Neuralynx. This enables us to use realtime visual stimulus adaptation upon features extracted form the recorded data, as well as gaze contingent stimulus changes. The second focus of this data driven research track, is the development of tools for analyzing time series of MEG, EEG, eCOG, LFP and spiking activity. The foci of these tools are, detection of synchronous activity, identification of information flow for systems that are both linearly and non-linearly coupled, and characterization of changes of networks based on graph theory. Especially in the domain of anesthesia research based on EEG, and for cognitive sciences based on MEG, LFP and eCOG we demonstrated the power of our new tools.

BCI realtime

MEG, EEG, eCOG, LFP, spike activity

cognition and anesthesia research