RESEARCH STATEMENT

Dr. James A. Bednar

The research program of my Computational Systems Neuroscience Group focuses on demonstrating how relatively simple computational models of interconnected neurons can explain a wide array of experimental neuroscience results from animals and humans. From a basic, general architecture compatible with the known wiring of neural pathways in the visual system, along with localized learning rules for connection strengths, my students and I have shown how complex and realistic wiring and functional properties of neurons can develop, including:

1. preferences for all of the spatial features known to be mapped across the primary visual cortex (V1), within the same architecture, including receptive fields selective for retinotopy, orientation, ocular dominance, motion direction, spatial frequency, temporal frequency, disparity, and color,

2. preferences for each of these organized into realistic spatially topographic maps,

3. lateral connections between these neurons that reflect the structure of the maps,

4. realistic surround modulation effects, including their diversity, caused by interactions between these neurons,

5. contrast-gain control and contrast-invariant tuning for the individual neurons, ensuring that they retain selectivity robustly,

6. both simple and complex cells, to account for the major response types of V1 neurons, and

7. long-term and short-term plasticity (e.g. aftereffects), emerging automatically from mechanisms originally implemented for development.

Together, these phenomena arguably represent the bulk of the generally agreed stimulus-driven response properties of V1 neurons. Accounting for such a diverse set of phenomena could have required an extremely complex model, e.g. the union of the many previously proposed models for each of the individual phenomena. Yet our results show that it is possible to account for all of these using only a small set of plausible principles and mechanisms, within a consistent biologically grounded framework.

The overall hypothesis is that much of the complex structure and properties observed in the visual cortex emerges from interactions between simple but highly interconnected computing elements, with connection strengths and patterns self-organizing in response to visual input and other sources of neural activity. Through visual experience, the geometry and statistical regularities of the visual world become encoded into the structure and connectivity of the visual cortex, leading to a complex functional cortical architecture that reflects the physical and statistical properties of the visual world.

These results offer a consistent explanation for a wide body of experimental evidence and create a very rich model of the cortex in which the interactions between properties can be studied in future work. In collaboration with experimental neuroscientists, we have also tested predictions of these models with methods from fMRI, psychophysics, and two-photon imaging, recently demonstrating that results from low-level modeling can be applied successfully to predict phenomena for high-level vision, such as face perception.

The results of these studies have been published in 32 academic papers, 35 conference presentations, and a 537-page book from Springer, together cited more than 700 times, and have also been reported on

BBC Scotland television, Radio Scotland and Radio Borders, and the Scotsman, Metro, and Scottish Daily Mail newspapers. An additional 8 papers have been submitted (1), invited (3), or are in the late stages of preparation by student or post-doc co-authors (4). Each of these publications is listed on the curriculum vitae, and all published papers are downloadable from homepages.inf.ed.ac.uk/jbednar.

My J. Physiology (Paris) review article (in press) outlines how each of my research projects and student projects fits into an overall approach for modeling that is building up to a comprehensive explanation of a very wide array of experimental data about the visual and other sensory cortices. Our current work consists of extending this approach to include detailed spatiotemporal responses (Stevens, Ph.D.), incorporate feedback from higher areas to V1 to complete the major sources of input to visual cortex neurons (Rudiger, Ph.D.), and to make the models able to handle and realistically process the full range of low-level variations in images (Ball, Ph.D.; several M.Sc. projects) in order to have a simple yet accurate account for how visual cortex circuitry (and thus cortical circuitry in general) is constructed and functions during sensory experience. This approach will be validated using systematic data collected from animal visual systems by collaborators.

Once progress has been made on these goals, a wide range of further projects will open up, made possible by having a simple, consistent account for such a large fraction of the observed behavior of the primary visual cortex. First, the same architecture should apply to other sensory (and even motor) systems, because at no point do the models contain any cortical mechanisms specific to vision. Second, behavioral (e.g. psychophysical) results can be predicted and computationally evaluated systematically, potentially giving a coherent explanation to a large range of observations. Third, theoretical work in collaboration with researchers in machine learning and information theory will help elucidate the relationship between the model mechanisms and high-level objectives for which the system may be optimized (such as sparse coding, information maximization, estimation of probability distributions, and recovery of latent variables). Fourth, the resulting model should make an excellent first stage in image processing applications, providing a systematic transformation of the visual input from a highly redundant, noisy signal into a sparse representation of features relevant to a behavioral task.

Together, these studies will go a long way towards explaining and understanding cortical processing for sensory stimuli.

Topographica simulator

All of these projects have been made possible by the *Topographica* open-source Python-based neural simulator, originally created using funds obtained from an NIH grant proposal that I wrote to do my postdoctoral work at the University of Texas at Austin. The modular design of the simulator allows very large and complex models to be constructed from general-purpose components, which allows a large family of interrelated models to be maintained over time. Now freely available from topographica.org, the simulator has been downloaded more than 13,000 times and contains contributions from more than twenty-five developers whose work I coordinate, including numerous students at all levels.

Current collaborators

Frédéric Chavane, Neuroscience, Université de la Méditerranée, France.
David Fitzpatrick, Neuroscience, MPI Florida, USA.
Yves Frégnac, Neuroscience, CNRS, France.
Thomas Mrsic-Flogel, Neuroscience, University College London, UK.
Peter J. B. Hancock, Psychology, Stirling University, UK.
Anya Hurlbert, Neuroscience, Newcastle University, UK.
Laurent Perrinet, Neuroscience, Université de la Méditerranée, France.
Tony J. Prescott, Psychology, University of Sheffield, UK.
Peggy Seriès, Informatics, University of Edinburgh, UK.
Alexander Thiele, Neuroscience, Newcastle University, UK.

TEACHING STATEMENT

Dr. James A. Bednar

Experience

As Director of the Edinburgh Doctoral Training Centre in Neuroinformatics and Computational Neuroscience, I am responsible for overseeing all aspects of the admissions, training, and project selection for the 60 current students in our program and the 10-15 new PhD students who start each year. I provide feedback on and make decisions about more than 50 PhD and Master's projects and 60-80 PhD applicants in any given year, and have thereby gained extensive experience in a very wide range of interdisciplinary research areas in the intersection between computational fields and neuroscience.

Students have also been heavily involved in all aspects of my own research program. Student projects successfully completed under my supervision since 2005 include 7 PhDs (two co-supervised), 14 Master's projects, and 11 undergraduate honors projects. These projects focus on research on computational neuroscience or on simulation software development, and include students interested both in neural modelling and in computer systems design or programming in general. Half of my MSc students have gone on to PhD study, and a majority of my PhD students have gone on to postdoctoral research positions outside of my group in neuroscience or computational neuroscience.

I have taught 12 formal courses at the University of Edinburgh since 2005: 7 for graduate students in my research area of computational neuroscience, and 5 upper-division/Master's service courses in software engineering, focusing on the construction of large-scale, long-term software projects like my *Topographica* simulation software. All but two of these sessions were for courses I designed, including one based on my own textbook and one based on a previous course. For these courses I have three times been nominated by the *Edinburgh University Students Association* for a teaching award. I have also held secondary roles in courses for neural networks, artificial intelligence, cognitive science, computer system design, technical writing, and introductory computer science.

I would be happy to teach courses in neural networks, artificial intelligence, computer programming, computational brain modeling, the visual system, perception, cognitive science, and technical/academic writing.

Philosophy

In my teaching, I work hard to relate the course material to my own and the student's own experiences in research and software development, so that the course material will capture the students' imaginations (and thus be remembered). I also work hard to limit the total number of topics covered during lectures, to prevent the interesting and important ideas from being lost in a sea of details and superficial descriptions. The goal is always to focus on what the students should remember after they graduate, rather than trying to cover every possible issue.

My courses are each structured to make effective use of every available means of communication and interaction with students. Classtime is only one such opportunity, and it is a valuable resource not to be spent on approaches better suited to textbooks, written notes, office hours, and email. For instance, one-sided communication is usually most effective in a written form that can be perused at the reader's own pace, and I make this type of material available online. One-on-one communication works best in office hours, after class, or in email, where both instructor and student can exchange suggestions and give feedback. Classtime, in turn, is most effective when used for group interaction, discussions, and other group activities.

I consider teaching and advising to be a crucial and very enjoyable part of an academic career, and am eager to continue working with new generations of undergraduate and graduate students.

CURRICULUM VITAE

Dr. James A. Bednar

Senior Lecturer (permanent research/teaching staff)
Institute for Adaptive and Neural Computation
School of Informatics
College of Science and Engineering
University of Edinburgh
Informatics Forum, 10 Crichton Street, Edinburgh
EH8 9AB, Scotland, UK

jbednar@inf.ed.ac.uk
Tel(US): 011 44 131 651 3092
Fax(US): 011 44 131 650 6899
Tel(UK): 0131 651 3092
homepages.inf.ed.ac.uk/jbednar
U.S. Citizen

- **Degrees**

Doctor of Philosophy in Computer Science, University of Texas at Austin, 2002.

Master of Arts in Computer Science, University of Texas at Austin, 1997.

Bachelor of Arts in Philosophy, University of Texas at Austin, 1994.

Bachelor of Science in Electrical Engineering, University of Texas at Austin, 1993.

- **Career since graduation**

Senior Lecturer, School of Informatics, University of Edinburgh, 2012-

Lecturer, School of Informatics, University of Edinburgh, 2004-2012

Postdoctoral researcher, Department of Computer Sciences, University of Texas at Austin, 2002-2004.

- **Principal research grants**

Engineering and Physical Sciences Research Council grant EP/F500385/1, *LSI Doctoral Training Centres - Neuroinformatics and Computational Neuroscience*, October 1, 2008 – March 31, 2017. PI: David Willshaw, Co-PIs: Mark van Rossum and James A. Bednar. £4,782,908.

Biotechnology and Biological Sciences Research Council grant BB/F529254/1, *LSI Doctoral Training Centres - Neuroinformatics and Computational Neuroscience*, September 1, 2008 – August 31, 2015. PI: David Willshaw, Co-PIs: Mark van Rossum and James A. Bednar. £458,080.

National Institute of Mental Health (Human Brain Project) grant #1R01-MH66991, *Computational Modeling of Cortical Maps*, April 22, 2002 – May 31, 2006. Co-investigator; PI: Risto Miikkulainen. $765,500.

- **PhD research student supervision:**

PhD theses completed since 2007

Chen Zhao (2011). *Neural Mechanisms for Face and Orientation Aftereffects*. Ph.D. thesis, School of Informatics, The University of Edinburgh, Edinburgh, UK.

Stuart P. Wilson (2011). *Figuring Time by Space: Representing Sensory Motion in Cortical Maps*. Ph.D. thesis, Department of Psychology, The University of Sheffield, Sheffield, UK. Co-supervised with Tony J. Prescott. Next position: EPSRC postdoctoral fellow at Sheffield.

Jan Antolik (2010). *Unified Developmental Model of Maps, Complex Cells and Surround Modulation in the Primary Visual Cortex*. Ph.D. thesis, School of Informatics, The University of Edinburgh, Edinburgh, UK. Next position: Postdocs at UCL and CNRS-Gif, France.

Judith S. Law (2009). *Modeling the Development of Organization for Orientation Preference in Primary Visual Cortex*. Ph.D. thesis, School of Informatics, The University of Edinburgh, Edinburgh, UK. Next position: postdoc with Mark van Rossum, Edinburgh.

Christopher M. Palmer (2009). *Topographic and Laminar Models for the Development and Organisation of Spatial Frequency and Orientation in V1*. Ph.D. thesis, School of Informatics, The University of Edinburgh, Edinburgh, UK.

Marina Papoutsi (2008). *Phonetic Encoding, Verbal Working Memory, and the Role of Broca's Area*. Ph.D. thesis, School of Informatics, The University of Edinburgh, Edinburgh, UK. Next position: Postdoc at Cambridge.

Judah Ben De Paula (2007). *Modeling the Self-Organization of Color Selectivity in the Visual Cortex*. Ph.D. thesis, Department of Computer Sciences, The University of Texas at Austin, Austin, TX. Co-supervised with Risto Miikkulainen (U. Texas).

Current principal PhD supervisor, Institute for Adaptive and Neural Computation, University of Edinburgh: Philipp Rudiger (since 2011), Jean-Luc Stevens (since 2011), Christopher Ball (since 2008).

PhD committee member/non-primary supervisor
Rui Costa, Institute for Adaptive and Neural Computation, University of Edinburgh (since 2011),
Stuart Yarrow, Institute for Adaptive and Neural Computation, University of Edinburgh (since 2010),
Alexander Enoch, Institute of Perception, Action, and Behavior, University of Edinburgh (since 2009),
Ian Saunders, Institute for Adaptive and Neural Computation, University of Edinburgh (since 2007),
David Reichert, Institute for Adaptive and Neural Computation, University of Edinburgh (2009-2010),
Xavier Oliver Duocastella, Institute for Adaptive and Neural Computation, University of Edinburgh (2008-2011),
Matthew Down, Institute for Adaptive and Neural Computation, University of Edinburgh (2008-2011),
Gaurav Malhotra, School of Psychology, University of Edinburgh (2008-2009),
Rowland Sillito, Institute of Perception, Action, and Behavior, University of Edinburgh (2006-2008),
Matthew Szenher, Institute of Perception, Action, and Behavior, University of Edinburgh (2004-2008),
Yiu Fai Sit, Department of Computer Sciences, University of Texas at Austin (2004-2009).

- **Teaching experience at Edinburgh**

Courses created
Computational Neuroscience of Vision (MSc; taught S2007, S2008, S2009, S2011, S2012)
Neuroinformatics Research (MSc; taught S2005)
Software Architecture, Process, and Management (MSc,undergraduate; taught S2006, S2007, S2008, S2012; based on SEOC2)

Courses taught
Neural Computation (MSc; taught A2010)
Software Engineering with Objects and Components 2 (MSc,undergraduate; taught S2005)
Principles of Neuroscience (MSc; organizer for Neuroinformatics week A2010, A2011)

Courses tutored/mentored
System Design Project (undergraduate)
Introduction to Cognitive Science (undergraduate)

- **Postgraduate MSc student supervision:** 14 completed since 2005.

Bilal Khan (2011). *Modelling the Pathway to Auditory Cortex*. Master's thesis, The University of Edinburgh, Scotland, UK.

Konstantin Kudryavtsev (2011). *High Performance Cortical Simulator*. Master's thesis, The University of Edinburgh, Scotland, UK. Registered in Physics via the Edinburgh Parallel Computing Centre.

Jean-Luc Stevens (2011). *A Temporal Model of Neural Activity and VSD Response in the Primary Visual Cortex*. Master's thesis, The University of Edinburgh, Scotland, UK.

Philipp Rüdiger (2011). *Estimating Simple and Complex Cell Receptive Fields from Natural Image Stimuli and 2-Photon Imaging Recordings of V1 in Ferrets*. Master's thesis, The University of Edinburgh, Scotland, UK.

Ravikiran Mattaparthi (2011). *User Interface with Real-World Units*. Master's thesis, The University of Edinburgh, Scotland, UK.

Gautham Ganapathy (2011). *Reconciling Models of Visual Cortex Development with Anatomical Patterns of Lateral Connectivity*. Master's thesis, The University of Edinburgh, Scotland, UK.

John Jacob (2009). *Enhancing the Performance of a Cortical Simulator by Running it on a Graphics Processing Unit*. Master's thesis, The University of Edinburgh, Scotland, UK.

Stuart Wilson (2007). *Self-Organisation Can Explain the Mapping of Angular Whisker Deflections in the Barrel Cortex*. Master's thesis, The University of Edinburgh, Scotland, UK.

Kateryna Gerasymova (2008). *Computational Model of All Known Feature Maps in the Primary Visual Cortex*. Master's thesis, Humboldt-Universitaet zu Berlin, Germany. Visiting student.

Tikesh Ramtohul (2006). *A Self-Organizing Model of Disparity Maps in the Primary Visual Cortex*. Master's thesis, The University of Edinburgh, Scotland, UK.

Veldri Kurniawan (2006). *Self-Organizing Visual Cortex Model Using a Homeostatic Plasticity Mechanism*. Master's thesis, The University of Edinburgh, Scotland, UK.

Chok Ming Ng (2006). *Topographica Model of Somatosensory Cortex*. Master's thesis, The University of Edinburgh, Scotland, UK.

Julien Ciroux (2005). *Simulating the McCollough Effect in a Self-Organizing Model of the Primary Visual Cortex*. Master's thesis, The University of Edinburgh, Scotland, UK.

Christopher Ball (2005). *Motion Aftereffects in a Self-Organizing Model of Primary Visual Cortex*. Master's thesis, The University of Edinburgh, Scotland, UK.

- **Administrative experience**

  Director of the Doctoral Training Centre in Neuroinformatics at the University of Edinburgh since September 2010.

  Deputy Director of the Doctoral Training Centre in Neuroinformatics at the University of Edinburgh 2005-2010.

- **Committee membership**

University of Edinburgh

Strategy committee for University of Edinburgh School of Informatics, since 2011.

University of Edinburgh ECDF Oversight by Researchers Group (joint Informatics representative), since 2011.

Computing committee for University of Edinburgh School of Informatics, 2004-2006.

Executive committee for
University of Edinburgh Doctoral Training Centre in Neuroinformatics, since 2004.
University of Edinburgh Institute for Adaptive and Neural Computation, since 2004.

UK

Panel member for UK EPSRC ICT Responsive Mode grant proposal reviews, April 2012.

International

Technical committee for *International Joint Conference on Neural Networks (IJCNN*2008,2010,2012)*.

Programme committee for
INCF short course *Towards an integrative computational neuroscience*, Edinburgh, August 2012.
7th International Workshop on Self-Organizing Maps (WSOM 2009).
International Conference on Development and Learning (ICDL-08,ICDL-09).
International Conference on Machine Learning (ICML-2004).

Scientific Advisory Panel for the EU-funded BIOTACT project (biotact.org), since 2009.

Board of Directors for the *Organization for Computational Neuroscience*, 2005-2008.

Review editorial board for *Frontiers in Neuroinformatics*, since 2009, and
Frontiers in Computational Neuroscience, since 2012.

Review committee for the *Computational Neuroscience Conference (CNS 2005,2006,2008,2011,2012)*.
Editorial board for the journal *Neural Information Processing – Letters and Reviews*, since 2003.

- **Invited international presentations**

Title TBA:

Biological and Computer Vision Interfaces workshop at the *12th European Conference on Computer Vision*, Florence, Italy, October 12-13, 2012.

"Building a Comprehensive Model for the Development and Function of the Visual Cortex":

Brain Corporation, San Diego, July 9, 2012.

Neuromathematics and Models of Perception lecture series, Institut Henri Poincaré, Paris, France, December 5, 2011.

Ladislav Tauc Conferences & GDR MSPC Neurosciences Joint Meeting, CNRS, Gif-sur-Yvette, France, December 16, 2010.

Fitzpatrick Lab, Duke University Medical Center, January 25, 2010.

Department of Computer Sciences, University of Texas at Austin, August 4, 2009.

Glion2008 Workshop on Learning and Dynamics in Vision, Glion, Switzerland, October 28, 2008.

"Computational Maps in the Visual Cortex":

Faculty of Mathematics and Physics, Charles University, Prague, October 19, 2007.

Department of Neurobiology and Anatomy University of Texas Medical School at Houston, Texas, July 6, 2005.

Department of Computer Science and Engineering, Oregon Graduate Institute School of Science & Engineering, Oregon Health & Sciences University, April 6, 2004.

Department of Electrical Engineering and Computer Science, Tulane University, April 2, 2004.

Department of Computer Science, Colorado State University, March 25, 2004.

Department of Electrical & Computer Engineering, University of Houston, Texas, March 22, 2004.

Department of Computer Science and Engineering, University of South Carolina, March 5, 2004.

"Modeling Cortical Function and Development with *Topographica*".

FACETS CodeJam workshop #1, the University of Heidelberg, April 3, 2007.

Center for Perceptual Systems, University of Texas at Austin, November 18, 2002.

"Learning to See: Modeling the Development of Visual Function":

Life Sciences Department (INSERM U483), Université Pierre et Marie Curie, Paris, November 26, 2002.

Department of Computer Science & Engineering, Michigan State University, May 7, 2002.

Department of Computer Science, Georgetown University, March 18, 2002.

- **Invited UK presentations**

Title TBA:

London Mathematical Society and Engineering and Physical Sciences Research Council (EPSRC) symposium *Grand Biological Challenges for Mathematicians: From Cells and Microbes to Brains*, July 9-19, 2012.

"Semi-Declarative Model Specification in Python"

BrainScaleS CodeJam Workshop #5, Edinburgh, UK, March 14, 2012.

"Building a Comprehensive Model for the Development and Function of the Visual Cortex":

Visual Cognition Lab, University of Edinburgh, December 4, 2009.

Department of Psychology, University of Sheffield, November 28, 2008.

UK-COLAMN Workshop on Cortical Microcircuitry, University College London, September 4, 2008.

"Computational Maps in the Visual Cortex":

Department of Physiology, University College London, March 28, 2008.

School of Biology, University of Newcastle, March 28, 2006.

Centre for Theoretical and Computational Neuroscience, University of Plymouth, May 25, 2005.

"Learning to See: Modeling the Development of Visual Function":

Centre for Brain & Cognitive Development, School of Psychology, Birkbeck, University of London, September 17, 2002.

- **Guest lecturing:**

"Corso Interdisciplinare in Neuroinformatics":

University of Catania, Scuola Superiore, March 29–April 2, 2009. One-week full-time version of my *Computational Neuroscience of Vision* course.

"Modeling Topographic Maps in the Visual System":

INCF short course in neuroinformatics, University of Edinburgh, August, 2012.

Principles of Neuroscience MSc course, University of Edinburgh, 2005-2011.

Edinburgh Neuroinformatics Summer School, University of Edinburgh, August 26, 2004.

Edinburgh Neuroinformatics Summer School, University of Edinburgh, September 13, 2002.

- **Workshop organisation**

Co-chair (with Sharon Crook and Hans Ekkehard Plesser), *Creating, Documenting, and Sharing Network Models*, Edinburgh, UK, September 20-21 2011.

Chair, "Modeling Cortical Map Development," workshop at the *Fifteenth Annual Computational Neuroscience Meeting* (CNS-2006, Edinburgh, UK), July 2006.

Co-chair (with Risto Miikkulainen), "Modeling Cortical Map Development," workshop at the *Tenth Annual Computational Neuroscience Meeting* (CNS-2001, San Francisco, CA), July 2001.

- **Open-source software packages**

Topographica software for flexible simulation of hierarchies of interconnected topographic maps. Eleven releases since 2005 available at http://topographica.org.

LISSOM (Laterally Interconnected Synergetically Self-Organizing Map) software for simulating the development of visual maps with intracortical connections, v2.0 (1998) – v5.0 (2004).

- **Reviewing**

Reviewer for the funding agencies *Medical Research Council (MRC)* (2010,2009), *Biotechnology and Biological Sciences Research Council (BBSRC)* (2009,2006), *Engineering and Physical Sciences Research Council (EPSRC)* (2012 (as panel member),2006,2005,), *Economic and Social Research Council (ESRC)* (2006), *Neurological Foundation of New Zealand* (2006), *The Wellcome Trust* (2005).

Reviewer for the journals *Neural Computation* (2009,2008,2007,2006,2005), *Journal of Computational Neuroscience* (2011,2010), *Vision Research* (2012,2010), *PLoS Computational Biology* (2011), *Neuroinformatics* (2010), *Cerebral Cortex* (2005), *Frontiers in Neuroinformatics* (2008), *Proceedings of the Royal Society of London, Series A* (2009), *Network — Computation in Neural Systems* (2012,2005,2002,2001,1999), *Neural Networks* (2008,2004), *Biological Cybernetics* (1997). *IEEE Transactions on Evolutionary Computation* (2005), *IEEE Transactions on Autonomous Mental Development* (2011), *Developmental Science* (2011,2010,2008), *Connection Science* (2005), *Physical Review E* (2011,2010).

LIST OF PUBLICATIONS

2010 ISI/JCR impact factors are shown where available.

1. **Books published**

Risto Miikkulainen, James A. Bednar, Yoonsuck Choe, and Joseph Sirosh (2005). *Computational Maps in the Visual Cortex*. Springer, Berlin.

2. **Books edited**

Eilif Muller, Marc-Oliver Gewaltig, Michael Hines, Markus Diesmann, Andrew P. Davison, James A. Bednar, and Rolf Kötter (eds.) (2012). *Python in Neuroscience*. Frontiers. E-Book and special section of *Frontiers in Neuroinformatics*. In press. 24 articles.

3. **Refereed journal articles**

James A. Bednar (2012). Building a mechanistic model of the development and function of the primary visual cortex. *Journal of Physiology (Paris)*. In press. 24 pages. Review. Invited contribution. Impact factor: **3.03**

Jan Antolik and James A. Bednar (2011). Development of maps of simple and complex cells in the primary visual cortex. *Frontiers in Computational Neuroscience*, 5:17. Impact factor: **2.586**

Chen Zhao, Peggy Seriès, Peter J. B. Hancock, and James A. Bednar (2011). Similar neural adaptation mechanisms underlying face gender and tilt aftereffects. *Vision Research*, 51(18):2021–2030. Impact factor: **2.33**

Stuart P. Wilson, James A. Bednar, Tony J. Prescott, and Ben Mitchinson (2011). Neural computation via neural geometry: A place code for inter-whisker timing in the barrel cortex?. *PLoS Computational Biology*, 7(10):e1002188. Impact factor: **5.515**

Stuart P. Wilson, Judith S. Law, Ben Mitchinson, Tony J. Prescott, and James A. Bednar (2010). Modeling the emergence of whisker direction maps in rat barrel cortex. *PLoS One*, 5(1):e8778. Impact factor: **4.41**

Marina Papoutsi, Jacco A. De Zwart, J. Martijn Jansma, Martin Pickering, James A. Bednar, and Barry Horwitz (2009). From phonemes to articulatory codes: An fMRI study of the role of Broca's area in speech production. *Cerebral Cortex*, 19:2156–2165. Impact factor: **6.844**

James A. Bednar (2009). Topographica: Building and analyzing map-level simulations from Python, C/C++, MATLAB, NEST, or NEURON components. *Frontiers in Neuroinformatics*, 3:8. 9 pages. Invited contribution.

James A. Bednar (2008). Understanding neural maps with Topographica. *Brains, Minds, and Media*, 3:bmm1402. 8 pages. Invited contribution.

Vinod Valsalam, James A. Bednar, and Risto Miikkulainen (2007). Developing complex systems using evolved pattern generators. *IEEE Transactions on Evolutionary Computation*, 11(2):181–198. Impact factor: **4.371**

James A. Bednar, Amol Kelkar, and Risto Miikkulainen (2004). Scaling self-organizing maps to model large cortical networks. *Neuroinformatics*, 2:275–302. Impact factor: **3.027**

James A. Bednar and Risto Miikkulainen (2003). Learning innate face preferences. *Neural Computation*, 15(7):1525–1557. Impact factor: **2.290**

James A. Bednar and Risto Miikkulainen (2000). Tilt aftereffects in a self-organizing model of the primary visual cortex. *Neural Computation*, 12(7):1721–1740. Impact factor: **2.290**

4. **Refereed book chapters**

James A. Bednar and Risto Miikkulainen (2007). Constructing visual function through prenatal and postnatal learning. In: *Neuroconstructivism, Vol. 2: Perspectives and Prospects*, Denis Mareschal, Mark H. Johnson, Sylvain Sirois, Michael Spratling, Michael S. C. Thomas, and Gert Westermann, eds., 13–37. Oxford University Press, Oxford, UK. Invited contribution.

Risto Miikkulainen, James A. Bednar, Yoonsuck Choe, and Joseph Sirosh (1997). Self-organization, plasticity, and low-level visual phenomena in a laterally connected map model of the primary visual cortex. In: *Perceptual Learning*, R. L. Goldstone, P. G. Schyns, and D. L. Medin, eds., volume 36 of *Psychology of Learning and Motivation*, 257–308. Academic Press, San Diego, CA.

5. **Book chapters**

James A. Bednar (2003). The role of internally generated neural activity in newborn and infant face preferences. In: *Face Perception in Infancy and Early Childhood*, Olivier Pascalis and Alan Slater, eds., 133–142. NOVA Science Publishers, New York. Invited contribution.

Risto Miikkulainen, James A. Bednar, Yoonsuck Choe, and Joseph Sirosh (1999). Modeling self-organization in the visual cortex. In: *Kohonen Maps*, Erkki Oja and Samuel Kaski, eds. Elsevier, Amsterdam.

Joseph Sirosh, Risto Miikkulainen, and James A. Bednar (1996). Self-organization of orientation maps, lateral connections, and dynamic receptive fields in the primary visual cortex. In: *Lateral Interactions in the Cortex: Structure and Function*, Joseph Sirosh, Risto Miikkulainen, and Yoonsuck Choe, eds. The UTCS Neural Networks Research Group, Austin, TX. Electronic book, ISBN 0-9647060-0-8, http://nn.cs.utexas.edu/web-pubs/htmlbook96.

6. **Refereed conference proceedings papers**

Gaurav Malhotra, Martin Pickering, Holly P. Branigan, and James Bednar (2008). On the persistence of structural priming: Mechanisms of decay and influence of word-forms. In: *Proceedings of the 30th Annual Conference of the Cognitive Science Society*, B. C. Love, K. McRae, and V. M. Sloutsky, eds., 657–662. Austin, TX: Cognitive Science Society.

James A. Bednar and Risto Miikkulainen (2006). Joint maps for orientation, eye, and direction preference in a self-organizing model of V1. *Neurocomputing*, 69(10–12):1272–1276. Impact factor: **1.429**

Stefanie Jegelka, James A. Bednar, and Risto Miikkulainen (2006). Prenatal development of ocular dominance and orientation maps in a self-organizing model of V1. *Neurocomputing*, 69:1291–1296.

Vinod Valsalam, James A. Bednar, and Risto Miikkulainen (2006). Establishing an appropriate learning bias through development. In: *Proceedings of the Fifth International Conference on Development and Learning (ICDL-2006)*.

James A. Bednar, Judah B. De Paula, and Risto Miikkulainen (2005). Self-organization of color opponent receptive fields and laterally connected orientation maps. *Neurocomputing*, 65–66:69–76.

Vinod Valsalam, James A. Bednar, and Risto Miikkulainen (2005). Constructing good learners using evolved pattern generators. In: *Proceedings of the Genetic and Evolutionary Computation Conference, GECCO-2005*, H.-G. Beyer et al., eds., 11–18. New York: ACM. Winner of the *Best Paper* award for A-Life, Evolutionary Robotics, and Adaptive Behavior.

James A. Bednar and Risto Miikkulainen (2004). Prenatal and postnatal development of laterally connected orientation maps. *Neurocomputing*, 58-60:985–992.

James A. Bednar, Yoonsuck Choe, Judah De Paula, Risto Miikkulainen, Jefferson Provost, and Tal Tversky (2004). Modeling cortical maps with Topographica. *Neurocomputing*, 1129–1135.

James A. Bednar and Risto Miikkulainen (2003). Self-organization of spatiotemporal receptive fields and laterally connected direction and orientation maps. *Neurocomputing*, 52–54:473–480.

James A. Bednar and Risto Miikkulainen (2002). Neonatal learning of faces: Environmental and genetic influences. In: *Proceedings of the 24th Annual Conference of the Cognitive Science Society*, Wayne Gray and Christian Schunn, eds., 107–112. Erlbaum, Hillsdale, NJ.

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7. **Conference poster and talk abstracts**

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8. **Patents**

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9. **Articles in preparation**

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References

Professor David Willshaw
School of Informatics
University of Edinburgh
10 Crichton Street, Edinburgh
EH8 9AB UK
Tel: +44 131 650 4404
Fax: +44 131 650 6899
willshaw@inf.ed.ac.uk
http://homepages.inf.ed.ac.uk/willshaw/

Professor Yves Frégnac
Centre National de la Recherche Scientifique
CNRS UPR-3293
1 Avenue de la Terrasse
91198 Gif-sur-Yvette, France
Tel: +33 169 823 415
Fax: +33 169 823 427
yves.fregnac@unic.cnrs-gif.fr
http://www.unic.cnrs-gif.fr/people/Yves_Frégnac

Professor Tony Prescott
Department of Psychology,
The University of Sheffield,
Western Bank, Sheffield
S10 2TN, UK
Tel: +44 114 222 6547
Fax: +44 114 276 6515
T.J.Prescott@sheffield.ac.uk
http://www.shef.ac.uk/psychology/staff/academic/tony-prescott

Dr Peggy Seriès, Lecturer
School of Informatics
University of Edinburgh
10 Crichton Street, Edinburgh
EH8 9AB UK
Tel: +44 131 650 3088
Fax: +44 131 650 6899
pseries@inf.ed.ac.uk
http://homepages.inf.ed.ac.uk/pseries/