PERSONAL INFORMATION

Last name:	**El-Boustani**
First name:	**Sami**
Gender:	Male
Nationality:	Swiss
Marital Status:	Married
Position:	SNSF Assistant Professor
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EDUCATION

09/2000 – 04/2005 **Bachelor and Master in Theoretical Physics**
École Polytechnique Fédérale de Lausanne (Switzerland)
Master project supervisor: Philippe-André Martin
Thesis title: Equilibrium correlations in charged fluids coupled to radiation field

09/2005 – 06/2006 **Master in Cognitive Sciences**
École Normale Supérieure of Paris (France)
Master project supervisor: Alain Destexhe
Thesis title: Information processing in networks exhibiting irregular activity

09/2006 – 09/2010 **PhD in Neurosciences – Université Pierre et Marie Curie Paris 6**
Unit of Neuroscience, Information & Complexity (Gif-sur-Yvette, France)
Thesis title: Learning and Coding Correlations in Stochastic Network States
PhD Supervisor: Alain Destexhe
Defense date: 16/09/2010
Referees: Larry F. Abbott, Haim Sompolinsky, Nicolas Brunel & Laurent Bourdieu

08/2009 **Methods in Computational Neuroscience**
Directors: Michael Berry and Adrianne Fairhall
Marine Biological Laboratory (Woods Hole, USA)

08/2007 **Advanced Course in Computational Neuroscience**
Directors: John Rinzel, Nicolas Brunel, Peter Latham and Israel Nelken
Programme of European Neuroscience Schools (Arcachon, France)

EMPLOYMENT HISTORY

03/2011 – 04/2015 **Postdoctoral Fellow**
Mriganka Sur Laboratory
Supervisor: Mriganka Sur
Massachusetts Institute of Technology – MIT (Cambridge, USA)

05/2015 – Present **Postdoctoral Fellow**
Laboratory for Sensory Processing - LSENS
Supervisor: Carl Petersen
École Polytechnique Fédérale de Lausanne – EPFL (Lausanne, Switzerland)

SUPERVISION AND MENTORING

01/2012 – 04/2015 Supervision in the Sur laboratory (MIT, USA)

01/2012 – 04/2015 **Rajeev Vijay Rihkye** (Rotation project and PhD work)
Topic: Population coding of natural visual statistics in mouse V1 using two-photon calcium imaging of layer 2/3 neurons.

10/2012 – 12/2012 **Kisuk Lee** (Rotation project)
Topic: Recurrent network model to recapitulate somatostatin-interneurons contribution to surround suppression effect in mouse primary visual cortex.

10/2013 – 12/2013 **Chen Sun** (Rotation project)
Topic: Charcaterization of synaptic inputs temporal coordination during two-photon dendritic calcium imaging.

07/2011 – 09/2011 **Anubhav Jain** (UROP student program)
Topic: Investigations in space-time interactions during natural viewing.

TEACHING EXPERIENCE

11/2018 **Course Instructor (for master students)**
Lecture: Plasticity in the Visual Cortex
Master 2: Biologie Intégrative et Physiologie, Sorbonnes University (Paris, Fance)

07/2014 – 07/2015 **Course Instructor (for undergraduate students)**
MITx: 7.QBWr Quantitative Biology Workshop – Introduction to Visual Neuroscience with hands-on Matlab and ImageJ, MIT (Cambridge, USA)
Summary information: During this 3 hours course, students were introduced to visual neuroscience and were taught how to use software such as ImageJ and Matlab to work on calcium imaging data.

08/2012 **Teaching Assistant (for graduate students and postdocs)**
Methods in Computational Neuroscience
Marine Biological Laboratory (Woods Hole, USA)

01/2012 **Course Instructor (for graduate students and postdocs)**
Title: Model-based Approaches in Sensory Systems
MIT Independent Activities Period for-credit program, MIT (Cambridge, USA)
Summary information: This course was intended to help graduate and undergraduate students learn state-of-the-art data analysis techniques that could be applied to their own research projects. This course was divided in 3 lectures of 2 hours covering several approaches including reverse correlation, maximum entropy and GLM models.

09/2010 **Teaching Assistant (for graduate students and postdocs)**
Workshop on Animal Research in Neuroscience in the framework of the FACETS European project (Gif-sur-Yvette, France)

11/2003 – 12/2003 **Substitute Teacher (for high school students)**
École de Culture Générale, Jean-Piaget (Geneva, Switzerland)

SCIENTIFIC REVIEWING ACTIVITY FOR JOURNALS

Journal of Computational Neuroscience, PLoS Computational Biology, Neural Computation, Journal of Physiology (Paris), International Journal of Bifurcation and Chaos, Brain and Cognition

MEMBERSHIP IN SCIENTIFIC SOCIETIES

Society for Neuroscience (SfN)
Organization for Computational Neurosciences (OCNS)
Swiss Society for Neuroscience (SSN)

ORGANISATION OF CONFERENCES

07/2013 **Workshop at Computational Neuroscience Meeting (Paris, France)**
Title: “Recent advances in experimental and computational characterization of neural assemblies” – co-organized with Adrien Peyrache

PRIZES, AWARDS AND FELLOWSHIPS

11/2018 **SNSF Eccellenza Professorial Fellowship** (ranked 1st)

09/2018 **Bettencourt Schueller foundation** laureate (declined)

06/2018 **ATIP-Avenir** program CNRS-INSERM (declined)

10/2013 **“La Recherche” prize** for the best paper in Neuroscience in 2012

03/2012 – 05/2016 **Marie Curie International Outgoing Fellowship** (FP7-PEOPLE-2010-IOF)

03/2011 – 03/2012 **European Molecular Biology Organization (EMBO) Fellowship**

03/2011 **Human Frontier Science Program (HFSP) Fellowship** (declined)

09/2009 – 09/2010 **La Fondation pour la Recherche Médicale Fellowship**

09/2006 – 09/2009 **French Ministry of Research Fellowship**

PUBLICATIONS (* co-first authors)

S. El-Boustani*, B.S. Sermet*, J.M. Mayrhofer, C.C.H. Petersen, Parallel and distinct thalamo-cortical inputs in somatosensory cortices, (in preparation)

S. El-Boustani*, J.M. Mayrhofer*, B.S. Sermet, M.P. Auffret, C.C.H. Petersen, Emergence of sensory-motor transformation in the secondary somatosensory cortex, (in preparation)

J.M. Mayrhofer*, **S. El-Boustani***, M.P. Auffret, C.C.H. Petersen, Tongue-Jaw motor cortex – Neuronal characteristics during multi-modal and goal-directed behaviors, (in preparation)

J PK Ip, **S. El-Boustani**, M. Sur, Mechanisms of experience-dependent plasticity in visual cortex circuits, The Oxford Handbook of Cortical Plasticity (under revision)

S. El-Boustani*, J PK Ip*, V. Breton-Provencher, H. Okuno, H. Bito, M. Sur, Locally coordinated synaptic plasticity shapes cell-wide plasticity of visual cortex neurons *in vivo*, Science, 6395:1349-1354 (2018)

S. El-Boustani & M. Sur, Response-dependent dynamics of cell-specific inhibition in cortical networks in vivo, Nature Communications, 5:5689 doi: 10.1038/ncomms6689 (2014)

S. El-Boustani, N.R. Wilson, C.A. Runyan & M. Sur, Reply to 'Interneuron subtypes and orientation tuning', Nature, 508: E1-E4 (2014)

L. Estebanez*, **S. El-Boustani***, A. Destexhe & D. Shulz, Ce que les vibrisses disent au cerveau tactile, Médecine/Sciences 39: 93-98 (2014)

L. Estebanez*, **S. El-Boustani***, A. Destexhe & D. Shulz, Correlated input reveals coexisting coding schemes in a sensory cortex, Nature Neuroscience 15 : 1691-1699 (2012)

S. El-Boustani*, P. Yger*, Y. Frégnac & A. Destexhe, Stable learning in stochastic network states, Journal of Neuroscience 32(1) : 194-214 (2012)

P. Yger*, **S. El-Boustani***, A. Destexhe & Y. Frégnac, Topologically invariant macroscopic statistics in balanced networks of conductance-based integrate-and-fire neurons, Journal of Computational Neuroscience 31(2) : 229-45 (2011)

S. El-Boustani & A. Destexhe, Brain dynamics at multiple scales: can one reconcile the apparent low-dimensional chaos of macroscopic variables with the seemingly stochastic behavior of single neurons?, International Journal of Bifurcation and Chaos 20(6) : 1687-1702 (2010)

S. El-Boustani*, O. Marre*, S. Béhuret, P. Baudot, P. Yger, T. Bal, A. Destexhe & Y. Frégnac, Network-state modulation of power-law frequency-scaling in visual cortical neurons, PLoS Computational Biology 5(9) : e1000519 (2009)

O. Marre*, **S. El-Boustani***, Y. Frégnac & A. Destexhe, Prediction of spatio-temporal patterns of neural activity from pairwise correlations, Physical Review Letters 102(13) : 138101 (2009)

S. El-Boustani & A. Destexhe, A master equation formalism for macroscopic modeling of asynchronous irregular activity states, Neural Computation 21(1) : 46-100 (2009)

S. El-Boustani, M. Pospischil, M. Rudolph & A. Destexhe, Activated cortical states: experiments, analyses and models, Journal of Physiology (Paris) 101 : 99-109 (2007)

R. Brette, M. Rudolph, T. Carnevale, M. Hines, D. Beeman, JM. Bower, M. Diesmann, A. Morrison, PH. Goodman, FC. Jr Harris, M. Zirpe, T. Natschläger, D. Pecevski, B. Ermentrout, M. Djurfeldt, A. Lansner, O. Rochel, T. Vieville, E. Muller, AP. Davison, **S. El-Boustani**, A. Destexhe, Simulation of networks of spiking neurons : a review of tools and strategies, Journal of Computational Neuroscience 23(3) : 349-98 (2007)

S. El-Boustani, PR. Buenzli & PA. Martin, Equilibrium correlations in charged fluids coupled to the radiation field, Physical Review E 73, 36113 (2006)

MAJOR SCIENTIFIC ACHIEVEMENTS

Sensory integration in the rodent somatosensory cortex
Woolsey and Van der Loos discovered in the early seventies a remarkable somatotopic organization in the rodent primary whisker somatosensory cortex (wS1) whereby discrete cortical entities, so-called barrels, are anatomically related to single facial whiskers with similar spatial arrangement. Although this distinct cytoarchitecture suggests that single cortical columns are dedicated to the sole processing of their corresponding whisker kinetics, many studies have challenged this simple model. This body of work has left the field with a complex phenomenology preventing a unified description of tactile functional processing. In collaboration with Daniel Shulz's lab, I designed a novel experimental paradigm to systematically explore the functional properties of single-neurons in rat wS1 in response to complex multi-whisker stimuli (Estebanez et al., 2012). **Using advanced reverse correlation techniques, we revealed the existence of distinct functional classes dedicated to the encoding of local antagonist whisker motions and global coherent motions across the whisker pad respectively.** This demonstrated that wS1 is endowed with the capacity to encode richer features of tactile scenes than previously thought. During the project my collaborator Luc Estebanez performed most of the experiments while I designed the approach, developed the protocols and analyzed the data.

Stable learning in sensory systems in vivo
A central question in the study of learned behaviors is the cellular mechanisms by which new memories are acquired. In his seminal work, Donald Hebb hypothesized that synaptic efficacy strengthening underlies these processes and that these changes occur when two connected neurons are co-active within a short time window. However, the original Hebbian rule required additional mechanisms to stabilize learned memories in active networks over long periods of time. As a collaborative project between the laboratories of Alain Destexhe and Yves Frégnac, I introduced a new plasticity rule of spike-timing dependent plasticity endowed with heterosynaptic metaplasticity that could reproduce a broad ensemble of experimental phenomenology (El-Boustani et al., 2012). **We showed that this rule can stabilize synaptic engrams in networks without being erased by the ongoing activity or evoking pathological activity states.** Driven by this modeling study, I devised new experiments in Mriganka Sur's laboratory to investigate the molecular mechanisms that underlie heterosynaptic plasticity in primary visual cortex (V1) of mice. Using a combination of single-cell two-photon imaging and optogenetic manipulation, we were able to induce receptive field plasticity in single-neurons of awake mice and study synaptic reorganization along dendritic branches (El-Boustani et al., 2018). We found that local homeostatic interactions take place around potentiated spines in stretches of dendrites and that this heterosynaptic plasticity involves AMPA receptors reorganization through redistribution of the immediate early gene Arc. **This work demonstrates how local homeostatic plasticity can orchestrate cell-wide plasticity in dendrites displaying heterogeneous functional organization and how this cooperative plasticity might be disrupted in neurological disorders displaying abnormal Arc expression such as Fragile X syndrome (Ip et al., submitted).** For this project, I designed protocols, performed experiments with Jacque Ip and analyzed the data.

Interneuron cell-type specific computation
Although glutamatergic neurons compose a majority of cortical neurons, GABAergic interneurons play a key role in shaping sensory processing and plasticity of the mature and developing brain. Interneurons can be divided into classes that differ in molecular, morphological and functional properties. Considerable attention has been drawn to parvalbumin-expressing (PV) and somatostatin-expressing (SST) interneurons, the two key cell-types that target pyramidal neurons. Several studies have attributed immutable functions to these interneurons by showing that they inhibit the response of their targets through either of two fundamental arithmetic operations, namely subtraction or division. However opposite conclusions were reached leaving the problem partly unresolved (El-Boustani et al., 2014). During my postdoctoral work in the Sur laboratory I addressed this issue by using precisely timed optogenetic manipulation in combination with two-photon calcium imaging or targeted electrophysiology (El-Boustani & Sur, 2014). **We showed experimentally and with computational models that the function of these interneurons adapts to the stimulus ensemble. In particular, SST interneurons effect on target cells can either be divisive or subtractive depending on the size of the visual stimulus presented.** This more general description of interneuron functions was used to reconcile divergent published results.

Analysis of spontaneous and sensory-evoked activity *in vivo*
Spontaneous activity of cortical neuron networks is characterized by stochastic-like firing patterns at various scales ranging from the single-cell to population signals such as local field potentials. However, the exact dynamical nature of these stochastic states remains poorly understood. In order to dissect out higher-order correlation patterns present in the spontaneous and evoked activity, we developed model-inspired analysis tools that were applied to intracellular and multielectrode extracellular recordings. **We found that the subthreshold response of neurons in the cat V1 can reflect correlations in the visual stimulus by pooling coordinated presynaptic inputs** (El-Boustani et al., 2009). At the extracellular level, we developed a Markovian model that can accurately predict spatio-temporal spike pattern of several neurons recorded simultaneously. This approach was applied in the cat parietal cortex in different sleep states - SWS and REM sleep. **This analysis revealed that the cortical spontaneous activity in lightly anesthetized or awake animals was characterized by weak pairwise correlations among neurons** (Marre et al., 2010). I developed the models and performed analysis together with Olivier Marre.