

## **Gianluigi Mongillo**

CR Research Scientist (since October 2009 – titularisation: October 2010)

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## **Education**

### **Ph.D., Neurophysiology**

University of Rome “La Sapienza”, Rome (Italy), 2005

Dissertation: Learning dynamics leading to persistent activity in recurrent networks of spiking neurons.

Supervisor: Prof. Daniel J. Amit

### **M.Sc., Physics**

University of Rome “La Sapienza”, Rome (Italy), 2000

## **Fellowships**

Postdoctoral fellowship, École des Neurosciences de Paris Île-de-France, Paris (France), 2008-09

Postdoctoral fellowship, Hebrew University of Jerusalem, Jerusalem (Israel), 2008-09

Postdoctoral fellowship, Group for Neural Theory, École Normale Supérieure, Paris (France), 2006-07

Postdoctoral fellowship, GATSBY Unit, University College of London, London (UK), 2005-06

Research Student, Hebrew University of Jerusalem, Jerusalem (Israel), 2000-02

## **Publications in Peer-reviewed Journals**

**Mongillo G**, Rumpel S, Loewenstein Y. Inhibitory Connectivity Defines the Realm of Excitatory Plasticity. *Nature Neuroscience* **21**:1463-1470 (2018).

**Mongillo G**, Rumpel S, Loewenstein Y. Intrinsic Volatility of Synaptic Connections – A Challenge to the Synaptic Trace Theory of Memory. *Current Opinion in Neurobiology* **46**:7-13 (2017).

**Mongillo G**, Loewenstein Y. Neuroscience: Formation of a Percept in the Rat Cortex. *Current Biology* **27**:R423-R425 (2017).

Barri A, Wang Y, Hansel D, **Mongillo G**. Quantifying Repetitive Transmission at Chemical Synapses: A Generative-Model Approach. *eNeuro* **3**:ENEURO-0113 (2016).

Tartaglia EM, Brunel N, **Mongillo G**. Modulation of Network Excitability by Persistent Activity: How Working Memory Affects the Response to Incoming Stimuli. *PLoS Computational Biology* **11**:e1004059 (2015).

Tartaglia EM, **Mongillo G**, Brunel N. On the Relationship Between Persistent Delay Activity, Repetition Enhancement and Priming. *Frontiers in Psychology* **5**:1590 (2014).

**Mongillo G**, Shteingart H, Loewenstein Y. The Misbehavior of Reinforcement Learning. *Proceedings of the IEEE* **102**:528-541 (2014).

**Mongillo G**, Shteingart H, Loewenstein Y. Race Against the Machine. *Proceedings of the IEEE* **102**:542-543 (2014).

**Mongillo G**, Hansel D, van Vreeswijk C. Bistability and Spatiotemporal Irregularity in Neuronal Networks with Nonlinear Synaptic Transmission. *Physical Review Letters* **108**:158101 (2012).

Roxin A, Brunel N, Hansel D, **Mongillo G**, van Vreeswijk C. On the Distribution of Firing Rates in Networks of Cortical Neurons. *Journal of Neuroscience* **31**:16217-16226 (2011).

**Mongillo G**, Denève S. Online Learning with Hidden Markov Models. *Neural Computation* **20**:1706-1716 (2008).

**Mongillo G**, Barak O, Tsodyks MV. Synaptic Theory of Working Memory. *Science* **319**:1543-1546 (2008). (Featured in Faculty of 1000)

Preview in: Fusi S. A Quiescent Working Memory. *Science* **319**:1495-1496 (2008).

Editor's Choice: Stern P. A Working Model of Working Memory. *Science Signaling* **1**, ec105 (2008).

Romani S, Amit DJ, **Mongillo G**. Mean-field Analysis of Selective Persistent Activity in Presence of Short-term Synaptic Depression. *Journal of Computational Neuroscience* **20**:201-217 (2006).

**Mongillo G**, Curti E, Romani S, Amit DJ. Learning in Realistic Networks of Spiking Neurons and Spike-driven Plastic Synapses. *European Journal of Neuroscience* **21**:3143-3160 (2005).

Curti E, **Mongillo G**, La Camera G, Amit DJ. Mean-field and Capacity in Realistic Networks of

Spiking Neurons Storing Sparsely Coded Random Memories. *Neural Computation* **16**:2597-2637 (2004).

Amit DJ, **Mongillo G**. Selective Delay Activity in the Cortex: Phenomena and Interpretation. *Cerebral Cortex* **13**:1139-1150 (2003).

**Mongillo G**, Amit DJ, Brunel N. Retrospective and Prospective Persistent Activity Induced by Hebbian Learning in a Recurrent Cortical Network. *European Journal of Neuroscience* **18**:2011-2024 (2003).

Amit DJ, **Mongillo G**. Spike-driven Synaptic Dynamics Generating Working Memory States. *Neural Computation* **15**:565-596 (2003).

**Mongillo G**, Amit DJ. Oscillations and Irregular Emission in Networks of Linear Spiking Neurons. *Journal of Computational Neuroscience* **11**:249-261 (2001).

### **Book Chapters**

**Mongillo G**. *Models of Working Memory*. Encyclopedia of Computational Neurosciences, Dieter Jaeger and Ranu Jung Editors. Springer (2014).

**Mongillo G**. *Hebbian Learning*. Encyclopedia of the Sciences of Learning, Norbert M. Seel Editor. Springer (2012).

**Mongillo G**, Brunel N. Preface to *Retrospective and Prospective Persistent Activity Induced by Hebbian Learning in a Recurrent Cortical Network* by G Mongillo, DJ Amit, N Brunel. *European Journal of Neuroscience* **18**:2011-2024 (2003). Selected Papers of Daniel Amit, N Brunel, S Fusi, P del Giudice, G Parisi and MV Tsodyks Editors. World Scientific (2012).

**Mongillo G**, Romani S. Preface to *Mean-field Analysis of Selective Persistent Activity in Presence of Short-Term Synaptic Depression* by S Romani, DJ Amit, G Mongillo. *Journal of Computational Neuroscience* **20**:201-217 (2006). Selected Papers of Daniel Amit, N Brunel, S Fusi, P del Giudice, G Parisi and MV Tsodyks Editors. World Scientific (2012).

### **Conferences (since 2007)**

Barak O, **Mongillo G**, Tsodyks MV. *Synaptic Theory of Working Memory*. 16<sup>th</sup> Annual Meeting of the Israeli Society for Neuroscience. Eilat, Israel, 2007.

Barak O, **Mongillo G**, Tsodyks MV. *Synaptic Theory of Working Memory*. Computational and Systems Neuroscience. Salt Lake, Utah (USA), 2008.

**Mongillo G**, Hansel D. *A Unified Phenomenological Model of Short-Term Synaptic Transmission and Stochastic Release*. Program No. 718.06. 2009 Neuroscience Meeting Planner. Chicago, IL: Society for Neuroscience, 2009. Online.

Harish O, Mochizuki K, **Mongillo G**, Hansel D, Funahashi S. *Patterns of Errors in Oculomotor Delayed-Response Tasks: A Window into Working Memory Role in Action Selection*. Program No.

- 404.09. 2011 Neuroscience Meeting Planner. Washington, DC: Society for Neuroscience, 2011. Online.
- Barri A, Wang Y, Hansel D, **Mongillo G**. *A Generative-Model Framework To Quantify Release and Short-Term Plasticity at Chemical Synapses*. 8<sup>th</sup> FENS Forum of Neuroscience, July 14-18 2012, Barcelona, Spain.
- Barri A, Wang Y, Hansel D, **Mongillo G**. *Quantifying Release and Short-Term Plasticity at Chemical Synapses: A Generative-Model Framework*. Program No. 144.23. 2012 Neuroscience Meeting Planner. New Orleans, LA: Society for Neuroscience, 2012. Online.
- Tartaglia EM, Brunel N, **Mongillo G**. *Repetition Suppression/Enhancement Effects as a Result of Attractor Dynamics in Local Cortical Networks*. CNS\*2013, July 13-18 2013, Paris, France.
- Mongillo G**, Rumpel S, Loewenstein Y. *Synaptic Volatility and the Reorganization of Electrical Activity in Neuronal Networks*. Cosyne Meeting, March 5-8 2015, Salt Lake City, Utah, US.
- Tanaka K, Igarashi Y, **Mongillo G**, Okada M. *Tonic vs. Oscillatory Multi-Item Memory Maintenance: Performances and Capacity*. Cosyne Meeting, March 5-8 2015, Salt Lake City, Utah, US.
- Durnez M, Constantinidis C, Funahashi G, Hansel D, **Mongillo G**. *Persistent Activity as a Result of Stimulus-Driven Network-Wide Re-Organization of the Pattern of Firing Rates*. Society for Neuroscience Meeting, October 17-21 2015, Chicago, Illinois, US.
- Barri A, Hansel D, **Mongillo G**. *The statistics of cortical activity is beneficial for extensive memory storage*. Cosyne Meeting, February 25-28 2016, Salt Lake City, Utah, US.
- Lisi M, **Mongillo G**, Gorea A. *Humans exhibit discrete confidence levels in perceptual decision-making*. Cosyne Meeting, February 25-28 2016, Salt Lake City, Utah, US.
- Wimmer K, Barbosa J, Galan A, Constantinidis C, **Mongillo G**, Compte A. *Persistent neurons drive stable population-level working memory representations*. Cosyne Meeting, March 1-4 2018, Denver, Colorado, US.
- Invited Talks (since 2007)**
- Synaptic Theory of Working Memory*. Minischool and Workshop on Multiple Time Scales in the Dynamics of the Nervous System. The Abdus Salam International Centre for Theoretical Physics, June 16-20 2008, Trieste, Italy.
- Active Memory Maintenance with Short-Term Synaptic Plasticity*. 5<sup>th</sup> European Conference on Complex Systems (ECCS08). Hebrew University of Jerusalem, September 14-17 2008, Jerusalem, Israel.
- Synaptic Theory of Working Memory*. Kokoro Research Center, Kyoto University, May 27 2010, Kyoto, Japan.
- Irregular Spiking and Multistability in Recurrent Networks with Nonlinear Synaptic Transmission*. 3<sup>rd</sup> France-Israel Binational Conference in Neuroscience, Neurology and Psychiatry. The University of Haifa, February 14-17 2010, Haifa, Israel.

*Balanced Working Memory.* Workshop on Working Memory and Executive Control. Weizmann Institute of Science, March 22-24 2010, Rehovot, Israel.

*Spatiotemporal Irregularity and Multistability in Balanced Networks with Short-Term Synaptic Plasticity.* Seminar Cycle on Computational and Systems Neuroscience. Universitat Pompeu Fabra, February 4 2011, Barcelona, Spain.

*Mechanisms for Simple Choices.* Symposium on Working Memory and Decision Making in Paris. Paris Descartes University, March 8-9 2011, Paris, France.

*A Unified Phenomenological Model of Short-Term Synaptic Plasticity and Stochastic Release.* USTC-CNRS Joint Symposium on Synaptic Plasticity and Network Dynamics in the Central Nervous System. School of Life Sciences, University of Science and Technology of China, March 23-24 2011, Hefei, China.

*Bistability and Spatiotemporal Irregularity in Neuronal Networks with Nonlinear Synaptic Transmission.* Mean-Field Methods and Multi-Scale Analysis of Neuronal Populations Dynamics. Centre Internationale de Rencontres Mathematiques, October 3-7 2011, Marseille, France.

*Balanced Working Memory Through Nonlinear Synaptic Transmission.* Japan-France Joint Symposium on Neural Dynamics and Plasticity: From Synapse to Network. Kyoto University, January 12-13 2012, Kyoto, Japan.

*Bistability and Spatiotemporal Irregularity in Neuronal Networks with Nonlinear Synaptic Transmission.* Emergent Dynamics of Oscillatory Networks, 7<sup>th</sup> Crimean School and Workshop, May 20-27 2012, Mellas (Crimea), Ukraine.

*Quantifying Short-Term Plasticity and Variability at Chemical Synapses: A Generative-Model Approach.* Bernstein Center for Computational Neuroscience Heidelberg/Mannheim, June 2013, Heidelberg, Germany.

*Spatio-Temporal Irregularity and Multi-Stability in Balanced Networks with Short-Term Synaptic Plasticity.* Workshop on Relevance of Synaptic Plasticity for Multistable Behaviour in Neural Systems, CNS\*2013, July 2013, Paris, France.

*The Effect of Cortical Synaptic Volatility on the Organization of Spiking Activity: Experiments and Theory.* 5-th France-Israel Binational Neuroscience Conference, February 2014, Sde Boker, Israel.

*Re-organization of Spiking Activity by Synaptic Volatility in a Cortical Network Model.* 5-th ELSC Workshop in Theoretical Neuroscience, The Hebrew University of Jerusalem, June 2014, Jerusalem, Israel.

*Synaptic Volatility and the Reorganization of Electrical Activity in the Cortex.* University of Antwerp, November 2014, Belgium.

*The Inhibitory Network Dominates Cortical Computation.* 4-th Bernstein Sparks Workshop: Beyond Mean-Field Theory in Neuroscience, Bernstein Center for Computational Neuroscience Goettingen, June 2015, Goettingen, Germany.

*Inhibitory Plasticity Defines the Realm of Excitatory Plasticity.* École Polytechnique Fédérale de Lausanne, November 2015, Lausanne, Switzerland.

*Inhibitory Plasticity Defines the Realm of Excitatory Plasticity.* 6-th France-Israel Binational Neuroscience Conference, July 2016, Marseille, France.

*Inhibitory Plasticity Defines the Realm of Excitatory Plasticity.* NeuroMath, Mathematical and Computational Neuroscience Meeting, National Institute of Higher Mathematics, September 2016, Cortona, Italy.

*Memory, Balance and the Statistics of Cortical Activity.* International Workshop – Finding the right balance: On the interplay between excitation and inhibition in neural dynamics. December 2016, Mizpe Ramon, Israel.

*Inhibitory Connectivity Defines the Realm of Excitatory Plasticity.* Models of Life, College de France, January 2017, Paris, France.

*Inhibitory Connectivity Defines the Realm of Excitatory Plasticity.* Symposia on Memory, Intensive Research Program on the Mathematics of Memory, Centre de Recerca Matematica, March 2017, Barcelona, Spain.

*Inhibitory Synapses as a Cellular Substrate for Long-term Memory Storage.* Rencontre [C@UCA](#), Juin 2017, Fréjus, France.

*Inhibitory Synapses as a Cellular Substrate for Long-term Memory Storage.* 1<sup>st</sup> AM\*IDEX CompNeuro Days, Institut de Neurosciences de la Méditerranée, July 2017, Marseille, France.

*Inhibitory Connectivity Defines the Realm of Excitatory Plasticity.* TU Berlin, January 2018, Berlin, Germany.

*Synaptic Volatility, Inhibitory Plasticity and the Synaptic Trace Theory of Memory.* Kavli Institute for Theoretical Physics, UC Santa Barbara, September 2018, Santa Barbara CA, US.

*Different Sites for Synaptic Storage and their Impact on Network's Memory Capacity.* Frankfurt Institute for Advanced Studies (FIAS), November 2018, Frankfurt, Germany.

## **Research Supervision**

### **Doctoral Thesis:**

Alessandro Barri (co-direction with David Hansel), ED Cerveau Cognition Comportement: *Network mechanisms of memory storage in the balanced cortex.* (start date: 2010 – end date: 2014).

### **Member of Doctoral Advisory/Examination Committees:**

Tal Neimann (Hebrew University of Jerusalem, Israel – Supervisor: Y Loewenstein).

Laureline Logiaco (ED Cerveau Cognition Comportement, Paris – Supervisor: A Arleo, W Gerstner).

Marie Gleizes (ED CLESCO Toulouse – Supervisor: C Fonta, L Nowak).

Mirjana Maras (ED Cerveau Cognition Comportement, Paris – Supervisor: S Dèneve)

Istvan Biro, University of Antwerp, Antwerp, Belgium, *The dynamical response properties of neocortical neurons under recreated in vivo-like background synaptic activity* (Supervisor: M Giugliano).

Alessandro Barri, ED Cerveau Cognition Comportement, *Network Mechanisms of Memory Storage in the Balanced Cortex* (Supervisor: D Hansel, G Mongillo).

Laureline Logiaco, ED Cerveau Cognition Comportement, *Temporal Modulation of the Dynamics of Neuronal Networks with Cognitive Function: Experimental Evidence and Theoretical Analysis* (Supervisor: A Arleo, W Gerstner).

Alexander K Seeholzer, École Polytechnique Fédérale de Lausanne, Lausanne. *Two different time scales of neuronal modeling* (Supervisor: W Gerstner).

### **Masters Internships:**

Leonardo Miele, UPMC: *On Confidence and decision: Experiment and modeling*. M1.

Tie Xu, Physique Theorique des Systemes Complexes: *Numerical investigation of multi-stability in balanced networks with partially symmetric connectivity*. M2.

Alexandre Mahrach, Master Modélisation, Simulation et Algorithmique des Systèmes Hors-Équilibre (MSA, UPMC): *Balanced States in Neuronal Networks with Diverse Inhibitory Populations*.

Stefano Polizzi, Physique Theorique des Systemes Complexes: *Learning with self-consistent temporal fluctuations*. M2.

Anna Aniszewska, CogMaster: *Efficient input representations in the granular layer through dense coding in the inhibitory Golgi cells' network*. M2.

Oussama Sabri, CogMaster: *Memory and the statistics of the cortical activity*. M2.

Kevin Berlemont, Physique Theorique des Systemes Complexes: *Cavity approach to dense, strongly coupled binary networks*. M2

### **Masters Thesis:**

Enrico Di Nardo, University of Pisa, Italy: *Memory retrieval in balanced neural networks with dynamical synapses*.

### **Teaching**

Fall Course on Computational Neuroscience. Bernstein Center for Computational Neuroscience. September 21-25 2009, Goettingen, Germany.

15<sup>th</sup> Advanced Course on Computational Neuroscience. August 2-27 2010, Freiburg, Germany.

Okinawa Computational Neuroscience Course. June 13-30 2011, Okinawa, Japan.

16<sup>th</sup> Advanced Course on Computational Neuroscience. August 1-26 2011, Bedlewo, Poland.

White Nights of Computational Neuroscience: Neurotheory from Cell to Cognition. Academical University, June 4-17 2012, Saint Petersburg, Russia.

Cours avancé de Neurosciences Théoriques, Responsable: J-P Nadal – Master de Sciences Cognitives (ENS, EHESS, Paris Descartes). 9 hours. 2009-present.

Perception Visuelle, Responsable P Mamassian – Master de Sciences Cognitives (ENS, EHESS, Paris Descartes). 3 hours. 2012-present.

Neural Networks: Sensory Processing and Information Representation, Responsables: A Arleo, R Lambert – Master en Biologie Intégrative et Physiologie (UPMC). 3 hours. 2012-present.

### **Conference and Workshop Organization**

*Working Memory and Decision Making in Paris* (with David Hansel). March 8-9 2011. University Paris Descartes.

*Computational Neuroscience Conference, CNS\*2013* (with Alain Destexhe, Boris Gutkin). July 13-18 2013. University Paris Descartes.

*Random Matrices, Dynamics of Large Networks and Neuroscience* (with David Hansel and Carl van Vreeswijk). Symposia Series: Open Questions in Neuroscience. March 11 2014. University Paris Descartes.

*Still Searching for the Engram: Should We?* (with David Hansel and Carole Levenes). Symposia Series: Open Questions in Neuroscience. March 11 2014. University Paris Descartes.

*Functional Stability in a Dynamic Connectome* (with Yonatan Loewenstein). Cosyne 2015 Workshop. March 9 2015. Snowbird, Utah, US.

*NeuroBridges 2015* (with Ahmed El Hady and Yonatan Loewenstein). September 7-9 2015. University Paris Descartes.

*Coding, Correlations and the Dimensionality of Neural Activity* (with Rainer Engelken and Fred Wolf). Cosyne 2016 Workshop. March 1 2016. Snowbird, Utah, US.

### **Review Panels**

Emergence(s), Mairie de Paris (2013).

DIM “Problématiques transversales aux Systèmes Complexes”, Région Île de France (2014).

Future and Emerging Technologies (FET), European Commission (2014, 2015, 2016).



Israel Science Foundation (2015).

International Graduate School of Science and Engineering (IGSSE), Technical University of Munich, Germany (2015).

Collaborative Research in Computational Neuroscience, Joint NSF, ANR and BMBF Program (2016).

Deutsche Forschungsgemeinschaft (2016).

Future and Emerging Technologies (FET), Flagship ERA-NET Joint Transnational Call in the Domain of the Human Brain Project (HBP), European Commission (2017).

### **Editorial Duties**

Review Editor, Frontiers in Computational Neuroscience.

Associate Editor, Frontiers in Cognitive Sciences.

**Reviewer for:** Cerebral Cortex, Cognitive Neurodynamics, eLife, eNeuro, Europhysics Letters, Frontiers in Computational Neuroscience, International Journal of Neural Systems, Journal of Mathematical Neuroscience, Journal of Neuroscience, Journal of Physiology (Paris), Journal of Statistical Mechanics: Theory and Experiments, Nature Communications, Neural Computation, Neural Networks, Physical Review Letters, Physical Review E, PloS Computational Biology, PloS ONE, Proceedings of the IEEE, Science, Scientific Reports.