BIOGRAPHICAL SKETCH

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NAME: Luca Mazzucato

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POSITION TITLE: Assistant Professor

EDUCATION/TRAINING

INSTITUTION AND LOCATION	DEGREE	Completion Date	FIELD OF STUDY
University of Padua	Laurea (eq. to M.Sci.)	2002	Theoretical Physics
SISSA/ISAS, Trieste	Ph.D.	2005	Elementary Particle Theory
Tel Aviv University	Postdoctoral	2008	Theoretical Physics
BCNN Summer Course, Princeton University	N/A	2012	Neuroscience
Stony Brook University	Postdoctoral	2013	Neuroscience

A. Personal Statement

The goal of my research is to elucidate how sensory perception arises from the complex interaction between sensory inputs and internal states, generating flexible context-dependent behavior. During my neuroscience training at Stony Brook University, I focused on elucidating the role of top-down modulations, such as arousal and expectation, in modulating sensory processing. To achieve this goal, I combined machine-learning methods for the statistical analysis of neural data with biologically plausible modeling of cortical circuits based on recurrent spiking networks. First as a post doc in Alfredo Fontanini's lab, then as a Principal Investigator, I applied this theoretical framework to construct a unified model of spontaneous and stimulus-evoked activity in sensory cortex. Using this model, I elucidated how global states of arousal, triggered by an anticipatory cue, accelerate sensory processing; for this project I received a K25 Award from NIDCD and a Swartz Foundation Award. Even though the model was originally developed to describe the taste system, the theoretical framework I developed has the potential to explain neural activity from other sensory and frontal cortices, under a variety of behavioral conditions. I recently joined the University of Oregon, where my lab will aim at carrying out this systematic exploration, elucidating how global states modulate the temporal dynamics of auditory and visual processing under different behavioral conditions.
My computational expertise in theoretical neuroscience, combining data analysis with theoretical modeling, is instrumental in fruitfully carrying out the proposed project. Moreover, my currently funded project and the future scientific goals of my lab closely align with the aims for the proposed project. My track record of close and productive collaborations with both computational and experimental labs points to a successful future collaboration with the other members of the proposed team.

B. Positions and Honors

Positions and Employment

2002 Research Assistant, Department of Physics, University of Padua, Italy.
2002-2005 PhD, Elementary Particle Theory, SISSA, Trieste, Italy.
2005-2008 Postdoctoral associate, Tel Aviv University, Israel.
2006 Visiting Researcher, Hebrew University, Jerusalem, Israel
2008-2011 Research Assistant Professor, Simons Center for Geometry and Physics, Stony Brook.
2009 Visiting Scientist, University of California, Santa Barbara.
2012 Senior Postdoctoral Associate, Stony Brook University (with A. Fontanini and G. La Camera).
2013-2017 Research Assistant Professor, Stony Brook University.
2017-2018 Associate Research Scientist, Columbia University, New York.
2017-current Assistant Professor, University of Oregon, Eugene.

Other Experience and Professional Memberships

2010-	Member, Italian National Journalist Guild ("Ordine dei Giornalisti")
2013-	Member, Society for Neuroscience
2015-	Member, American Physical Society
2015-	Member, Association for Chemical Senses

Honors

2006	Marie Curie Research Training Network Fellowship
2011	Howard Hughes Medical Institute Teaching Award
2013	Stony Brook Science Playwriting Competition
2013	Swartz Fellow in Theoretical Neurobiology
2015	Cosyne Travel Grant

C. Contribution to Science

1. In order to understand how cortical circuits encode sensory stimuli in terms of spatiotemporal activity patterns, I developed a theoretical framework to elucidate both spontaneous and stimulus-evoked activity in the gustatory cortex of alert rats. Using hidden Markov models to extract patterns from population spike trains, I found that spontaneous cortical activity unfolds through pattern sequences similar to the ones observed in response to taste stimuli. I then developed a biologically plausible model of sensory cortex dynamics based on a recurrent spiking network, explaining the intrinsic generation of both spontaneous and stimulus-evoked pattern sequences within the same unified paradigm. This analytical and modeling framework will provide the basis for characterizing sensory cortex dynamics in the proposed project.
    a. A. Jezzini*, L. Mazzucato*, G. La Camera, A. Fontanini, "Processing of hedonic and chemosensory features of taste in medial prefrontal and insular networks," J Neurosci. 2013 Nov 27;33(48):18966-78.
    b. L. Mazzucato, G. La Camera, A. Fontanini, "Dynamics of multistable states during ongoing and evoked cortical activity," J Neurosci. 2015 May 27;35(21).
2. To test network models of cortical circuits against neural data, I developed a dimensionality reduction method, validated it on synthetic data, and applied to electrophysiological recordings from alert rats. Using this method, I demonstrated that a spiking network model of sensory cortex explains the observed variability of neural population activity during both spontaneous and stimulus-evoked periods. This dimensionality reduction method will be instrumental in testing the predictions of the proposed model to the empirical data collected within the proposed specific aims.
    a. L. Mazzucato, A. Fontanini, G. La Camera, "Stimuli reduce the dimensionality of cortical activity," Front. in Syst. Neuro. 2016; 10:11.
3. Global states of arousal, triggered by an anticipatory cue, can affect the speed of sensory processing: in particular, expected stimuli are recognized faster than unexpected ones. To elucidate the circuit origin of anticipation, I developed a biologically plausible model of how top-down cues modulate neural activity in sensory cortex. Using a recurrent spiking network, I showed that cues trigger a state of arousal by inducing an acceleration in the pace of cortical pattern sequences. Using a hidden Markov model, I confirmed the model prediction on population spike trains recorded from the rodent gustatory cortex during a behavioral experiment. This network model of anticipation will provide the basis for elucidating how global states shape sensory processing in the proposed specific aims.
    a. L. Mazzucato, A. Fontanini, G. La Camera, "Expectation-induced modulation of metastable activity underlies faster coding of sensory stimuli," BioRxiv 199380 [Preprint]. October 6, 2017. Available from: https://doi.org/10.1101/199380.
4. Episodic memory requires linking discontiguous events in time and depends on the hippocampus. Temporal association learning is often studied using trace fear conditioning. To elucidate learning-induced changes in functional couplings during this task, I developed a novel method for analyzing large neural populations from 2-photon calcium images combining factor analysis, hidden Markov models, and information theory tools. Based on results from this new analyses I proposed a new model of temporal associations via stochastic re-activation of overlapping neural ensembles in CA1 pyramidal cells.
    a. M. Ahmed, J. B. Priestley, A. Castro, F. Stefanini, E. Balough, E. Lavoie, L. Mazzucato, S. Fusi, A. Losonczy, "Changes in Effective Hippocampal Network Coupling Mediate Learning and Memory of Associations Between Temporally Discontiguous Stimuli." Biological Psychiatry 83 (9), S115. doi:10.1016/j.biopsych.2018.02.304.

5. My early work in Theoretical Physics was focused on how macroscopic phenomena emerge from the collective dynamics of many strongly coupled degrees of freedom. In particular, how gravity emerges holographically from quantum field theory. The culmination of this project was the first direct derivation of the holographic correspondence, the central tenet of string theory.
    a. M. R. Douglas, L. Mazzucato and S. Razamat, "Holographic dual of free field theory," Phys. Rev. D 83 (2011) 071701.
    b. L. Mazzucato, "Superstrings in AdS," Phys. Rept. 521 (2012) 1-68 (review).

D. Research Support

Ongoing Research Support

K25 DC013557 Mazzucato (PI)
07/01/2014-06/30/2019
Title: Spontaneous activity in the gustatory cortex

The relationship between ongoing and stimulus-evoked activities is a long-standing issue in Computational and Systems Neuroscience and is currently the subject of active debate. The funded project aims at developing novel analytical and modeling tools towards clarifying the extent to which ongoing and evoked activities are intertwined; at uncovering the dynamical features of ongoing neural activity in the gustatory cortex and elucidating its role in modulating the processing of taste-related information under different behavioral contexts; in particular, at explaining the role of anticipatory cues in priming sensory cortices. The successful completion of the project will provide a new perspective on the cortical mechanism underlying sensory processing and its top-down modulations bearing important implications on issues related to public health, such as the role played by attention and expectation in food consumption disorders.

Role: PI

Sep 2017 – open Mazzucato (PI)
Start-up funds. University of Oregon
The goal of these funds is to set up the PI's laboratory and support preliminary studies.

Completed Research Support

Swartz Foundation Award 66438 Mazzucato (PI)
10/01/2013-09/30/2014
Title: Unveiling the relationship between ongoing and stimulus-evoked network dynamics: An analytical and modeling approach

The main goal of this project was to build a mechanistic and biologically plausible model of the relationship between ongoing and stimulus-evoked arising in cortical sensory networks. The goal was achieved and the results were published.

Role: PI