Francesca Callegari, Ph.D. Student

Research Interest

In the field of neuroengineering, I focus my research on the development of engineered 3D, modular, and heterogeneous neuronal cultures, aiming at reproducing *in vitro* functionally interconnected brain regions on a chip for physiological, pathological, drug delivery, and electrical stimulation studies. In a complementary effort, I directed my studies to computational neuroscience, developing computational models of neuronal networks that reproduce the electrical output of the *in vitro* models. These computational tools aim at supporting the design of the yet essential experimental sessions. Still, in the future, they could even predict and replace them, providing great ethical and economic advantages.

Keywords: in vitro models, neuronal cultures, networks, computational models

Education

2020 – · · · ·

Ph.D. student Bioengineering and Robotics, University of Genova.
Curriculum: *Bioengineering*
Tutor: *Prof. Paolo Massobrio*
Ongoing research
Period abroad at: IFISC *(Institute for Cross-Disciplinary Physics and Complex Systems), joint research institute of the University of the Balearic Islands* (UIB) *and the Spanish National Research Council* (CSIC)

2018 – 2020

M.Sc. Bioengineering, University of Genova.
Thesis title: *Development of a bio-compatible device to recreate in vitro 3D interconnected brain regions coupled to Micro-Electrode Arrays*.
Tutor: *Prof. Paolo Massobrio*
Final Mark: *110/110 cum laude*
Description:

- **Motivation and application domain:** The brain is characterized not only by a large number of neurons but also by an extensive connectivity within its districts. The finely regulated interactions between these different areas are suggested to be the basis of the rise of complex patterns of activity. Due to the complexity of the system itself, unraveling the mechanisms underlying brain functions, such as sensory processing and memory consolidation, requires devising simplified *in vitro* models. The main objective of my Master's degree project was to create an *in vitro* model that reproduces as much as possible the high complexity of the brain. Possible applications are understanding the physiology, the pathogenesis, and the reaction to drugs of these complex neuronal circuits.
- **General objectives and main activities:** I designed and implemented a new 3D-printed device for engineered cultures, which allows not only to build 3D modular interacting sub-populations of heterogeneous neurons but also to promote their connection in three dimensions. The geometry of the prototype was carefully devised with CAD techniques to be compatible with commercially available MEA systems to investigate the activity of neural networks during their development.

Education (continued)

Acquired skills:

- Analysis of electrophysiological data
- CAD techniques
- 3D printing techniques

2015 – 2018 **B.Sc. Biomedical Engineering**, University of Genova.
Thesis title: *Characterisation of the electrical activity of cortical neuronal cultures under chemical modulation.*
Final Mark: *110/110 cum laude*

2010 – 2015 **Diploma in Languages**, Liceo Lingustico Grazia Deledda.

Certificates

2021 **Qualification to the Profession of Engineer**, University of Genova, Italy.
2020 **24 CFU for teaching**, University of Genova, Italy.

Teaching Experience

AA 2022 – 2023 **Supporting Lecturer for Laboratory work.** Master's class *Computational Neuroscience* (12 hours), Bioengineering, DIBRIS, University of Genova, Italy.

AA 2021 – 2022 **Supporting Lecturer for Laboratory work.** Master's class *Neural and Brain Computer Interfaces* (40 hours), Bioengineering, DIBRIS, University of Genova, Italy.

Supporting Lecturer for Laboratory work. Master's class *Computational Neuroscience* (15 hours), Bioengineering, DIBRIS, University of Genova, Italy.

Research Publications and Dissemination

Journal Articles

1. G. Biella, **F. Callegari**, A. N. Castagno, *et al.*, "Visual prostheses based on Silicon PhotoMultiplier: The SPEye project," *Nuclear Instruments and Methods in Physics Research, Section A: Accelerators, Spectrometers, Detectors and Associated Equipment*, vol. 1048, p. 167 935, Mar. 2023, ISSN: 01689002. DOI: 10.1016/j.nima.2022.167935, JIF: 1.4, Quartile: Q1 (in 2022).

2. M. Brofiga, F. Poggio, **F. Callegari**, M. Tedesco, and P. Massobrio, "Modularity and neuronal heterogeneity: Two properties that influence in vitro neuropharmacological experiments," *Frontiers in cellular neuroscience*, vol. 17, Mar. 2023, ISSN: 1662-5102. DOI: 10.3389/FNCEL.2023.1147381, JIF: 5.3, Quartile: Q1 (in 2022).

3. **F. Callegari**, M. Brofiga, and P. Massobrio, "Modeling the three-dimensional connectivity of in vitro cortical ensembles coupled to Micro-Electrode Arrays," *PLOS Computational Biology*, vol. 19, no. 2, D. Marinazzo, Ed., e1010825, Feb. 2023, ISSN: 1553-7358. DOI: 10.1371/journal.pcbi.1010825, JIF: 4.3, Quartile: Q1 (in 2022).

4. **F. Callegari**, M. Brofiga, F. Poggio, and P. Massobrio, "Stimulus-Evoked Activity Modulation of In Vitro Engineered Cortical and Hippocampal Networks," *Micromachines*, vol. 13, no. 8, p. 1212, Jul. 2022, ISSN: 2072-666X. DOI: 10.3390/MI13081212, JIF: 3.4, Quartile: Q2 (in 2022).

5. M. Brofiga, M. Pisano, **F. Callegari**, and P. Massobrio, "Exploring the Contribution of Thalamic and Hippocampal Input on Cortical Dynamics in a Brain-on-a-Chip Model," *IEEE Transactions on Medical Robotics and Bionics*, vol. 3, no. 2, pp. 315–327, May 2021, ISSN: 2576-3202. DOI: 10.1109/TMRB.2021.3072234, JIF: 3.7, Quartile: Q1 (in 2022).

Conference Proceedings

1. M. Brofiga, **F. Callegari**, F. Poggio, *et al.*, "Interconnected brain regions-on-a-chip: Role of connectivity and heterogeneity in the electrophysiological activity," in *Eighth National Congress of Bioengineering*, Pàtron editore, 2023, ISBN: 9788855580113.
2. M. Brofiga, M. Pisano, M. Tedesco, **F. Callegari**, and P. Massobrio, "3F(eature)s model: modularity, heterogeneity and three-dimensionality to design *in vitro* neuronal model," s1, *Biomed Sci Eng*, vol. 5, PAGEPress Publications, Sep. 2021. DOI: 10.4081/BSE.2021.158.
3. **F. Callegari**, M. Brofiga, M. Pisano, and P. Massobrio, "Effects of heterogeneous inputs on cortical activity in medium-scale neuronal networks on chip," in *30th Annual Computational Neuroscience Meeting: CNS*2021–Meeting Abstracts, J Comput Neurosci*, vol. 49, Dec. 2021, pp. 141–142. DOI: 10.1007/s10827-021-00801-9.

Books and Chapters

1. A. Andolfi, M.Brofiga, **F. Callegari**, *et al.*, "Brain-on-a-chip: Engineered neuronal populations and microtransducer arrays," in *Biofabrication: an integrated bioengineering approach for the automated fabrication of biological structures for clinical and research applications*. Pàtron editore, 2021, ISBN: 978-885-5535-28-1.

Orals, Talks, and Seminars

1. **F. Callegari**, M. Brofiga, M. Tedesco, and P. Massobrio, "How 3D scaffolds with different mechanical properties affect the activity of neuronal networks in *in vitro* models," **Accepted Oral Presentation - to be held end of July**, 45th Annual International Conference of the IEEE Engineering in Medicine and Biology Society), Jul. 2023.
2. **F. Callegari**, F. Poggio, M. Brofiga, M. Tedesco, and P. Massobrio, "Developmental conditions and culture medium influence the neuromodulated response of *in vitro* cortical networks," **Accepted Oral Presentation - to be held end of July**, 45th Annual International Conference of the IEEE Engineering in Medicine and Biology Society), Jul. 2023.
3. **F. Callegari**, "Computational models to reproduce *in vitro* observations," **Seminar** to Bioengineering Master's Class, DIBRIS, University of Genova, Italy, 2022.
4. **F. Callegari**, "Women in STEM: My personal experience as a Bioengineer," **Talk** at the IEEE Women in Engineering International Leadership Summit (ILS), 2022.
5. **F. Callegari**, "Computational models for interconnected brain regions," **Seminar** to Bioengineering Master's Class, DIBRIS, University of Genova, Italy, 2021.

Posters

1. **F. Callegari**, M. Brofiga, and P. Massobrio, *Towards understanding in vitro brain circuits: A study on cortico-hippocampal and cortico-thalamic cultures*, **Accepted Poster**, 12th International Conference on Microelectrode Arrays for Life Sciences (MEA meeting), 2022.
2. F. Poggio, M. Brofiga, **F. Callegari**, and P. Massobrio, *Neuronal heterogeneity as necessary condition to perform pharmacological studies on brain-on-a-chip models*, **Co-author to Presented Poster**, 12th International Conference on Microelectrode Arrays for Life Sciences (MEA meeting), 2022.

3. **F. Callegari**, M. Brofiga, M. Pisano, and P. Massobrio, *Effects of heterogeneous inputs on cortical activity in medium-scale neuronal networks on chip*, **Poster Presentation**, 30th Annual Computational Neuroscience (CNS) Meeting, 2021.

Thesis

1. **F. Callegari**, "Development of a 3D-printed biocompatible device to recreate in vitro 3D interconnected brain regions coupled to micro-electrode arrays," M.S. thesis, DIBRIS, University of Genova, Italy, 2020.
2. **F. Callegari**, "Caratterizzazione dell'attività elettrica in reti di neuroni corticali modulate da stimolazione chimica," BA thesis, DIBRIS, University of Genova, Italy, 2018.

Intellectual property

Patents

- **Inventor** of **Italian Patent** with Number 102021000004313
- **Inventor** of **International Patent** with International Publication Number WO 2022/180187 A1

Registered Software

- **Author** of the **Registered Software** at SIAE with Number D000017416

Skills

Languages	**Italian** - Native **English** - Professional (CAE certificate CEFR level C2 on 29/06/2015, IGCSE Grade A* on 11/2013) **Spanish** - Fluent (DELE B2 certificate on 31/07/2013) **French** - Basic (DELF B2 certificate on 12/08/2013)
Laboratory	Cell Culture Creation and Handling, Cell Biology Techniques, *In vitro* modelling, Work under Sterile Conditions, Cryopreservation, Microscopy, Immunocytochemistry Protocols
Coding and Data Analysis	**Python, Matlab**: Advanced **C/C++, VB, SQL**: Basic
Electronics and Simulations	**Simulink, Arduino**: Basic
3D design and Graphics	**Fusion 360, ImageJ**: Intermediate **Blender, GIMP**: Basic
Office Automation	**MS Office** (Excel, Word, PowerPoint, ...): Advanced **LaTeX**: Basic
Soft Skills and Strengths	Curiosity, Ability to Plan and Organize, Adaptability, Eye for Details, Problem-Solving, TeamWork, Love Learning New Things, Good Listener, Patience, Openness to criticism, Critical thinking