PhD THESIS DEFENSE: Use of Advanced Imaging Tools for Assessing the Performance of Novel Therapeutic Techniques for Restoring Vision

MARINA CUNQUERO NAVARRO

September 16, 2024
15:00
ICFO Auditorium

Studying vision restoration is paramount for addressing degenerative blinding diseases, which significantly impact quality of life and public health. With more than 230M people worldwide affected by moderate to severe vision loss, and an estimated increase in blindness from 38M to 115M by 2050, the urgency for effective treatments is clear. Vision, being the most complex and crucial human sense, relies on an intricate network of structures. Light is captured by photoreceptors in the retina and translated into neural signals processed by the brain, enabling sight. Degenerative diseases often involve the progressive deterioration of photoreceptors, leading to blindness. Currently, there is no cure but various approaches are being researched to restore sight. These include gene and cell therapies targeting diseased tissue, as well as methods like optogenetics and neuroprosthetics to modulate neuron activity and bypass dysfunction. By understanding and manipulating neural activity, scientists aim to restore vision or slow down the degenerative processes.

The results of this PhD thesis highlight progress across four areas for vision restoration research. Chapter 2a explores a new retinal implant using biocompatible reduced graphene oxide microelectrodes, demonstrating its ability to record neural signals from retinal tissue and capture light-induced firing patterns in retinal ganglion cells. It also details a protocol for retinal calcium imaging, facilitating future studies combining electrical stimulation with optical techniques. Chapter 2b focuses on adapting an ophthalmoscope for in vivo, single-cell resolution imaging of the retina in rodents, aiming to set the basis for future implementations to monitor the functionality of implanted retinal prostheses. Chapter 3 delves into the potential of human-induced pluripotent stem cell-derived retinal organoids for vision research. Using advanced imaging techniques, researchers successfully observed the formation of distinct retinal cell types within the organoids and identified differences in calcium dynamics between healthy and diseased models. Future work aims to refine MEA recordings and investigate the link between retinal organoid structure and function. Chapter 4 introduces a novel three-photon excitation technique offering deeper brain penetration and higher precision compared to traditional methods. This approach successfully regulates neuronal activity in zebrafish with minimal light exposure, showcasing its potential for revolutionizing the study of neural circuits and development of neuromodulation therapies. Taken together, these advancements across retinal implant design, in vivo monitoring of the retina, studying the potential of patient-derived organoid models, and development of non-invasive three-photon brain stimulation techniques, pave the way for future development of more effective vision restoration therapies.

Hosted by: Academic Affairs