08 Accelerator Grants

Strengthening the data analysis pipeline for avian Diffuse Optical Tomography through AI

Accelerator Grant

- Carlos Botero, Dept. of Integrative Biology, University of Texas at Austin, USA
- Joseph Culver, Dept. of Radiology, Washington University in St. Louis, USA
- Onur Güntürkün, Dept. of Psychology and Institute for Cognitive Neuroscience, Ruhr University Bochum, Germany
- **Young-Gyu Yoon, School of Electrical Engineering, Korea Advanced Institute of Science and Technology, Daejeon, Republic of Korea**

Our HSFP project on “Probing the evolutionary ecology of cognition through High-Density Diffuse Optical Tomography, DOT” aims to revolutionize the way in which we study avian cognition by developing new optical imaging technology that can enable the cost-effective characterization of brain functional connectivity (i.e., the ‘blueprint’ of cognition) across hundreds of avian species in a realistic timeframe.

With this HFSP Accelerator project, Young-Gyu Yoon will introduce new expertise to our team by incorporating cutting-edge artificial intelligence (AI) tools into our workflows at two critical stages: signal processing and interspecific comparisons. Specifically, he will support and extend our original goals in three critical ways: (1) by adapting existing AI tools to the denoising of optical imaging data, (2) by contributing to the development of unsupervised AI models that can identify the regions of a brain that operate as single functional units, and (3) by developing algorithms to identify sub-patterns of functional connectivity that are repeated within networks of different species or individuals.

Improved signal-to-noise ratio will allow us to characterize functional variation in neuron activity with greater precision, whereas motif mining will complement the suite of graph theory metrics we originally proposed as targets of comparisons across species/individuals. Data-driven parcellation will represent a major advancement in comparative neurobiology because it will allow for the unbiased characterization of functional connectivity networks in species for which little or no anatomical knowledge is currently available. This accelerator proposal not only extends the scope of our original HFSP project but also the research of the Yoon Lab, through an exciting interdisciplinary exchange of ideas and approaches from computer science, neuroimaging, engineering and eco-evolutionary biology.

Cross-talk between the skin microbiome, immunity and sensory innervation in neurophysiology

Accelerator Grant

- Simone Di Giovanni, Dept. of Brain Sciences, Imperial College of Science, Technology and Medicine, London, UK
- Eran Elinav, Dept. of Systems Immunology, Weizmann Institute of Science, Rehovot, Israel
- Rong Fan, Dept. of Biomedical Engineering, Yale University, New Haven, USA
- **Woojung Shin, Dept. of Bio and Brain Engineering, Korea Advanced Institute of Science and Technology, Daejeon, Republic of Korea**

Skin microbiota plays a crucial role in regulating the physiology of the skin. Given that the skin is body's largest organ that neuronal cells are populated, it has been hypothesized that reciprocal interactions exist between skin microbiome, immune system, and sensory neurons. In our original HFSP research proposal, we assembled a team of experts in neurophysiology, spatial transcriptomics, and bacterial metagenomics to investigate these cross-talk mechanisms. Utilizing mouse models and human tissue explants, we proposed to perturb either the microbiome or neurons and examine the resulting effects on the physiology of other components.

The new HFSP Accelerator project will leverage a human skin cell culture model, called Skin-on-a-chip, to provide the original research project with a scalable human model to investigate causal relationships. This innovative platform recreates the microenvironment of the human skin, including microbiome-immune-neuron interactions, within a microchip. Unlike traditional cell culture models, Skin-on-a-chip enables co-culturing microbiome with human cells with direct contact and microfluidics properties, allowing us to test our hypotheses under conditions highly relevant to humans. By adopting Skin-on-a-chip technology, we can address questions that are challenging to answer using animal models and tissue explants.

The Skin-on-a-chip model will be established based on techniques developed by the research group of Woojung Shin. We will create a synthetic skin microbiome community and co-culture bacteria in Skin-on-a-chip alongside immune cells and sensory neurons. Our investigations will focus on how the changes in the skin microbiome affect the functions of immune cells and neurons. Additionally, we will also specifically activate or inhibit neurons to examine their impact on the skin microbial population. We anticipate that this new sub-project will significantly strengthen our original narrative and enable us to clearly answer the questions in skin physiology by adopting a broader research perspective and complementary methodologies.