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Introduction to the Optics and the Brain 2023 feature issue

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Abstract: A feature issue is being presented by a team of guest editors containing papers based on contributed submissions including studies presented at Optics and the Brain, held April 24-27, 2023 as part of Optica Biophotonics Congress: Optics in the Life Sciences, in Vancouver, Canada

1. Introduction

We introduce the *Biomedical Optics Express* feature issue for Optics and the Brain, held April 24-27, 2023 as part of Optica Biophotonics Congress: Optics in the Life Sciences, in Vancouver, Canada. This meeting served as a forum for discussion of existing and emerging techniques as well as future directions to shed new light on the healthy and diseased brain. Optics offers a unique toolkit for multiscale imaging of the living and intact brain from the microscopic to macroscopic scale. At the same time, genetic labeling strategies provide optical contrast to image neural function, and optogenetics permits the control of cellular function with light. To cover the expertise needed to achieve these diverse goals, the meeting brings together engineers, optical and medical scientists, biologists, chemists and physicians. The articles within this special issue represent the broad scope of the community that participates in Optics and the Brain.

Diffuse optics can probe centimeters deep in human tissue with near-infrared light, to reach the living brain non-invasively. A review article [1] highlights the measurement of oxidized cytochrome-c-oxidase using a non-invasive optical imaging method of near-infrared spectroscopy (NIRS) in adults and neonates. Another study [2] using conventional hemoglobin NIRS shows that a virtual reality game task can modulate brain functional networks better than simple grasping movements. This finding has implications for the recovery of grasping abilities in post-stroke patients with hand paralysis.

Optical methods also elucidate structural and biochemical composition of brain tissue. In cancer diagnostics, another study [3] investigated the use of laser-induced breakdown spectroscopy (LIBS) and electrical spark-assisted laser-induced breakdown spectroscopy (SA-LIBS) in differentiating glioblastoma (GBM) and oligodendroglioma (OG) against non-tumor infiltrated brain tissues. The authors showed advantages of SA-LIBS in discriminating tumorous tissues, as well as multiparameter characterization. In another work [4], a two-photon microendoscope intended for label-free imaging in stereotactic neurosurgery was demonstrated. The device was small enough to fit in a surgical cannula. Another work [5] demonstrated label-free imaging of myelin in a block of human brain tissue using serial-sectioning polarization sensitive optical coherence tomography

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and quantitative birefringence microscopy. These technologies will aid in understanding the brain's complex fiber architecture over microscopic to mesoscopic scales. Finally, reminding us that 'optics' extends to the x-ray regime, another study [6] showed the viability of speckle-based phase contrast imaging and demonstrated the potential benefit of the dark-field modality for virtual histology of brain tissue.

With the advent of optogenetics, advanced optical systems can now control and image brain circuits with high spatiotemporal precision in 3D. One study [7] demonstrated an improvement to Fast Light Targeting (FLiT), a technique previously developed for 3D holographic patterning with rapid temporal sub-millisecond switching that is not limited by the refresh rate of the spatial light modulator. The authors' novel design shows better performance with reduced aberrations. Another work [8] demonstrated a simple design for two-photon optogenetic holographic stimulation with multiple laser wavelengths, a fiber bundle, and spatial light modulator. The simplified approach can be used to perform scanless two-photon imaging combined with optogenetic stimulation to modulate and record activity at the individual neuron-level.

Overall this special issue highlights the breadth of technologies and applications represented by the Optics and the Brain community, and the wide range of spatial scales and brain observables that can be measured or modulated by optical methods. The articles in this special issue represent a just small sample of the high-quality brain-related research published in *Biomedical Optics Express* recently [1–46]. We thank the *Optica* editorial board and staff for supporting this effort, and we express gratitude to the community at large for providing high quality submissions and reviews for this special issue.

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