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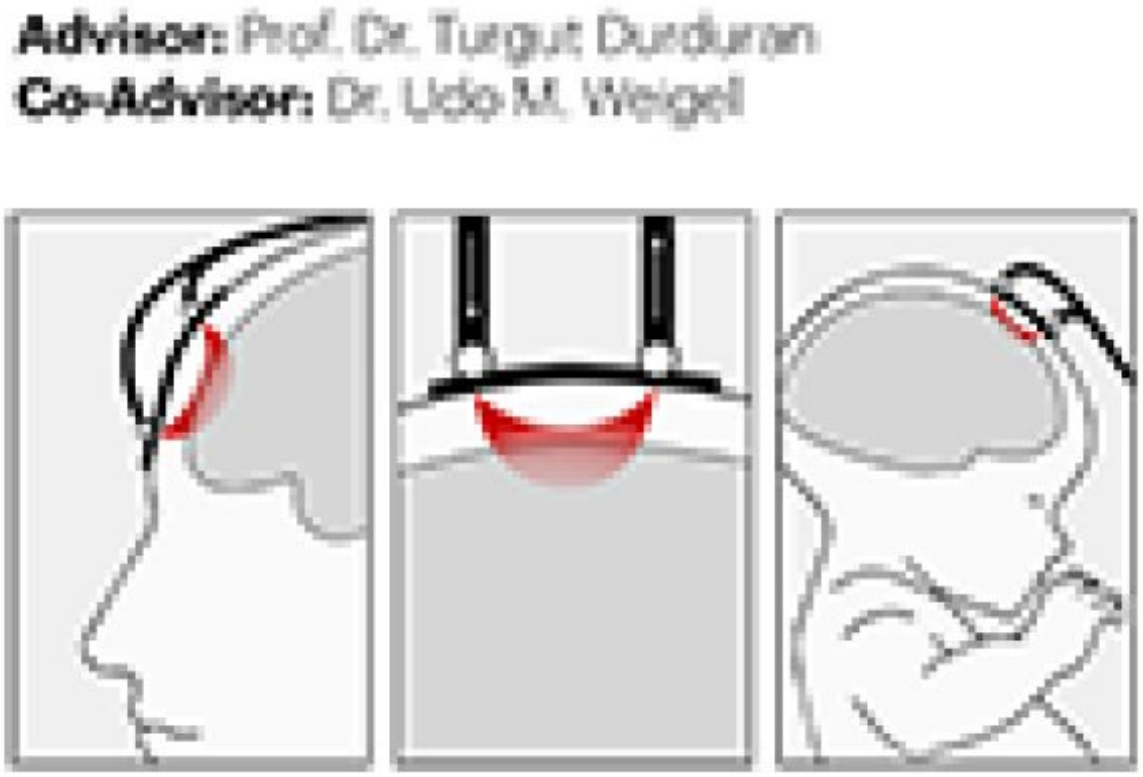

PhD Thesis Defense MARTINA GIOVANNELLA 'Hybrid Diffuse Optical Neuromonitoring of Cerebral Haemodynamics: From the Smallest Premature born Infants to Adults'

MARTINA GIOVANNELLA

June 04, 2019

Tuesday, June 4, 11:00. ICFO Auditorium

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Medical Optics

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Hybrid diffuse optical devices allows for the non-invasive and continuous monitoring of the cerebral haemodynamics and metabolism. Such devices can be portable and are relatively

inexpensive, therefore available at the bed- or cot-side. These advantages make the technology appealing and useful for a variety of applications. For my Ph.D. thesis, I have worked on the development of new devices that integrate diffuse correlation (DCS) and time resolved near-infrared spectroscopy (TRS) and on broadening their field of applications. Preterm newborn infants are one of the target populations for such a neuro-monitor. Premature newborns are at a risk of impaired neurodevelopment due to brain lesions that can be developed during first hours and days of life. In spite of the fact that these lesions are often due to episodes of abnormalities of the cerebral haemodynamics, related to oxygen supply to the brain and its consumption, these parameters are not currently monitored due to the lack of an appropriate technology. In order to meet this need, the BabyLux project aimed at developing a hybrid diffuse optical device that could be used to assess the cerebral well-being of the premature newborn infants.

In the framework of this project, I have developed and built the BabyLux device. Specifically, I have integrated DCS, to measure microvascular blood flow, and TRS, to measure microvascular blood oxygenation, into a user-friendly device, a prototype for a future medical grade device. In this thesis I report results of tests in laboratory settings in order to assess the device performance in best-case scenario. Furthermore, I explore the device?s limits in precision and accuracy, through simulated DCS and TRS data with realistic noise added, and I describe the influence of a variety of experimental and analysis parameters. In addition, I demonstrate a high correlation between cerebral blood flow (CBF) measurement performed by the BabyLux device and by the gold standard positron emission tomography with 15 O-labeled water on a neonatal piglet model. This proves the robustness of the BabyLux solution for blood flow measurement and provides a calibration formula to convert the DCS-measured blood flow index into traditional flow units. Finally, the device was tested in clinical settings, on healthy term newborns. It allowed for following cerebral haemodynamics and metabolism during the transition after birth. Reproducibility over probe replacement appeared improved with respect to commercial oximeters for tissue blood oxygen saturation and comparable to other technologies for the blood flow.

For an additional study on adult healthy volunteers, I have constructed a hybrid device integrating a commercial DCS and a prototype for a TRS device. This could serve as a neuro-monitor for following the cerebral response to transcranial direct current stimulation. This is a non-invasive form of stimulating the brain that has proven to be effective for cognitive augmentation and for treating pathological conditions.

In conclusion, the work presented in this thesis paves the way to a new generation of neonatal neuro-monitors that can be developed for extensive, multi-center clinical testing and ultimately allow a robust and accurate assessment of the cerebral well-being of the newborns. As far as the adult brain is concerned, I have introduced a new method for monitoring the cerebral response during transcranial direct current stimulation that can be exploited for protocol and dosage definition and, eventually, for the on-line monitoring

of the cerebral response to the stimulation, tailoring the intervention to each subject?s condition.

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Tuesday, June 4, 11:00. ICFO Auditorium

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