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Neurovascular imaging

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In this e-book we present a collection of papers submitted to *Frontiers in Neuroenergetics* in response to the "Special topic" initiative titled "Neurovascular Imaging." Advances in imaging technology, both optical and MRI based methods, traditionally have played (and continue playing) a major role in the advancement of neuroscience in general and in the understanding of cerebral blood flow and metabolism in particular. Therefore, our initial intent was to highlight the technological advances and impact they had on neurovascular/neurometabolic research, including description of the key biological results. However, it was the last aspect of our proposal – the biological results – that was met with the most overwhelming enthusiasm. Thus, while improvements of imaging technology are featured in the majority of the included articles, the main focus is on using those technological advances to better understand neurovascular and neurometabolic coupling.

So, what does it take to make significant progress in understanding of this coupling? First, as in every study in this e-book, it requires a team of investigators armed with state-of-the-art measurement tools and a novel ("transformative") approach, a.k.a. *imagination*. Second, one has to recognize the limitations of their measurement tools and consider the *measurement theory* – the relationship between the experimental "observables" and the underlying physiological parameters (Harris et al., 2010; Lindauer et al., 2010; Logothetis, 2010; Vanzetta and Slovin, 2010). For example, although BOLD fMRI measures deoxyhemoglobin, one has to consider both intra- and extravascular contributions to the signal and effects of vessel size, which vary as a function of the magnetic field of an MRI scanner. Likewise, one has to account for specific experimental conditions producing a biological behavior that might or might not translate to the intact brain situation (Filosa, 2010). Finally, merely the number of physiological parameters, which interact to produce a biological behavior, necessitates the use of computational modeling (Buxton, 2010). In particular, a solid theoretical framework is required to bridge between micro- and macroscopic levels of description – a critical step for translation of basic science observations in healthy brain (Cauli and Hamel, 2010; Hamilton et al., 2010; Saka et al., 2010; Sirotin and Das, 2010; Vazquez et al., 2010; Kleinfeld et al., 2011) and in experimental disorders (Luckl et al., 2010) to human studies (Koch et al., 2010; Lindauer et al., 2010; Obrig et al., 2010; Lin et al., 2011).

With the continuing development of optical (Akkin et al., 2010; Gregg et al., 2010; Hu and Wang, 2010; Srienc et al., 2010) and MRI (Harel et al., 2010; Hyder et al., 2010; Lin et al., 2011) imaging technology, and the steadily increasing availability of specific fluorescent and MR-visible indicators (Barros, 2010), our ability to probe the biological mechanisms underlying functional hyperemia is on a steep rise. Importantly, new methods allow not only measurement, but also well-controlled manipulations (Allegra Mascaro et al., 2010; Kleinfeld et al., 2011) crucial for testing causality rather than simply establishing a correlation between measurement parameters (that does not automatically imply that one of the parameters drives the other). Moreover, the present collection of papers reaches well beyond the current state of knowledge, defining important questions and roadmaps for future research (Buxton, 2010; Cauli and Hamel, 2010; Hamilton et al., 2010; Vazquez et al., 2010; Kleinfeld et al., 2011; Lin et al., 2011).

For us, *Neurovascular Imaging* is a lifetime-long affair that combines the magic of imaging ("seeing is believing") with the enigma of neurovascular communication waiting to be resolved, and the excitement of basic discovery with satisfaction of the usefulness/medical relevance of the results. We hope that the present collection of papers will be of particular encouragement for the young people in the field. The *Neurovascular Imaging* train is on a fast track toward genuine understanding of neurovascular and neurometabolic mechanisms with outstanding clinical importance.

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