Foreword

It is a great pleasure to write a preface for this book, which I see as the first comprehensive treatment of human brain mapping using multimodal approaches. The content and ambitions addressed in these pages represent some of the most challenging and advanced applications in imaging neuroscience. Since the inception of modern brain mapping two decades ago, there has been an implicit hope that different measurements of brain activity might be integrated to provide an unprecedented and multilateral view of its structure and function. This book provides a compelling review of this integrative approach and reflects the excitement of those working in the field.

Until the introduction of positron emission tomography (PET) and functional magnetic resonance imaging (fMRI), the principal way of measuring brain activity noninvasively was by measuring electrical signals from the brain using electroencephalography. In the late 1980s and early 1990s, PET and fMRI heralded a new era in imaging neuroscience; allowing scientists to pinpoint the metabolic and haemodynamic correlates of electrical activity, anywhere in the brain. Over the past decade, much thought has been given to combining electromagnetic and haemodynamic measurements to look at aspects of functional anatomy that could not be seen with one modality alone. An analogy for this multimodal approach is the ability to perceive depth with binocular vision, compared to using one eye alone. To harness multimodal perspectives on brain dynamics, people thought that we would need underlying generative models of neuronal activity that could explain both electromagnetic and haemodynamic signals. From this emerged the notion of multimodal fusion, in which sense could be made of multimodal data by reference to a common generative model. Perhaps rather surprisingly, this line of thinking has proved much less fruitful than exploring the relationships between electromagnetic and haemodynamic signals directly. This relationship can go in one of two directions. One can use the spatial deployment of haemodynamic signals, across the brain, to predict or constrain the sources of electromagnetic activity. Conversely, one can look for the physiological correlates of electromagnetic signals using fMRI. Although technically very challenging, the latter approach has furnished the greatest insights into the relationship between fast neuronal dynamics and their spatially resolved haemodynamic correlates. It is this relationship that is studied with EEG–fMRI and is the subject of this book.

There has been an enormous interest in the relationship between electrophysiological and brain mapping signals. This relationship has been addressed invasively and noninvasively with multimodal or conjoint recordings. It is of great importance, not only for our basic understanding of brain mapping signals per se, but it also has profound implications for understanding the functional anatomy of epilepsy and related disorders. It is interesting to note that it was the epilepsy community that advanced the noninvasive side of this endeavour more than any other field in neuroimaging. They have overcome some profound technical difficulties, entailed by having to acquire minuscule electromagnetic signals in the context of a magnetic resonance imaging environment. Furthermore, they have had to deal with the confounding effects of artefacts and data modelling that far exceed the challenges usually incurred by conventional brain mapping. It is therefore of no surprise that many of the contributors to this book have been pioneers not only in neuroimaging but also in MRI physics and its clinical applications.

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