INTRODUCTION TO FUNCTIONAL MAGNETIC RESONANCE IMAGING: PRINCIPLES AND TECHNIQUES
By Richard B. Buxton
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There can be no argument that magnetic resonance imaging (MRI) has revolutionised basic and clinical neuroscience. This book provides an accessible and comprehensive review of the current state of functional MRI (fMRI), the use of MRI ‘that goes beyond anatomy to measure aspects of local physiology’. The book does well as an ‘introduction’, given the complex nature of some of the issues (such as image reconstruction). I very much enjoyed reading it.

The book is organised into three sections, with Section I essentially providing an overview of what is discussed in detail in Sections II and III. Section I also includes a brief review of energy metabolism in the brain and the basic (classical) physics of nuclear magnetic resonance (NMR) (an appendix discusses NMR in more detail, including the quantum physics perspective). Section II expands the principles of MRI, while Section III focuses on fMRI in particular. Section II thus covers image acquisition and reconstruction, including the basic concepts of T1, T2 and T2* relaxation, diffusion, gradient-echo and spin-echo sequences, slice-selection, phase-encoding, frequency-encoding, Fourier transforms and K-space, as well as various image artefacts. Section III covers techniques for perfusion imaging, including an introduction to tracer kinetics, contrast agents and arterial spin labelling (ASL), before finishing with the popular technique of blood oxygen level-dependent (BOLD) imaging.

The book is well-written and suitable for graduate-level and beyond. There is some formalisation of important concepts, but the level of mathematics is not particularly advanced. There are many helpful illustrations, and text boxes that cover certain issues in more detail. Key references follow each chapter. My only complaint concerns the macro-organisation of the book, which appears to reflect pedagogical choices (probably reflecting the graduate courses from which the book evolved): the use of Section I to summarise the concepts that are later expanded in Sections II and III may facilitate comprehension of the large number of requisite concepts. The downside however is that, when the book is read in a linear fashion, the summary in Section I becomes too dense in places (leading to some confusion), whereas parts of Sections II and III can involve repetition of concepts already grasped from Section I. On the upside, this redundancy is likely to help if one wishes to dip into selected chapters of the book. For example, most chapters (e.g. those on ASL or BOLD) begin with a brief summary of the relevant concepts covered earlier in the book.

As well as providing a theoretical background, the book is likely to be helpful for users of MRI. For example, though the book does not attempt an exhaustive list of current imaging sequences, it describes the basic background and relationship between the most common ones (e.g. FLASH, GRASS, MP-RAGE, which will be familiar acronyms to many MRI researchers/clinicians). More emphasis is placed on the most popular current technique for fMRI, echo-planar imaging, given its relevance to BOLD imaging. Indeed, BOLD imaging receives the greatest attention, covered in the final four chapters. The last two of these concern statistical analysis of BOLD data and efficient design of BOLD experiments, which are interesting for a researcher conducting brain mapping experiments, but perhaps somewhat incidental to other readers (I would have preferred that more space be given instead to the discussion of the physiological basis of the BOLD signal, linking back to the initial discussion of energy metabolism in the brain, and perhaps discussing recent work relating the BOLD signal to neurophysiological measurements such as local field potentials).

The main value of the book, in my opinion, is to illustrate the huge potential of fMRI, in terms of its flexibility and range of applications; for example, to measure cerebral blood volume, flow and oxygenation. The book also captures the excitement surrounding the future of diffusion tensor imaging and ASL. Moreover, the author does an excellent job of explaining the complex ideas behind fMRI in relatively simple terms. In these senses, the book is a clear success.

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