

BOOK REVIEW

Looking Inside the Brain: The Power of Neuroimaging

By Denis Le Bihan (translated by Teresa Lavendar Fagan)

2015 Princeton University Press, 168 pages

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Images of the brain produced by magnetic resonance imaging (MRI) are unquestionably important to neuroscience's quest to unlock the mysteries of the brain. Clinicians and scientists can use MRI to see inside the brain (and other regions of the body) in non-invasive ways not possible just a few decades ago. In recent years MRI has expanded its power and repertoire well beyond anatomy to image white matter connectivity with diffusion imaging (DTI or dMRI) and begin to understand which regions of the brain that are active during specific tasks using functional MRI (fMRI) techniques. These advancements have allowed scientists to ask many exciting questions about the human brain's structure and function *in vivo*. Not surprisingly, adoption of MRI methods has been rapid and broad in recent years. Searching "fMRI" on PubMed in the summer of 2015 yielded nearly 400,000 citations and a steeply rising slope of publications per year. A quick check of the undergraduate neuroscience textbooks on my bookshelf revealed that each of them discussed MRI imaging in some way. Consequently, the topic of neuroimaging is very well suited to the undergraduate science curriculum.

As a neurobiologist with no direct experience using MRI or other neuroimaging methods I found the book to be a quick and easy read as well as an interesting tale. Le Bihan's writing found an appropriate and comfortable balance between storytelling and scientific content. *Looking Inside the Brain* is neither a comprehensive history of neuroimaging nor a how-to manual; it is neither a novel nor a textbook. Yet somehow it is a hybrid of all these things coming together as an accessible and interesting introduction to the power and promise of neuroimaging with frequent doses of history, science, and most importantly wonder. As a pioneer of diffusion, MRI Le Bihan writes from his position as an insider with authentic enthusiasm and awe as well as occasional humor. He uses his experiences to share behind-the-scenes information, revealing the sometimes messy steps necessary to the evolution of new technologies. Le Bihan's narrative not only explains the foundational principles of brain imaging in accessible language with helpful analogies, but also includes unique insights and anecdotes not apparent from textbooks or research literature.

I found many things to like in this book. First, Le Bihan emphasizes the interdisciplinary teamwork that was necessary to developing MRI technologies. He regularly points out how a variety of clinicians, computer scientists, physicists, neuroscientists, psychologists, and others made

critical and unique contributions both to the technology of creating MRI instruments and to the uses of MRI in research and medicine. This interdisciplinary emphasis allows the author to introduce important topics in the social, natural, and physical sciences. The writing does not shy away from scientific content, yet it does not dwell on these topics so long as to lose readers. As scientific topics arise within the narrative Le Bihan explains them on a need to know basis. Without a single equation to be found, readers learn about topics such as neurovascular coupling, isotopes, anisotropy, and neuroanatomy. Although the explanations expect a curious and engaged reader, they do not assume specific scientific knowledge; Le Bihan conveys the essence of the science in ways that are occasionally oversimplified for the sake of keeping the narrative moving efficiently.

The book is tied strongly and consistently to the research literature, making frequent references to specific studies in an impressively wide variety of contexts. The range of neuroscience discussed easily moves back and forth between molecular and cellular to anatomical to physiological to behavioral levels of analysis. Moreover, throughout the book Le Bihan weaves comments on evolution of the brain in unique and interesting ways. Within the discussions of research Le Bihan points out strengths and weaknesses of techniques and emphasizes the need for rigorous experimental design and understanding error. He explains how images can be too blurry or too slow, how controls should be designed, and how interpreting images can be more challenging than acquiring images.

The book is organized in seven chapters, each with multiple subsections and multiple stories. Although some chapters naturally focus more on the technology of MRI with others focusing more on the human brain and behavior, both the physics and the neuroscience are interwoven from start to finish. The book has a clear narrative, to be read in sequence, like a novel. It is not a textbook or encyclopedia where a reader could strategically read a single chapter or section and its index is limited. The narrative generally (though not strictly) follows a historical timeline, starting with early attempts at functional mapping of brain regions via familiar stories such Broca. The book ends with a clear eye to the future by emphasizing the author's ambitious NeuroSpin facility in France.

My reservations about this book are small and cosmetic. Because *Looking Inside the Brain* is the size

and shape of a novel, the figures are located in color plates in the center pages. I am a bit embarrassed to admit, as an instructor who is more likely to select a textbook for its figures over its text, I did not always turn to the figures while I was reading. Even though I was skipping some images as I read, I was surprised by the persistent strength of my desire for those figures to be thoughtfully integrated alongside the text, as textbooks are organized. When I did turn to the figures, I was pleased that many came directly from the research literature; but I was often disappointed that many images were too small and/or insufficiently described by their captions. In realizing my own laziness to flip to the figures as they were mentioned in the text I could not help but wonder how undergraduates might interact (or not) with these important images. In addition, I was disappointed with the referencing style that made direct citations rare and inconsistent. I found myself wishing for the more explicit citation format of a journal article even while enjoying the narrative format.

I envision this book could work exceptionally well in several different types of undergraduate courses. Because the writing is so accessible yet founded in research literature, *Looking Inside the Brain* could readily anchor a non-majors course on neuroscience or neuroimaging. The diverse research studies mentioned throughout could provide non-science majors with generous opportunities to find ways that neuroimaging has been applied to their specific interests. As examples, students could follow Le Bihan's lead to learn how neuroimaging has informed understandings of how the human brain processes music, color, emotion, risk, language, bias, etc. Furthermore, the book introduces more than enough interesting scientific concepts that an instructor (or students) could readily select and expand upon favorite topics mentioned briefly in

the book that would easily fill a semester-long course. In fact, this book got me thinking actively about how I might be able to design such a course about the brain for non-majors. For students with stronger interests and backgrounds in the sciences this book could also serve as a very appropriate and interesting supplement to an undergraduate introductory neuroscience course. Because it is an easy and fast read that provides an insider's view on the creation and use of MRI, it has strong potential to introduce or reinforce many topics in a neuroscience course. For an advanced seminar course focusing on neuroimaging this book could provide a fitting preview to the material ahead by introducing the history, foundations, and applications of MRI in a convenient format. Finally, I could also imagine this book serving as a very appropriate and engaging extra credit opportunity for just about any undergraduate neuroscience course.

In summary, the most important strengths of *Looking Inside the Brain* are its accessible writing and its inclusion of research questions addressed by neuroimaging across very broad and interesting territories. This accessible diversity opens up many opportunities to help introduce undergraduates to research literature on neuroimaging and encourage them to engage more deeply on specific topics of personal interest related to brain form and function.

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