Neuroimaging I

Basic Science

HUMAN BRAIN FUNCTION
Assessment and Rehabilitation

NEUROIMAGING I: Basic Science
Edited by Erin D. Bigler

NEUROIMAGING II: Clinical Applications
Edited by Erin D. Bigler

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Preface

Until recent advents in neuroimaging, the brain had been inaccessible to *in vivo* visualization, short of neurosurgical procedures or some unfortunate traumatic exposure. It is a tribute to the early contributors to clinical neuroscience that through what, by today's standards, would be deemed extremely crude measurements, advancements in understanding brain function were made. For example, the theories of higher cortical functions of the brain by Aleksandr Luria or Hans-Lukas Teuber in the 1950s were essentially based on military subjects who sustained traumatic head wounds during World War II. These researchers could inspect the patient and determine where penetrating entrance and exit wounds were on the head; sometimes they had skull films to identify entrance and exit fracture wounds, sometimes neurosurgical reports were available, and Luria even had the opportunity to acutely examine some patients with exposed wounds. Thus, one would take whatever information might be available and *infer* what regions of the brain were involved but could never actually visualize the brain. Of course, this changed dramatically with the introduction of brain imaging in the 1970s, but it really was not until the 1990s that analysis and image display technologies finally caught up with the basic brain-imaging methods of computerized tomography (CT) and magnetic resonance imaging (MRI). In contemporary neuroimaging, in addition to the standard arsenal of CT and MRI, methods of functional imaging now include positron emission tomography (PET), single photon emission computed tomography (SPECT), and functional magnetic resonance imaging (fMRI), along with more sophisticated methods for electrophysiological and magnetoencephalographic assessment of brain function. All of these imaging methods are addressed in this text by leaders in their respective fields. With these technologies, we are no longer relegated to the role of our predecessors—wondering about what the brain may actually look like in the living individual and what regions are pathologically involved.

Despite these marvelous developments in brain imaging, one must not lose sight of the fact that brain imaging only represents a molar view of brain structure and function. Thus, although the science of brain imaging and function

advances, current technology still has some major limitations. Hopefully, both the clinical utility and scientific advancement of contemporary brain imaging, along with its limitations, will be evident as one reads this text. As significant as the advancements have been in the last two decades, we are only at the threshold of some of the most important and exciting research in imaging and understanding human brain function. Accordingly, this volume attempts to capture some of the current progress in the area of human brain imaging as it relates to function.

Knowing full well how rapidly this field changes, I have made an effort to keep this two-volume series as contemporary as possible. Part of the rapidity of change in neuroimaging has to do with improvements in technology. Brain imaging is technology driven. Even as I write this Preface, new methods of image acquisition and display are being published, superseding older technologies. Understandably, researchers and writers in this field always have a sense of being "behind" and "outdated." It is analogous to purchasing the ultimate personal computer only to find that 6 months after purchase it is outdated. Thus, being outdated represents an unfortunate risk of researching and writing in this area. As such, the various chapters that constitute this volume have been written from the perspective of an overview of the field and content area, not as the most up-to-date treatise on the subject.

This volume contains three sections, which to a certain extent are all interrelated: Overview, Basic Methods and Techniques, and Appendix. In Chapter 1, I review some of the history of neuroimaging, with an emphasis on contemporary displays of brain imaging. Since the standard and most exquisite method for gross brain imaging is magnetic resonance (MR), the second chapter, by Schultz and Chakraborty, overviews MR image analysis. Chapter 3, by Sowell and Jernigan, examines the developing brain as assessed via neuroimaging. Over the lifespan, there are developmental changes that can be detected and demonstrated by brain imaging methods. This also is addressed in Chapter 4, in which using the MR method, a normative database for brain structure, is discussed. Further analysis techniques using MRI to assess brain structure are provided by Kertesz in Chapter 6. The technologies of PET imaging, electrophysiological techniques to display neurocognitive networks, and magnetoencephalography are reviewed by Bookheimer (Chapter 5), Gevins (Chapter 7), and Papanicolaou and Tarkka (Chapter 8). Chapter 9 by Tiede and colleagues demonstrates the magnificent power of contemporary image display, with which essentially any major neural structure can now be presented with three-dimensional computer display. Chapter 10 by Gur and colleagues provides a brief foray into the next level of image analysis, wherein the precision of MRI is used to not only examine structure–function relationships but also to assess a more dynamic assessment of structure–function.

The text concludes with an Appendix that features an MRI brain atlas. The Appendix provides the reader with a general, but not exhaustive, atlas of major brain structures discussed in the two volumes in this series. With the exception of Chapter 9, all of the chapters presented in Parts I and II of this volume assume that the reader has some familiarity with brain imaging and anatomy, but none take the time to explicitly point out where given structures may be located. To provide the reader with structural localization, the MRI atlas is presented in three planes—axial, sagittal, and coronal. This is not to be considered a detailed atlas; rather, it should be used for general location of the various structures

discussed in this volume and in Volume II in this series. For a more thorough atlas of MRI brain anatomy, the reader is referred to Duvernoy (*The Human Brain Surface, Three-Dimensional Anatomy and MRI,* New York: Springer-Verlag, 1991) or Truwitt and Lempert (*High Resolution Atlas of Cranial Neuroanatomy,* Baltimore, MD: Williams & Wilkins, 1994), which served as the basis for the current atlas.

Erin D. Bigler

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