

Neuroimaging I

Basic Science

HUMAN BRAIN FUNCTION

Assessment and Rehabilitation

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NEUROIMAGING I: Basic Science

Edited by Erin D. Bigler

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Neuroimaging I

Basic Science

Edited by

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Springer Science+Business Media, LLC

Library of Congress Cataloging-in-Publication Data

Neuroimaging / edited by Erin D. Bigler.

p. cm. -- (Human brain function)

Includes bibliographical references and index.

Contents: v. 1. Basic science.

1. Brain--Imaging. I. Bigler, Erin D., 1949- . II. Series.

[DNLN: 1. Brain. 2. Diagnostic Imaging--methods. 3. Brain

Mapping--methods. 4. Cognition--physiology. 5. Brain--atlases.

WL 141 N4829 1996]

RC386.6.D52N48 1996

616.8'04754--dc20

DNLN/DLC

for Library of Congress

96-29400

CIP

ISBN 978-1-4899-1703-4

ISBN 978-1-4899-1701-0 (eBook)

DOI 10.1007/978-1-4899-1701-0

© Springer Science+Business Media New York 1996

Originally published by Plenum Press, New York in 1996

Softcover reprint of the hardcover 1st edition 1996

10 9 8 7 6 5 4 3 2 1

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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

Contents

CHAPTER 1

Introduction 1
Erin D. Bigler

PART I OVERVIEW

CHAPTER 2

Magnetic Resonance Image Analysis
Robert T. Schultz and Amit Chakraborty

Introduction 9
Magnetic Resonance Image Construction 11
Measurement Reliability 25
Image Processing Techniques 26
Appendix 46
References 49

Chapter 3

Imaging the Developing Human Brain
Elizabeth R. Sowell and Terry L. Jernigan

Introduction 53
Progressing Myelin 55
Morphological Changes on Magnetic Resonance Imaging 63

Functional Imaging Studies	69
Logistical and Methodological Issues	71
An Exciting Development for Future Neurodevelopmental Studies ...	73
References	73

PART II BASIC METHODS AND TECHNIQUES

CHAPTER 4

A Normative Database from Magnetic Resonance Imaging	
<i>Duane D. Blatter, Erin D. Bigler, C. Sterling Johnson, Carol Anderson, and</i>	
<i>Shawn D. Gale</i>	

Quantitative Neuroimaging Methods	80
Quantitative Neuroimaging Findings	86
Quantitative Image Analysis Implications	93
References	94

CHAPTER 5

Positron Emission Tomography Studies of Cognition	
<i>Susan Y. Bookheimer</i>	

Introduction	97
Activation Imaging with Positron Emission Tomography:	
Methodological Considerations	98
Higher-Order Visual Processing	101
Language Processing	103
Memory	109
Music	113
Discussion	114
References	115

CHAPTER 6

Cerebral Asymmetries and Corpus Callosum Morphology	
<i>Andrew Kertesz</i>	

Neuroimaging and Asymmetry	122
Callosal Morphology and Function	124
References	127

CHAPTER 7

Imaging the Neurocognitive Networks of the Human Brain	
<i>Alan Gevins</i>	

Introduction: Evoked Potentials and Cognition	133
Basic Aspects of the Evoked Potential Method	134
Evoked Potential Events Associated with Cognition: Two Major	
Lines of Research	136

Neuroelectric Chronometrics	140
Imaging Distributed Neural Networks	143
Conclusion: Neuroimaging and Behavior	154
References	156

CHAPTER 8

Magnetoencephalography

Andrew C. Papanicolaou and Ina M. Tarkka

Introduction	161
The Inverse Problem	163
Instrumentation	164
Source Localization of Auditory Evoked Fields	166
Source Localization of Somatosensory Evoked Fields	169
Source Localization of the P3m Component	173
Concluding Remarks	179
References	180

CHAPTER 9

A Computerized Three-Dimensional Atlas of the Human Skull and Brain

*U. Tiede, M. Bomans, K. H. Höhne, A. Pommert, M. Riemer, Th. Schiemann,
R. Schubert, and W. Lierse*

Materials and Methods	186
Results	190
Simulation of an X-Ray Exposure and Neurosurgery Planning	191
Discussion	195
References	196

CHAPTER 10

Neurobehavioral Probes as Applied in Physiological Neuroimaging Studies: Methodological Considerations

Ruben C. Gur, Juan Manuel Gutierrez, James A. Holdnack, and Richard N. Mahr

Neuroimaging Methods	200
Application of Neuroimaging in Neuropsychology	205
Limitations and Future Directions	211
References	212

PART III APPENDIX

CHAPTER 11

MRI Brain Atlas	215
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Marc Steed and Erin D. Bigler

INDEX	335
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