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Fatta B. Nahab • Noriaki Hattori  
Editors

# Neuroimaging of Movement Disorders

 Humana Press

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ISBN 978-1-62703-470-8

ISBN 978-1-62703-471-5 (eBook)

DOI 10.1007/978-1-62703-471-5

Springer New York Heidelberg Dordrecht London

Library of Congress Control Number: 2013939745

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*... to the beautiful moon and the glorious earth*

*... to the patients who suffer from movement disorders, their caregivers, and our families and loved ones*

# Preface

One of the last frontiers of science remains the human brain. Despite the vast energy spent understanding this amazing machine, we still know so little. One of the revolutions sweeping neuroscience has been the use of various technologies to peer into the brain noninvasively to discover its inner workings. With ever improving machinery, data collection techniques, and analysis methods, researchers are now being presented with an exponentially increasing amount of data that they must wade through and interpret in the context of existing knowledge.

In the field of neurological movement disorders, this information explosion has been no different, though the causes and pathology of most disorders remain unknown. The use of neuroimaging has been important to unlocking the causes of abnormal motor control, though by comparison to other areas of neuroscience remains at a relatively early stage. Challenges to the use of neuroimaging in this field are further compounded by the very fact that this patient population has abnormal movements that may limit the ability to collect high-quality data. In addition, the field of neuroimaging possesses the double-edged sword of producing both true believers and skeptics at once by generating beautiful results that are all too frequently oversimplified and overinterpreted. These are just some of the challenges that need to be addressed in order to advance our understanding.

This book is not the first to cover the topic of Neuroimaging in Movement Disorders, and will certainly not be the last. Our goal was to bring together an impressive group of leaders in their respective fields from across the globe to discuss current knowledge. Furthermore, authors were encouraged to discuss controversies such as conflicting findings and methodological limitations in order to provide the reader with a comprehensive yet pragmatic understanding of the state of science. Lastly, these experts were asked to provide their insights about where future research is moving or should be directed.

The topics of the book chapters provide both comprehensive reviews of various neuroimaging methods and also more in-depth summaries of the contributions made by neuroimaging in individual movement disorders. Although many of the neuroimaging methods that are discussed have not been routinely used in clinical practice, the authors have done an excellent job of providing the reader with adequate

detail to understand the requirements for using these methods and in some cases even the starting knowledge to begin local implementation.

We are grateful to each contributor for the time and effort invested on this project. Without their devotion to sharing knowledge, the advancement of our common understanding would not be possible. It is also important to recognize the immense contributions made by patients and families to further our shared goal of curing these neurological disorders.

Fatta B. Nahab MD  
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# Abbreviations

1H-MRSI	Proton Magnetic Resonance Spectroscopic Imaging
AADC	Aromatic Amino Acid Decarboxylase
ACC	Anterior Cingulate Cortex
AD	Alzheimer's disease
ADC	Apparent Diffusion Coefficient
ADHD	Attention Deficit Hyperactivity Disorder
AHCD	acquired hepatocerebral degeneration
Ala	Alanine
ANOVA	Analysis of Variance
AOPTD	Adult Onset Primary Torsion Dystonia
aPS	Atypical Parkinsonian Syndrome
ASL	Arterial Spin Labeling
AT	Ataxia Telangiectasia
BCI	Brain-Computer Interface
BLS	Blepharospasm
BOLD	Blood Oxygenation Level Dependent
BSPDC	Bilateral Striato-Pallido-Dentate Calcinosi
CBD	Corticobasal Degeneration
CBF	Cerebral Blood Flow
CBS	Corticobasal Syndrome or Corticobasal Degeneration
CBV	Cerebral Blood Volume
CD	Cervical Dystonia
ChAc	Chorea-acanthocytosis
Cho	Choline
cMRI	Conventional Magnetic Resonance Imaging
CNS	Central Nervous System
Cre	Creatine
CSF	Cerebrospinal Fluid
CT	Computed Tomography
CVD	Cerebral Vascular Disease
DAT	Dopamine Transporter
DAVF	dural arteriovenous fistula

DBS	Deep Brain Stimulation
DCM	Dynamic Causal Modeling
DDS	Dopamine Dysregulation Syndrome
DeoxyHb	Deoxygenated Hemoglobin
DKI	Diffusion Kurtosis Imaging
DLB	Dementia with Lewy Bodies
DLPFC	Dorsolateral Prefrontal Cortex
DMN	Default Mode Network
DTI	Diffusion Tensor Imaging
DOPA	Dihydroxyphenylalanine
DWI	Diffusion Weighted Imaging
EEG	Electroencephalography
EPI	Echo Planar Imaging
ET	Essential Tremor
FA	Fractional Anisotropy
FDG	<sup>18</sup> F-deoxyglucose
FID	Free Induction Delay
FLAIR	Fluid-Attenuated Inversion Recovery
fMRI	Functional Magnetic Resonance Imaging
FOG	Freezing of Gait
FRDA	Friedreich's Ataxia
FSE	Fast Spin Echo
FXTAS	Fragile-X-associated Tremor/Ataxia Syndrome
GBA	Glucocerebrosidase
GLM	General Linear Model
Glx	Glutamate/Glutamine/GABA
GM	Gray matter
GMM	Gaussian mixed model analysis
GP <sub>i/e</sub>	Globus Pallidus (interna/externa)
gPS	Monogenetic Parkinsonian Syndromes
GRE	Gradient Recalled Echo
HD	Huntington's disease
IBGC	Idiopathic Basal Ganglia Calcification
ICD	Impulse Control Disorders
iPD	Idiopathic Parkinson disease
Lac	Lactate
LC	Locus Ceruleus
LN	Lenticular Nucleus
LN <sup>+</sup>	Lenticular Nucleus Hyperechogenicity
M1	Primary Motor Cortex
MCP	Middle Cerebellar Peduncle
MD	Mean Diffusivity
MEG	Magnetoencephalography
mI	Myoinositol
MR	Magnetic Resonance

MRPI	Magnetic Resonance Parkinsonism Index
MRS	Magnetic Resonance Spectroscopy
MS	Multiple Sclerosis
MSA	Multisystem Atrophy
MSA-C	MSA with predominant cerebellar findings
MSA-P	MSA with predominant parkinsonism
MTC	Magnetization Transfer Contrast
NBIA	Neurodegeneration with Brain Iron Accumulation
NAA	N-acetylaspartate
NIRS	Near Infrared Spectroscopy
NMR	Nuclear Magnetic Resonance
NPH	Normal pressure hydrocephalus
OCD	Obsessive Compulsive Disorder
OxyHb	Oxygenated Hemoglobin
PCA	Principal Component Analysis
PDD	Parkinson Disease with Dementia
PET	Positron Emission Tomography
PKAN	Panthothenate Kinase-associated Neurodegeneration
PMC	Premotor Cortex
PMd	Dorsal Premotor Cortex
PPI	Psychophysiological Interaction
PSP	Progressive Supranuclear Palsy
rCMA	Rostral Cingulate Motor Area
RD	Radial Diffusivity
ReHo	Regional Homogeneity
RF	Radio Frequency
RN	Red Nucleus
ROI	Region of Interest
RS-fMRI	Resting State Functional Magnetic Resonance Imaging
SCA	Spinocerebellar Ataxia
SCP	Superior Cerebellar Peduncle
SD	Spasmodic Dysphonia
SEM	Structural Equation Modeling
SMA	Supplementary Motor Area
SN	Substantia nigra
SNc	Substantia Nigra pars Compacta
SN <sup>+</sup>	Substantia nigra hyperechogenicity
SNR	Signal to Noise Ratio
SPECT	Single Photon Emission Computed Tomography
SPM	Statistical Parametric Mapping
SVM	Support Vector Machine
SWEDD	Scans Without Evidence of Dopaminergic Deficit
T	Tesla
T1WI	T1-weighted imaging
TBSS	Tract-based Spatial Statistics

TCS	Transcranial Sonography
TE	Echo Time
THI	Tissue Harmonic Imaging
TI	Inversion Time
TR	Repetition Time
Trace(D)	Trace of the Diffusion Tensor
TS	<i>Gilles de la Tourette</i> syndrome
UPDRS	Unified Parkinson Disease Rating Scale
VBM	Voxel-based Morphometry
VBR	Voxel-based Relaxometry
VCDR	voxels for all connectivity-defined sub-regions
Vim	Ventralis intermedius nucleus [thalamus]
VMAT	Vesicular Monoamine Transporter
Vop	Ventralis oralis posterior nucleus [thalamus]
vPD	Vascular Parkinsonism
WD	Wilson's Disease
WM	White matter
WMC	White matter changes

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