BRAIN MAPPING: THE DISORDERS.
By John C. Mazziotta, Arthur W. Toga and Richard S. Frackowiak.

Neuroimaging has become one of the growth areas in the clinical neurological sciences. The advent of CT scanners changed the entire strategy for diagnostic evaluation of patients with neurological disease. This trend was continued with the introduction of MRI scanners, which are now being used to provide information on structural changes too subtle to be appreciated by the unassisted observer. Waiting in the
wings as this action has developed over the last two to three decades has been functional brain imaging.

It is a current tenet of faith that phenomena of mind can be explained by the chemical and electrical dynamics of the brain. Hence, it has always been assumed that, were techniques only sensitive enough, all neurological disorders (and psychiatric disease) could be described in terms of functional changes in the brain. This notion has been particularly attractive because it suggests that more precise definitions of disease in terms of the underlying functional changes rather than the behavioural phenotypes may be possible. Also there has been the recognition that the behavioural phenotype observed may mask underlying pathological changes, either because it can be influenced by so many interacting factors, or because it lacks specificity. Finally, there has been the increasingly widely held hope that even the adult brain may retain sufficient capacity for adaptive functional reorganization that it can prevent behavioural manifestations of underlying pathology. This brings the promise of new treatment strategies.

These considerations have fuelled enthusiasm for functional brain mapping. Functional imaging methods use the electrophysiological, biochemical or physiological changes associated with neuronal activity to map areas of the brain that are involved in cognitive processing and their interactions. The earliest and most widely used general method was electroencephalography. This has become progressively more sophisticated in its implementation and has led to techniques with greater capacity for localization such as magnetoencephalography (MEG). Blood flow-based methods based on a variety of strategies represent a different technical evolutionary tree. These rely on the Oxford physiologist Sherrington’s observation in the last decade of the nineteenth century, that local increases in blood flow are coupled to neuronal activation in the brain. This work has led to development of the two perhaps most generally successful strategies of PET and, more recently, functional magnetic resonance imaging (fMRI). PET has also been used for more detailed functional mapping of receptor densities and their changes over time and, more recently, neurotransmitter release in studies.

However (as those who monitor research funding are so acutely aware), elegance of technology does not always go hand-in-hand with the subsequent clarity of scientific insight provided. It is incumbent on the functional imaging community to unequivocally demonstrate to colleagues that their elegant techniques are providing substantial new information. In many respects this hurdle has been well overcome in the basic neurosciences, particularly with the advent of fMRI. fMRI has already transformed neuro-psychology in a way similar to the transformation of clinical neurology that accompanied the introduction of the CT scanner. Until recently, the case has been less strongly made for clinical neuroscience.

Brain Mapping: the Disorders is one of the most impressive arguments for the potential utility of functional imaging techniques in clinical neuroscience that I am aware of. This comprehensive well-illustrated text is edited by John Mazziotta, Arthur Toga and Richard Frackowiak, who have led clinical functional imaging research with PET and MRI over the last two decades. In 26 chapters written by leaders in their respective fields, the book reviews major concepts in functional pathology that have been made apparent using modern brain mapping techniques. The chapters are organized with respect to clinical problems based around either technical issues (e.g. ‘pre-operative brain mapping’), diseases (e.g. memory disorders, dementia, the epilepsies, depression and schizophrenia) or general phenomena (e.g. ‘recovery of neurological function’).

A broad range of readers with an interest in neurological or psychiatric disease will find much to engage them in this large book. For example, in his beautifully written chapter on brain atlases, Paul Thompson describes how the spatial and temporal complexity of pathological changes can be well summarized using population-based brain atlases that integrate information across subjects or time. They can be used to fuse information from multiple modalities. Expressed as probabilistic atlases they can provide approaches for quantitative descriptions of changes that may be used to map brain development or the ravages of Alzheimer’s disease.

Movement disorders remain one of the more impressive disease entities in neurology because of their extraordinary range of manifestations (and lack of structural imaging correlates). The chapters on Parkinson’s disease, other hypokinetic disorders and hyperkinetic disorders draw a very broad picture of the current understanding of their functional pathology. Characteristic of other chapters in the book, studies using glucose uptake, blood flow, ligand binding PET and single photon emission computerized tomography (SPECT) are all covered. The focus is on the problems that the techniques address or the syndromes that they define. There is an important emphasis on integrating functional imaging with previous focal lesion studies. A critical general insight that comes through in the functional brain mapping studies is that widespread networks in the brain change their activities in response to even focal lesions, emphasizing the importance of considering the activity of the whole brain in understanding disease manifestations rather than retaining a narrow focus on interpreting solely the significant ‘lost function’ in a single region.

Some of the most exciting developments in functional imaging applications in clinical neuroscience in recent years have been in understanding psychiatric disease. The elegant chapter on psychiatric disorders by Sarah-Jane Blakemore and Chris Frith reviews the clinical phenomenology of structural imaging changes of schizophrenia before describing functional abnormalities in the brain. Clear experimental evidence is provided to define the now popular notion that cortical–cortical (or cortical–subcortical) integration is a primary functional–pathological feature of the syndrome of schizophrenia. This emphasis on disruption of normal functions rather than on the specific positive phenomenology has been
driven in large measure by data from functional imaging studies. Such work has driven a generation of new biological hypotheses concerning the aetiology of the disorder. At the same time, this work also offers the prospect that functional definition of specific pathology may contribute to more precise classification of the disorder relevant to understanding differential treatment responses, for example. This is especially attractive.

It is impossible to end a review of this book in a neurological journal without mentioning the excitement surrounding the studies of brain plasticity that are described in the concluding chapters. It has long been known that the developing brain shows an extraordinary ability to reorganize in order to minimize the behavioural consequences of even severe cerebral insults. What has begun to be appreciated more recently (particularly as a result of brain imaging and other mapping techniques included in electrophysiological approaches such as transcranial magnetic stimulation) is that the adult brain continues to be able to show functionally significant changes in response to injury to the nervous system. Mark Hallett’s chapter on plasticity emphasizes that it is not just that the brain adapts to its own lesions within, but that peripheral or spinal cord lesions also give rise to substantial changes, at least in functional organization of the motor cortex. I particularly appreciated that the discussion of plasticity in response to nervous system injury was coupled to another discussion on responses with learning. It is hopeful to consider both that we can use functional imaging techniques to tell us more about this critically important part of the human condition and that learning studies, in turn, could be used to inform those of us interested in disease and its treatment.

Neurological and psychiatric disorders will impose an increasing burden on our society as it ages with increasing medicalization of conditions such as behaviour problems or learning impairments. Functional brain imaging is an exciting and uniquely informative approach to diagnosis and monitoring, particularly of those disorders that do not have identifiable structural pathology. In providing a summary of the current state of the art and a guide to key concepts, the authors of Brain Mapping: the Disorders have provided us with a useful guide to this expanding set of tools.

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