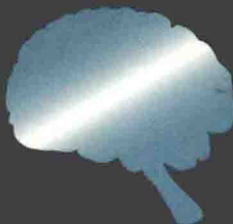




Clinical
Neuropsychology
Behavioral and Brain Science

A stylized, glowing blue silhouette of a human brain is positioned above the word 'Clinical' in the title.

John L. Bradshaw and Jason B. Mattingley

Clinical Neuropsychology

Behavioral and Brain Science

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Clinical Neuropsychology

Behavioral and Brain Science

Preface

If psychology is the scientific study of behavior, neuropsychology places that study firmly in the domain of its underlying neural and neuronal determinants. It has long been a truism that if one wishes to understand how a system works, a careful examination of all its potentialities for malfunction may provide unique insights. This volume will concentrate on the clinical aspects of brain malfunction, but will not ignore those experimental techniques, especially the newer ones of neuroimaging, which throw a complementary light on the general issue of brain–behavior interrelationships. While we can learn much from unfortunate experiments of nature, new minimally invasive neuroimaging techniques seem set to illuminate the essentially “mental” contributions of, for example, thought and imagination. For the first time *healthy* individuals can be scanned while mentally rehearsing all manner of material, and engaging in complex *everyday* tasks like viewing a video, composing music, or even knitting. The last, a project of our own, aims to determine those brain areas involved in complex, highly overlearned bimanually integrative skills that do not require vision.

We hope in this book to go some way toward simultaneously achieving several different aims: an account of the major neuropsychological and neurological syndromes in their own right; a description of those rare and intriguing anomalies of behavior, where relevant, which have long fascinated the general public from the reports of such gifted medical writers as Oliver Sacks and Harold Klawans; and an enhanced understanding of normal brain processes in language, speech, object recognition, attention, memory, movement control, and thought.

While psychology’s historical roots lie within the twin fields of physiology and philosophy, neurology and psychiatry sprang from a common medical stem and only now, after a period of separation, are beginning once again to grow together. The driving force behind their reunion is an increasing awareness of the organicity of so many disorders. The behavioral neurologist is of course comfortable with the aphasias, agnosias, amnesias, apraxias, and other movement disorders, and the clinical neurologist treats the patient with Parkinson’s disease

(PD); however, the Huntington's disease (HD) patient, with very similar disabilities, may be managed by the psychiatrist, who of course also treats patients with Tourette's syndrome (TS), schizophrenia, and mood disorders. The discipline of neuropsychiatry is doing much to blur many of these old lines of demarcation.

Lost or altered function can arise from destruction (by stroke, injury, or tumor) of the brain tissue directly involved in mediating that function, as with aphasia, apraxia, or agnosia; it can also stem from loss of activation due to damage elsewhere in the system, as in PD, or from changes in neurotransmitter activity or balance, as with the affective disorders. Clearly there are more degrees of freedom for treating disorders of the last type than is the case with the first, though cell transplantation is being employed or actively considered in the treatment of Parkinson's, Huntington's, and even Alzheimer's disease (AD).

Apart from practical handbooks of neuropsychological testing procedures, textbooks of neuropsychology have tended to adopt either a cognitive or a more traditional biological emphasis. The former owes much to modern computational and information-processing theory, and more or less explicitly rejects biological substrates in its emphasis upon software and "architecture." Indeed, for related ideological reasons it tends to eschew group studies, arguing that every individual, in sickness and health, is unique. The other, more traditional, biological approach, which we have adopted, seeks to ground function within structure, and to discuss commonalities of deficit consequent upon similarities of lesion. While we admit to finding this latter approach more satisfying, due presumably to our biological biases, and suspect that it may lend itself more readily to practical applications or therapeutic interventions, we would emphasize the potential complementarity of the two traditions.

The genesis of this volume arose from our teaching (senior undergraduate and graduate) and research. At one time or another we have empirically investigated aspects of many of the syndromes described herein, and we would emphasize the reality of the two-way nexus between teaching and research; both stimulate each other in unforeseen ways. A single convenient, integrative volume could not, we felt, religiously cover all primary sources, so we have selectively built upon existing major integrative reviews, where available, and fleshed them out with new, major, provocative, or intriguing material from primary sources published within the last two or three years. Similarly, rather than meticulously referencing every statement, we have tended to refer the reader to the major reviews listed as Further Readings at the close of each chapter, though occasionally, as in Chapter 6, in the absence of suitable material, we have adopted more traditional referencing procedures. The material in Further Readings has been carefully selected to provide an up-to-date, balanced, and comprehensive overview of the issues addressed. Some items in the Further Readings and not previously cited within the chapter may be of major integrative significance. The provision of a Summary and Conclusions section to each chapter aims to provide both a general survey and a balanced judgment of any controversial as-

pects previously discussed in detail. Not all chapters are of similar length, as their designation has been largely a matter of content. Thus controversial or unresolved issues have been treated at greater length, whereas short bridging chapters (e.g., Chapter 11) provide the necessary (largely nonclinical) background to those that follow. We have drawn together and reviewed many diverse areas of information, but if at times we may appear uncritical, it is because so much of the information is often so new and controversial that it cannot yet be properly assessed and evaluated. While we have attempted to address most major areas of relevance, and hope to have included most integrative reviews up to 1994, we note that the field is far too dynamic for us to be able to offer anything completely free of personal bias, or totally comprehensive or exhaustive.

The book is aimed at senior undergraduates, postgraduates, and researchers in the behavioral and medical sciences. We are extremely grateful to the many individuals who so readily provided us with illustrative material, and hope we have been able to acknowledge everyone appropriately. Our grateful thanks go to our partners, who are also our colleagues, Judy Bradshaw and Ada Kritikos, to our drafting artist and photographer Rosemary Williams, and to our research colleagues in psychology, neurology, and psychiatry, especially Jim Phillips, Bob Iansek, and Ed Chiu.

Contents

Preface *xiii*

Chapter 1 An Introduction to Clinical Neuropsychology

- Neuropsychology, Neuropsychiatry, and Behavioral Neurology 2
- Important Assumptions in Neuropsychology 3
- Conceptual Issues in Neuropsychology 6
- Cerebral Circulation and Stroke 11
- Stroke Syndromes Associated with Lesions in Major Arterial Fields 13
- Neuroimaging Techniques 17
- Neural Networks 21
- Summary and Conclusions 22
- Further Reading 24

Chapter 2 Disorders of Speech

The Aphasias

- Morphological Asymmetries in the Brain 26
- Other Evidence for Evolutionary Adaptations for Language 28
- Aphasia: General Considerations 31
- Wernicke's Aphasia 34
- Broca's Aphasia 37
- Other Types of Aphasia 38
- Subcortical Aphasias 42
- Illustrative Case History of Paroxysmal Aphasia 45
- Summary and Conclusions 47
- Further Reading 49

Chapter 3 Disorders of Reading and Writing*The Alexias and the Agraphias*

- Alexia with Agraphia 52
- Alexia without Agraphia, or Pure Alexia 53
- Surface Dyslexia 54
- Spelling Dyslexia 54
- Deep Dyslexia 55
- Phonological Dyslexia 57
- Literal Alexia 57
- The Agraphias 57
- Preservation of Implicit Understanding in Language Processing 58
- The Localization of Language Sites by Positron
Emission Tomography 60
- The Localization of Language Sites by Stimulation Mapping 63
- The Localization of Language Processes in Congenitally Deaf Users of
Visual Signing 64
- Summary and Conclusions 65
- Further Reading 67

**Chapter 4 A Right-Hemisphere Contribution to Language and a
Calculation Deficit**

- Major Left-Hemisphere Damage in Infancy 69
- Subtotal Left-Hemisphere Damage in Infancy 70
- Major Left-Hemisphere Damage in Adults 70
- Subtotal Left-Hemisphere Damage in Adults 70
- Evidence from Deep Dyslexia 71
- Commissurotomy Studies 72
- Right-Hemisphere Damage in Adults 74
- Acalculia 76
- Summary and Conclusions 80
- Further Reading 81

Chapter 5 Disorders of Object Recognition*The Agnosias and Related Phenomena*

Apperceptive Agnosia	86
Dorsal Simultanagnosia	87
Ventral Simultanagnosia	93
Associative Agnosia	94
Optic Aphasia	95
Category-Specific Deficits	98
Tactile Agnosia or Astereognosis	101
Auditory Agnosia	102
Amusia	103
Prosopagnosia	106
Color-Related Disorders	113
Disorders of Route Finding: Topographical Agnosia or Topographagnosia	114
Horologagnosia: A Recently Described Impairment of the Ability to Tell the Time	115
Disorders of Distortion and Perseveration	116
Visual or Optic Allesthesia	117
Delusional Misidentification Syndromes	117
Summary and Conclusions	119
Further Reading	122

Chapter 6 Disorders of Spatial Cognition*Unilateral Neglect*

Clinical Descriptions of Unilateral Neglect	125
Terminology and Deficits Related to Unilateral Neglect	129
Etiology of Unilateral Neglect	134
Neuroanatomical Correlates of Unilateral Neglect	134
Models of Unilateral Neglect	138
Current Issues in Unilateral Neglect	156
Recovery and Rehabilitation	174
Summary and Conclusions	183
Further Reading	186

Chapter 7 *The Acallosal Syndrome**Commissurotomy Studies*

- The Forebrain Commissures 188
- Prior Animal Studies 190
- The Human Acallosal Syndrome 191
- Zaidel's "Z" Lens Technique of Prolonged Visual Lateralization 193
- Subcortical Transfer of Information across the Divided Forebrain? 194
- Independent Processors, Wills, and Streams of Consciousness? 197
- The Congenital Acallosal Syndrome 199
- Case History: Alien-Hand Syndrome 200
- Summary and Conclusions 203
- Further Reading 204

Chapter 8 *Disorders of Memory**The Amnesias*

- Working Memory 209
- Regions Involved in Long-Term Memory 211
- Temporal Lobe Amnesia 214
- Diencephalic Amnesia and the Wernicke–Korsakoff Syndrome 215
- Preserved Implicit Covert or Incidental Memory 220
- Basal Forebrain Amnesia 222
- An Overview of the Structures and Functions Involved in the Amnesic Syndrome 223
- Case History: H. M. and the Lasting Consequences of Bilateral Medial Temporal Lobectomy 225
- Summary and Conclusions 226
- Further Reading 228

Chapter 9 *Dementia and Alzheimer's Disease*

- Causes of Dementia 232
- Alzheimer's Disease: General Considerations 233
- Criteria for Diagnosis and Manifestations of Alzheimer's Disease 234
- Memory Dysfunction in Alzheimer's Disease 236
- Language Deficits in Alzheimer's Disease 237

Other Deficits	238
Neuropathology in Alzheimer's Disease	238
The Role of β -Amyloid in the Etiology of Alzheimer's Disease	240
The Inheritance and Genetics of Alzheimer's Disease	242
Summary and Conclusions	246
Further Reading	248

Chapter 10 Movement Control I

Cortical Systems and Apraxia

Prefrontal Cortex	252
Premotor Cortex and Supplementary Motor Area	257
Primary Motor Cortex (Motor-Sensory Cortex)	261
Parietal Cortex	263
Apraxia: A Disorder of Voluntary Gesture and Action	264
Summary and Conclusions	274
Further Reading	276

Chapter 11 Movement Control II

Cerebellum and Basal Ganglia

Cerebellum	278
The Basal Ganglia	282
Summary and Conclusions	288
Further Reading	288

Chapter 12 Subcortical Movement Disorders I

Parkinson's Disease

Parkinson's Disease, Aging, and the Dopaminergic System	290
Positive and Negative Symptoms in Parkinson's Disease	294
Deficits in the Internal Generation of Programmed Activity	296
Cognitive Impairments	298
Dementia and Depression in Parkinson's Disease	301
Disease Progression	303
Management of the Disorder	303
Causes of Parkinson's Disease	306

Summary and Conclusions	308
Further Reading	310

Chapter 13 Subcortical Movement Disorders II

Huntington's Disease

Prevalence, Age of Onset, and Inheritance of Huntington's Disease	312
Symptomatology of Huntington's Disease	314
Cognitive Deficits in Huntington's Disease	316
The Neuropathology of Huntington's Disease	318
Summary and Conclusions	321
Further Reading	322

Chapter 14 Other Movement and Neuropsychiatric Disorders

Tics, Tourette's Syndrome, Obsessive–Compulsive Disorder, Autism, Affective Disorders, and Other Such Disabilities

Extrapyramidal Movement Disorders	325
Tic Disorders: General Features	329
Tourette's Syndrome: General Symptomatology	332
Hereditary and Environmental Factors in Tourette's Syndrome	335
Anatomical and Neurochemical Aspects of Tourette's Syndrome and Obsessive–Compulsive Disorder	336
Obsessive–Compulsive Disorder: General Symptomatology	338
Autism	340
Other Neuropsychiatric Deficits: Aggression and Violence	346
Affective Disorders	347
Summary and Conclusions	349
Further Reading	351

Chapter 15 A Disorder of Thought

Schizophrenia

One Disease or Many?	354
Course and Progression of Schizophrenia	356
Attentional Deficits	360
Feedback and Feed Forward in Schizophrenia	361

Brain Anomalies in Schizophrenia	362
Drug Treatment of Schizophrenia: The Dopamine Hypothesis	366
Schizophrenia as an Inherited Disorder	367
Environmental Factors	368
Case History	370
Summary and Conclusions	370
Further Reading	372

Chapter 16 Final Thoughts

*The Present and Future Status of Experimental and
Clinical Neuropsychology* 373

<i>References</i>	381
<i>Author Index</i>	431
<i>Subject Index</i>	451

An Introduction to Clinical Neuropsychology

THE INSCRUTABLE ARCANUM OF THE ORGANIZATION OF THE BRAIN . . . ATTRACTED US IRRESISTIBLY. WE SAW THAT AN EXACT KNOWLEDGE OF THE STRUCTURE OF THE BRAIN WAS OF SUPREME INTEREST FOR THE BUILDING UP OF A RATIONAL PSYCHOLOGY. TO KNOW THE BRAIN, WE SAID, IS EQUIVALENT TO ASCERTAINING THE MATERIAL COURSE OF THOUGHT AND WILL.

—SANTIAGO RAMÓN Y CAJAL, *Recollections of My Life*

The basic precept of neuroanatomists such as Cajal, that explanations of human behavior can develop from an understanding of the structural organization of the brain, represents an approach to brain–behavior relationships that lies at the opposite end of the spectrum to that of neuropsychology. From its narrowest interpretation, the primary goal of neuropsychology is to use detailed behavioral analyses to infer underlying structural and functional properties of the brain. Thus, the kinds of data yielded by neuroanatomical and neuropsychological approaches are likely to be quite different, even though their ultimate goals are essentially the same. Moreover, although the levels of explanation offered by the two approaches are often different, the insights provided by one may be useful in refining and constraining the interpretations of the other. In this volume, although our view of brain–behavior relationships is taken principally from a neuropsychological perspective, we shall also draw on insights obtained from neuroanatomical and neurophysiological studies. This reflects our basic philosophy that cognitive processes do not exist in a vacuum; they are determined by the inherent structure and function of the neural substrate.

In this introductory chapter, we provide an overview of some of the important conceptual and methodological issues in neuropsychology. Our intention is to familiarize the reader with the assumptions and principles upon which hypotheses about brain–behavior relationships are based, and to explain the differ-

ent approaches to data acquisition and interpretation in neuropsychological research. In addition, because we place considerable emphasis on studies of brain-lesioned patients, we have included sections on the cerebral vasculature and on the behavioral consequences of pathologies involving specific arterial territories. Finally, we consider two modern techniques, neuroimaging and artificial neural network modeling, both of which have had a considerable impact on contemporary models of the structural and functional organization of the brain.

Neuropsychology, Neuropsychiatry, and Behavioral Neurology

The discipline of neuropsychology began in the late 19th century with the patient studies of Broca, Wernicke, Lichtheim, and Hughlings Jackson. These workers adopted the principle of functional localization, in which specific cognitive functions are assumed to be subserved by discrete brain regions. Using the method of anatomoclinical correlation, these workers established associations between damage to particular brain regions and distinct manifestations of behavioral anomalies such as aphasia. The localizationist approach, which developed from Gall's original, though misguided, attempts to localize such various complex behaviors as "philoprogenitiveness" according to the topography of an individual's skull (Spurzheim, 1815; cited in Farah, 1994), became the cornerstone of the developing discipline of neuropsychology. However, whereas the early anatomoclinical studies persisted in assigning complex functions to specific brain regions, it was not until Hughlings Jackson established his famous dictum, that localizing a *lesion* and localizing a *function* are conceptually distinct, that real progress was made in elucidating the nature of human brain-behavior relationships.

Despite its relative youth, neuropsychology has already found a distinct niche within the fields of medicine and psychology. There are, however, several other disciplines that are clearly related; thus, *neuropsychiatry* involves "understanding the neurobiological basis, optimal assessment, natural history, and most efficacious treatment of disorders of the central nervous system with behavioral manifestations" (Cummings & Hegarty, 1994, p. 209). One subtle distinction between neuropsychology and neuropsychiatry is that the latter is often motivated by a desire to understand disordered behavior in terms of its implications for diagnosis and treatment. Similarly, the discipline of *behavioral neurology* (Devinsky, 1992) involves the use of data concerning the anatomy and physiology of the central nervous system (CNS) to guide interpretations of disordered behavior consequent upon neural damage. Although neuropsychology shares these aims, at least insofar as it too is concerned with patient diagnosis and management, it is ultimately concerned with elucidating the mechanisms underlying abnormal and *normal* behavior. Indeed, modern neuropsychology is based on data obtained not only from brain-damaged patients, but also from normal individu-

als; it exploits over 100 years of research in experimental psychology to help explain the patterns of disordered perceptual, cognitive, and motor processes seen in patients with neural damage.

There is also a sense in which neuropsychology itself can be further divided into distinct subspecialties. Whereas *clinical* neuropsychology is concerned with explaining how specific patterns of disordered human behavior may arise from disruption of particular brain processes, *cognitive* neuropsychology is focused primarily on explaining disordered behavior in terms of disruption to particular information-processing units, with (at best) only peripheral concern for their anatomical or physiological instantiation. Thus, the aim of cognitive neuropsychology is to understand information processing independently of the neural hardware. The reason for this approach, it has been argued (e.g., Caramazza, 1988), is that we know too little about normal brain processes and behavior to begin relating the two; this limitation becomes even more obvious when we attempt to understand the behavioral consequences of brain damage. An alternative view is that despite the obvious gaps in our knowledge, we nevertheless have a sufficiently detailed database from which to begin relating results of behavioral analyses with those obtained from studies of brain anatomy and physiology (e.g., Kosslyn, 1994). It is this latter view that we have adopted in this book; although in some cases the links we have proposed between particular behavioral anomalies and underlying brain processes remain tentative, we believe such endeavors facilitate the iterative process of developing and refining models of normal and disordered behavior.

Important Assumptions in Neuropsychology

Modularity

The prevailing assumption in neuropsychology is that cognitive processes are organized into distinct processing units or *modules*. In one conceptualization, modules are hardwired, autonomous, computational mechanisms that perform highly specific functions, such as feature detection (Fodor, 1983). The outputs from several modules may be combined in the service of more complex cognitive operations, though the content of any given module is not available to consciousness. The concept of modularity, or some variant thereof, underpins most theorizing in modern neuropsychology (Shallice, 1988). It is appealing from both a computational and an evolutionary perspective; dividing a computational system into smaller subunits permits rapid, parallel processing of many different inputs, and it permits changes in specific subunits without necessarily affecting the operations of others. In addition, local damage may impair only a subset of specialized functions, rather than causing a global reduction in processing efficiency.