Essentials of

Neuropsychological Assessment

SECOND EDITION

Treatment Planning for Rehabilitation

Rik Carl D'Amato
Lawrence C. Hartlage
Editors

SPRINGER PUBLISHING COMPANY

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Rik Carl D'Amato, PhD, an award-winning professor, researcher, and author, serves as head of the Department of Psychology in the faculty of social sciences and humanities at the University of Macau, China. Prior to this position, D'Amato served for 18 years as a professor at the University of Northern Colorado (UNC) in the School of Applied Psychology and Counselor Education. He was named an M. Lucile Harrison Professor for Excellence in the classroom, and an Albert M. and Jo Winchester Distinguished Professor for his university scholarship. D'Amato was awarded a Medal of Achievement for serving as editor-in-chief of *School Psychology Quarterly*, the American Psychological Association (APA) School Psychology Division journal, from 2003 to 2007. A prolific scholar, in 1999 he was named as one of the top 30 editorial board members in the field of school psychology.

D'Amato has published more than 200 articles, books, chapters, encyclopedia entries, and reviews, many of which address the integration of the practical and scientific aspects of ecological neuropsychology and learning. A hallmark of his career has been his collaboration with students or young professors and some 85% of his publications and presentations are coauthored with students or with student-faculty research teams. D'Amato has twice received the Who's Who Among America's Teachers award after being nominated by his students. In 2005, D'Amato's research group was awarded the Best Applied Neuroscience Paper award from the Division of Clinical Neuropsychology of the APA.

D'Amato served as assistant dean and director at the Center for Collaborative Research in Education in the College of Education and Behavioral Sciences at UNC. Previously, D'Amato served as professor, director, and chair of school psychology training. D'Amato received his PhD from Ball State University in 1987. D'Amato was selected as a Senior Fulbright Scholar to train teachers and collaborate on curriculum design at the Liepaja Pedagogical Institute-Higher School in Latvia (the Former Soviet Union). D'Amato is a Fellow in School Psychology of the APA. For his contributions around the world, in 2004 he was awarded the Neuropsychology Lifetime Achievement Award by the National Association of School Psychologists Neuropsychology Interest Group. Dr. D'Amato can be reached at the Department of Psychology, Faculty of Social Sciences and Humanities, University of Macau, Taipa, Macau SAR, China. Web site: http://www.umac.mo/psychology

Lawrence C. Hartlage, PhD, is a prolific researcher, teacher, and practitioner. Hartlage has served as president of the National Academy of Neuropsychology; the American Psychological Association Division of Neuropsychology; and the American Board of Professional Neuropsychology. Elected to Fellow status by seven Divisions of the American Psychological Association, he was a charter Fellow of the American Psychological Society and listed in the inaugural "Who's Who in Medicine and Healthcare."

Hartlage has authored and edited 13 books, 50 invited chapters, and more than 150 articles. He received his doctorate from the University of Louisville in 1968 and has diplomas in clinical psychology from the American Board of Professional Psychology and in neuropsychology from the American Board of Professional Neuropsychology. He has served as consultant to the Canadian Research Council, Center for Disease Control, North Atlantic Treaty Organization, National Institutes of Health, and the U.S. Surgeon General, as well as numerous military and private hospitals. Dr. Hartlage can be reached at phartlage@mail.mcg.edu

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Dedication

Love. Faith. Pride. These are gifts that, when freely given, can be returned in full measure. For all they have given to me, I dedicated this book to my two sons, Michael A. D'Amato, IV, and David D. D'Amato.
They have been my life blessings.

—Rik Carl D'Amato

This one's for Jeff and Mary Beth who make me a proud parent.

—Lawrence C. Hartlage

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Contributors

Mark Barisa, PhD, ABPP
St. Vincent Hospital
Indiana Neuroscience Institute
Indianapolis, Indiana

Andrew S. Davis, PhD
Neuropsychology Laboratory
Department of Educational Psychology
Ball State University
Muncie, Indiana

Jodene Goldenring Fine, PhD
Department of Psychiatry
Michigan State University
East Lansing, MI

Glen R. Finney, MD
Department of Neurology
College of Medicine
University of Florida

Arthur MacNeill Horton Jr., EdD, ABPP, ABPN
Neuropsychology Clinic
Psych Associates of Maryland
Bethesda, Maryland

Arthur MacNeill Horton III, BS
Eastern Virginia Medical School
Norfolk, VA

Lawrence J. Lewandowski, PhD
Department of Psychology
Syracuse University
Syracuse, New York

Benjamin J. Lovett, PhD
Department of Psychology
Syracuse University
Syracuse, New York

Kimford J. Meador, MD
Department of Neurology
McKnight Brain Institute
University of Florida
Gainesville, Florida

Fenwick T. Nichols, MD
Department of Neurology
Medical College of Georgia

Chad A. Noggle, PhD
St. Vincent Hospital
Indiana Neuroscience Institute
Indianapolis, Indiana

Cynthia A. Riccio, PhD
Department of Psychology
Texas A&M University
College Station, TX

Margaret Semrud-Clikeman, PhD
Center for Neurodevelopmental Study
Department of Psychology and Psychiatry
Michigan State University
East Lansing, Michigan

Stephanie R. Sinco, PhD Candidate
School of Applied Psychology and Counselor Education
College of Education and Behavioral Sciences
University of Northern Colorado
Greeley, Colorado

Jonathan E. Titley, PhD Candidate
School of Applied Psychology and Counselor Education
College of Education and Behavioral Sciences
University of Northern Colorado
Greeley, Colorado

Justin Walker, PhD Candidate
School of Applied Psychology and Counselor Education
College of Education and Behavioral Sciences
University of Northern Colorado
Greeley, Colorado

J. Michael Williams, PhD
Department of Psychology
Drexel University
Philadelphia, Pennsylvania

Deborah E. Witsken, PhD Candidate
School of Applied Psychology and Counselor Education
College of Education and Behavioral Sciences
University of Northern Colorado
Greeley, Colorado

Preface

The first edition of this text was published 21 years ago in 1987. At that time, neuropsychology was a relatively exotic specialty whose practitioners were typically found only in neurology programs at medical schools and in tertiary hospitals. In 1987, the majority of these practitioners, who numbered a few hundred at most worldwide, were primarily involved in the assessment of patients with severe neurological impairments or in the differentiation of organic versus functional disorders. Generally, in the Western world, they used the *Halstead-Reitan Battery* as their major assessment tool. At that time, neuroimaging was crude by today's standards, and the chief focus of most assessment activities was on lesion localization. That has all changed. The last two decades have heralded amazing discoveries, and we now understand the brain much better than ever before (Hartlage and D'Amato, 2008). This new understanding has led to novel neuroscience jobs in all sectors of society. Some would say that clinical neuropsychology has *come of age*. As a result of these new developments, a revision of this text was necessary.

Today's neuropsychology is different in many ways. We now understand more clearly the truly biological base of our behavior and the biochemical foundation of human thought. The number of trained neuropsychologists has dramatically increased, with membership in the American Psychological Association's Division of Clinical Neuropsychology currently at about 4,000. Membership in other organizations such as the National Association of Neuropsychology (with more than 3,300 members from 24 countries) and the International Neuropsychological Society (with more than 4,500 members) has also grown. The increase in the number of trained neuropsychologists has resulted in their greater availability, not only in hospitals, but also in private practices, community mental health programs, and universities.

Since the genesis of psychology, the brain has always been an area of interest. When we began studying the brain hundreds of years ago, researchers and practitioners alike sought to generate new knowledge and disseminate what they had discovered (Hinshelwood, 1900; Morgan, 1896). More recently, we have refocused our beliefs and now seek to provide *evidence-based* neuropsychological services that are efficient and effective (Traughber & D'Amato, 2005). This means that practitioners must become practitioner-scholars who can research alternative therapeutic approaches and select neuropsychological interventions with data that supports their effectiveness. No longer should we base practice on how we have done it in the past. We must abandon activities that lack empirical evidence and work to develop a research base for current rehabilitation practices. For example, Shaywitz (2003) has demonstrated an empirically-driven systematic approach to teaching reading that changes the brain. Data shows that her approach does indeed work. The United States Department of Education (2008) has joined the fray developing and maintaining a *What Works* clearinghouse web site for practitioners.

In fact, the research in areas like individual differences, normal aging, hemispheric processing, and learning problems suggest that neuropsychology may be relevant to understanding behavior along a considerable age continuum, and along a continuum ranging from patients that seem apparently normal to patients who are severely impaired. The field of clinical neuropsychology has grown to the point where many practitioners have now developed neuropsychological subspecialties, including the areas of pediatric neuropsychology, school neuropsychology, geriatric neuropsychology, forensic neuropsychology, and neurorehabilitation. However, this growth has been curtailed by medical providers who have sought profit over the provision of comprehensive neuropsychological services. Thus, the field continues to face a significant quandary. New assessment procedures and rehabilitation techniques are available while at the same time neuropsychological services have been reduced. Clinical neuropsychologists have had to reconceptualize and trim assessment activities in ways that could lead to reduced but effective neurorehabilitation. Although these service reductions could have slowed the development of the field, this does not seem to have been the case. The areas of neuroimaging, psychopharmacology, and adaptive technology appear to be at the forefront, helping to expand current neuropsychological practices.

The focus of assessment, once limited to lesion localization in neurologically impaired patients, now encompasses broader issues, and focuses on the uniqueness of each individual patient and how cerebral processing can influence rehabilitation and later life. Research has shown that we must focus on understanding individual differences in development, perception, temperament, and general cognitive ability, with neuropsychological substrates discussed as possible determinants of individual processes for each of these areas (Hartlage & D'Amato, 2008). The increased availability of neuropsychology practitioners has made neuropsychological services much more visible and viable. Understanding an individual's neuropsychological processes can be relevant to learning how the normal brain develops as well as to understanding patient behavioral disorders and difficulties. For example, the age, race, and presenting problems of patients have changed considerably in the last decade. To meet these changes the model of neuropsychology services has also changed. The greatest change in our second edition relates to how assessment is linked to treatment planning for rehabilitation. The previous edition focused on how to assess individuals rather than on how to offer successful treatment. Our goal for this edition is to connect assessments to treatment planning in a seamless fashion. It is time to abandon assessments that do not help us understand an individual or improve intervention.

Currently, there is increased variability in approaches to assessment. The last decade has seen the development of a number of psychometrically sophisticated measures and the field no longer is focused on using one of two key neuropsychological batteries (i.e., the *Halstead-Reitan*, the *Luria-Nebraska*). Many practitioners now use recently developed batteries such as the *NEPSY-II* or the *Dean-Woodcock Neuropsychological* system. Additional measures that focus on specific brain-related areas such as memory (e.g., *Test of Memory and Learning-II*) and executive functioning (e.g., *Delis-Kaplan*) also have become quite popular. These updated instruments can help provide better rehabilitation activities. In this edition, you will find that we cover more instruments in greater depth than in the previous edition. Qualitative procedures have also grown greatly (see Witsken, Stoeckel, & D'Amato, in press) and are discussed in a number of sections in our text. Our hope is that a stronger neuropsychological foundation will lead to improved treatment outcomes for children and adults.

This volume is intended for the neuropsychology student or beginning practitioner as an introduction to the diverse aspects of clinical neuropsychology, with special reference to how neuropsychology may relate to the issues likely to be encountered in practice. We are attempting to offer you the *essentials* of what is needed to achieve neuropsychological success with patients. This volume should also enable the non-neurologically trained practitioner to appreciate the range and type of clinical problems for which neuropsychology may make contributions toward diagnosis, management, and rehabilitation.

Chapter contributors were solicited on the dual criteria of recognized expertise in their respective areas and their ability to communicate this expertise in a clinically relevant form to professionals whose involvement with neuropsychology may just be beginning to develop. In order to achieve this goal, the editors have sought to present the richness of the individual clinical perspectives of the authors so that the practitioner will recognize that there is no one absolute standard, instrument, or approach that represents the essence of neuropsychology. Our hope is that our talented authors will have presented information in a way which will help readers understand and offer new and advanced neuropsychological services. It is important for us to acknowledge each author's dedication and commitment to excellence. We believe that the goal of clinical neuropsychology services should be to improve interventions for individuals while offering preventive activities at the societal level.

Rik Carl D'Amato, PhD
Macau SAR, China
Lawrence C. Hartlage, PhD
Augusta, GA

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PART I

Foundations of Neurological and Neuropsychological Practice

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1

Understanding the Past, Present, and Future of Clinical Neuropsychology

DEBORAH E. WITSKEN, RIK CARL D'AMATO, AND LAWRENCE C. HARTLAGE

Within the last several decades, clinical neuropsychology has gained increasing recognition as a discipline with relevance to such diverse practice areas as family medicine, neurology, neurosurgery, psychiatry, and psychology as well as to such research areas as behavior, learning, and individual differences. Although the history of neuropsychological practice is rooted in its efforts to develop techniques to assist in differentiating organic (or neurological) causes of behavior from functional (or environmental) causes of behavior, contemporary neuropsychology has begun to redefine its role, seeking the scientific knowledge and tools to be able to answer more refined and practical questions (Hartlage, 1987; Hartlage & D'Amato, 2007). The growth of neuropsychology over the past several decades is evident in the branching off of numerous related subspecialties, including pediatric neuropsychology, school neuropsychology, geriatric neuropsychology, forensic neuropsychology, and rehabilitation neuropsychology. Neuropsychology's application to rehabilitation in particular has emerged as a subdiscipline whose research base and practice have flourished in recent decades with advancements in cognitive rehabilitation and retraining. In fact, nearly half of practicing neuropsychologists report that they have engaged in some type of cognitive rehabilitation or retraining activities (Lee & Riccio, 2005; Seretny, Gray, Hartlage, & Dean, 1985).

NEUROPSYCHOLOGY AND OTHER ASSESSMENT APPROACHES

According to the National Academy of Neuropsychology (2001), neuropsychology is the "applied science of brain-behavior relationships." Neuropsychologists must apply a working understanding of psychology, physiology, and neurology to assess, diagnose, and treat patients with neurological, medical, neurodevelopmental, psychiatric, and cognitive disorders (D'Amato, Fletcher-Janzen, & Reynolds, 2005). In addition to using assessments of neurocognitive, behavioral, and emotional functioning to form hypotheses regarding a client's central nervous system functioning, neuropsychologists carefully consider how these factors interact with the individual's psychosocial environment (National Academy of Neuropsychology, 2001; Teeter & Semrud-Clikeman, 2007). Viewed from this perspective, neuropsychological assessment may serve a variety of purposes beyond an initial diagnosis. Assessments may be used to guide treatment decisions by identifying an individual's strengths, weaknesses, and needs; to design individual treatment programs tailored to these findings; to evaluate changing treatment needs; and to monitor treatment effectiveness (Lezak, Howieson, & Loring, 2004; Root, D'Amato, & Reynolds, 2005).

In a number of ways, clinical neuropsychology can be viewed as representing a synthesis of the best features of neurological, psychiatric, and psychological examination procedures, whereby the systematic neurological assessment of functional cortical systems is combined with the precise scaling of psychometric measurement. Neuropsychological assessment allows the examiner to reduce the subjectivity in traditional neurological examinations by conducting assessments that lead to quantifiable standardized scores, thereby increasing the reliability of the assessment as well as allowing for a more sensitive baseline for comparisons across time. In contrast with traditional clinical measures such as a mental status exam, which allow for imprecise estimates of dementia, dyscalculia, or dysphasia, neuropsychological assessment more precisely identifies which functional system is impaired or to what extent it is impaired.

The critical difference between traditional psychological assessment and clinical neuropsychology is the presumed neurological substrates of behavior being measured. In contrast with neuropsychology, traditional clinical and school psychology instruments do not necessarily link assessment results to specific brain functioning. While traditional measures in psychology can describe and in some cases predict behavior, this descriptive or prognostic function does not focus on the determinants in the form of biological substrates. Neuropsychology, on the other hand, uses measures that presumably assess either (1) specific anatomic loci (e.g., left posterior frontal lobe motor strip or right anterior parietal lobe sensory strip functional systems) with respect to presumed anatomic loci (e.g., rhythm sense) or (2) constellations of functional systems (e.g., short-term visual-spatial memory, long-term verbal memory) that have implications for specific aspects of brain function.

Likewise, neuropsychologists and traditional clinical and school psychologists may use many of the same diagnostic instruments, but the purpose of their use and implications for diagnosis differ on the dimension of referral to neurological substrates of findings. A traditional psychologist may use a test of dominant-hand fine motor coordination to determine whether or not an individual could perform a given job requiring such coordination, while the focus of the neuropsychologist on this measure would more likely involve the functional integrity of the contralateral cerebral hemisphere motor strip. So too, traditional psychologists relying on cognitive domain testing often select tests providing normative comparisons. However, these tests may not provide data that satisfy questions regarding brain functioning (Parrish, 2005). For example, a low IQ score on a Wechsler scale may be indicative of any number of factors (e.g., genetics, educational disadvantage, fatigue, limited attention, emotional functioning, brain functioning; Parrish, 2005). While neuropsychologists may incorporate similar measures in their evaluations, additional assessments that have been proved through rigorous scientific research to assess brain functioning are also frequently part of a neuropsychologist's tool bag (Parrish, 2005). Thus, the practice of clinical neuropsychology could be defined as the scientific application of psychological and psychometric measurement procedures to assess and understand behaviors related to the central nervous system.

TRAINING IN NEUROPSYCHOLOGY

This level of interpretation requires specialized training. Although many neuropsychologists are also trained as clinical or school psychologists, the reverse is less common. The use of some clinical neuropsychology assessment procedures in practice does not qualify one as a clinical neuropsychologist. By analogy, although a cardiologist uses a stethoscope, anyone who learns how to use a stethoscope does not automatically become a cardiologist (Hartlage, 1987). The fact that clinical and school psychologists and neuropsychologists frequently use similar tools has led to considerable debate surrounding neuropsychologists' training and licensure requirements. Several professional organizations have arisen to represent clinicians and researchers in neuropsychology. These organizations have contributed to establishing training standards and regulating credentialing in neuropsychology. Among these are the International Neuropsychology Association, Division 40 (Clinical Neuropsychology) of the American Psychological Association, and the National Academy of Neuropsychology. Two national professional credentialing boards in neuropsychology emerged to specify and regulate practitioner qualifications. These include the American Board of Professional Psychology, which recognizes clinical neuropsychology as a specialty area of practice within psychology, and the American Board of Professional Neuropsychology, which exclusively recognizes specialists in neuropsychology. Currently, most clinical neuropsychologists have obtained a doctoral degree in psychology with coursework, research, and practicum experiences in neuropsychology, followed by postdoctoral training with a neuropsychology emphasis. The International Neuropsychology Association recommends a PhD program in clinical neuropsychology either through a psychology or medical department or sufficient coursework in neuropsychology through a PhD in clinical, counseling, or school psychology. In addition to core coursework in general psychology, clinical psychology, neurosciences, and clinical neuropsychology, International Neuropsychology Association internship guidelines require an 1,800-hour internship under supervision of a board-certified clinical neuropsychologist, with at least 50% of the time devoted to clinical neuropsychology. Table 1.1 displays the recommended coursework and training.

Practicing neuropsychologists are generally expected to obtain licensure from their respective state psychology licensure board prior to seeking board certification in clinical neuropsychology.

THE PAST: INFLUENCES ON NEUROPSYCHOLOGICAL THEORY AND PRACTICE

Neuropsychology represents a unique integration of several convergent disciplines, including neurology, neuroanatomy, neurophysiology, neurochemistry, neuropharmacology, and psychology—particularly cognitive

Table 1.1

GUIDELINES FOR DOCTORAL TRAINING IN NEUROPSYCHOLOGY

EDUCATION

May be accomplished through a PhD program in clinical neuropsychology offered by a psychology department or medical facility or through completion of a PhD program in a related specialty (e.g., clinical, school, counseling psychology) that offers sufficient specialization in clinical neuropsychology.

REQUIRED CORE

A. Generic Psychology Core

1. Statistics and methodology
2. Learning, cognition, and perception
3. Social psychology and personality
4. Physiological psychology
5. Life span development
6. History

B. Generic Clinical Core

1. Psychopathology
2. Psychometric theory
3. Interview and assessment techniques
    1. Interviewing
    2. Intellectual assessment
    3. Personality assessment
4. Intervention techniques
    1. Counseling and psychotherapy
    2. Behavior therapy/modification
    3. Consultation
5. Professional ethics

(*Continued*)

Table 1.1

GUIDELINES FOR DOCTORAL TRAINING IN NEUROPSYCHOLOGY (*Continued*)

C. Neurosciences: Basic Human and Animal Neuropsychology

1. Basic neuroscience
2. Advanced physiological and psychopharmacology
3. Neuropsychology of perceptual, cognitive, and executive processes
4. Research design and research practicum in neuropsychology

D. Specific Clinical Neuropsychology Training

1. Clinical neuropsychology and neuropathology
2. Specialized neuropsychology assessment techniques
3. Specialized neuropsychological intervention techniques
4. Assessment practicum with children and/or adults
5. Clinical neuropsychology internship of 1,800 hours, preferably in a university setting

INTERNSHIP

The internship must devote at least 50% of a one-year full-time training experience to neuropsychology. In addition, at least 20% of the training must be devoted to general clinical training to ensure competent background in clinical psychology. Supervisors should be board-certified clinical neuropsychologists.

Source: Teeter & Semrud-Clikeman (2007).

and developmental psychology. In many respects, the advancement of neuropsychology has been intricately linked to developments in each of these fields (Boller & Grafman, 2000). For example, Broca's identification of a link between left hemispheric damage and aphasia and Wernicke's discovery of fluent aphasia disorders associated with left posterial temporal lobe damage significantly advanced the field's understanding of the potential to identify locations in the brain responsible for specific behavioral functioning (Boller & Grafman, 2000; Broca, 1865/1960). Following the recognition of the possibility of localization of functioning in the brain, efforts to develop quantitative techniques for assessing brain damage emerged. The field of educational psychometrics and the work of researchers such as Francis Galton, Alfred Binet, and Charles Spearman contributed to neuropsychology's integration of the normative perspective to understanding mental abilities, as well as its recognition of the importance of utilizing reliable and valid measurement tools (Lamberty, 2002; Lezak et al., 2004).

History of Rehabilitation in Neuropsychology

Some researchers consider the field of rehabilitation older than neuropsychology itself (Boake, 2003). More than a century ago, Paul Broca documented his intuitive rehabilitation program to restore reading skills in an adult patient who was unable to read aloud (Berker, Berker, & Smith, 1986; as cited in Boake, 2003). Broca concluded from his work with this patient that the patient was likely learning to read through visual techniques rather than the process the patient used when learning to read as a child (Boake, 2003). Another prominent American neuropsychologist, Shepherd Franz, who was known for using scientific methodology to study motor learning in hemiparesis and the effectiveness of therapy with clients with aphasia, was also a pioneer in neuropsychology rehabilitation (Boake, 2003; Prigatano, 2005). Like Broca, Franz noticed that his aphasic patients appeared to look more like they were learning a new skill rather than relearning an old habit, establishing a precedent for using techniques that focus on learning new skills to compensate for skills lost due to brain damage.

Neuropsychological rehabilitation gained momentum during the first and second World Wars, when rehabilitation centers to treat brain-injured soldiers were established in Europe. The most reputable brain injury rehabilitation centers were in Germany and Austria. Several of these centers offered comprehensive services, including a residential program or hospital, a psychological evaluation unit, and vocational skill assessment and training classes (Boake, 2003). The well-known German psychologist Kurt Goldstein documented his treatment recommendations for speech, reading, and writing impairments. In doing so, he provided a template for rehabilitation efforts that draw upon preserved areas to compensate for lost skills and behavioral methods for shaping desired behaviors (Boake, 2003). He has also been credited with several facets of current rehabilitation theory and practice, including systematic and long-term follow-up of patients, use and understanding of the limitations of psychometric techniques, and careful observation of clients' natural preference for forms of compensation or substitution. Goldstein also recognized fatigue effects during therapy, respected the uniqueness of each patient and resulting variable performance, addressed cognitive and personality deficits, and connected cognitive rehabilitation to functional activities (Newcombe, 2002).

During World War II, the renowned Russian psychologist Alexander Luria synthesized his theories of functional systems based on his study of veterans with penetrating brain injuries (Boake, 2003). Although his emphasis on rehabilitation emerged later in his career, his work extended rehabilitation beyond working with patients with aphasia to include intervention with patients demonstrating motor planning, visual perception, and executive functioning disorders (Christensen & Castano, 1996; Prigatano, 2005). Luria is also credited with recognizing the importance of obtaining a detailed neuropsychological profile to understand underlying patient deficits. This information can then be used to draft appropriate rehabilitation plans, based on the use of intact systems to compensate for impairments. Before initiating efforts to restore impaired functioning, Luria used direct training to reorganize the underlying neuropsychological system (Prigatano, 2005). Thus, Luria established a precedent by recognizing the importance of conducting a thorough assessment to facilitate intervention planning, as well as to evaluate if the neuropsychological interventions implemented for each patient are appropriate.

Historical Roots of Rehabilitation Approaches

In the years that followed, psychologists such as Oliver Zangwill and Edna Butfield brought attention to the importance of an empirical approach to understanding rehabilitation, utilizing control groups to account for expectations based on spontaneous recovery rather than the effects of rehabilitation (Boake, 2003). Zangwill was also credited with recognizing that rehabilitation may follow one of three paths: restoration, substitution, or compensation (Prigatano, 2005). Restoration involves direct retraining of impaired areas. Substitution approaches involve efforts to train brain-injured patients to use alternate strategies in place of those affected by impaired functions. Compensation relies on use of alternative strategies to solve problems caused by impaired functioning.

Many psychologists working with veterans with brain injuries recognized the importance of comparing results from psychological tests with the clients' vocational performance, foreshadowing the current emphasis on ecological validity of assessment practices to better predict practical functioning (Boake, 2003). Furthermore, rehabilitation following the work of Yehuda Ben-Yishay during the late 1970s and 1980s increasingly recognized the importance of systematically addressing the interpersonal and social needs of clients in order for them to successfully reenter their social environment (Prigatano, 2005). Based on the recognition that patients' emotional and motivational disturbances must be addressed in addition to cognitive deficits, holistic approaches emerged that included psychotherapy as part of the treatment for individuals with brain injuries (Prigatano, 2005). Weinstein's contribution of an understanding that many patients with brain injuries may, as a characteristic of the injury, demonstrate impaired awareness of their difficulties rather than perceived denial of their disability represented a breakthrough that has had important implications for rehabilitation (Prigatano, 2005). The history of the development of rehabilitation neuropsychology illuminates several common trends visible in today's practice. First, rehabilitation neuropsychology has traditionally emphasized careful scientific assessment of the neuropsychological impact of a brain injury to lead to targeted interventions. This tradition emphasizes the use of cognitive retraining or efforts to identify compensatory or remedial techniques (Lee & Riccio, 2005). Recently the importance of treating the whole person by addressing the individual's social and emotional needs and by identifying a practical rehabilitation program that will allow the individual to reintegrate into his or her social environment has been recognized (Prigatano, 2005).

THE PRESENT: APPROACHES TO NEUROPSYCHOLOGICAL ASSESSMENT AND INTERVENTION

Since the early work of researchers and practitioners such as Broca and Luria, assessment has played an essential role in the application of neuropsychology to rehabilitation, from identifying functionally impaired versus intact systems to assisting in developing appropriate treatment plans to evaluating their effectiveness. Neuropsychological assessment differs from traditional psychological assessment because it typically involves a comprehensive evaluation of several domains based on the recognition that damage to the brain can affect the entire neuropsychological systems (Rhodes, D'Amato, & Rothlisberg, in press). Traditionally, domains assessed in pediatric neuropsychology and school neuropsychology include Sensory and Perceptual Systems; Motor Functions, Intelligence/Cognitive Abilities, Executive Functioning/Attention, Memory, Communication/Language Skills, Academic Achievement, and Educational/Classroom Environmental (D'Amato & Rothlisberg, 1992; Rhodes et al., in press). (Table 1.2 outlines areas commonly assessed within these domains.) Although neuropsychology has faced criticism based on a mistaken belief that assessment focuses exclusively on the client's inherent deficits, neuropsychological assessment seeks to provide an understanding of how an individual's neuropsychological profile and environmental systems interact (D'Amato, Rothlisberg, & Work, 1999). Perhaps nowhere is this more evident than within the field of rehabilitation neuropsychology, in which the goal of assessment is to identify interventions that will improve the independence and quality of life of individuals with neuropsychological impairments.

Neuropsychological Assessment for Intervention

Despite shared goals, neuropsychologists differ widely with respect to their approach to assessment. Two distinct orientations within neuropsychology have emerged, one emphasizing the use of quantitative techniques, and the other espousing the use of qualitative techniques (D'Amato et al., 1999). In reality, the practice of most practitioners likely falls somewhere between these approaches. Some have argued that the differences between the two approaches are minimal (Bauer, 1994) and that there is little data to support the usage of one approach over the other (Kamphaus, 2001). The quantitative approach to neuropsychological assessment relies on comparisons of an individual's performance on standardized tests with those of a representative normative group to determine whether the individual's performance falls below expectations (Rhodes et al., in press). The accumulated data across various domains is analyzed to determine the individual's performance relative to normative standards, patterns of performance suggesting relative strengths and weaknesses, signs of right-left hemispheric differences, and indicators of possible brain damage (Jarvis & Barth, 1994; Reitan & Wolfson, 1985). Proponents of this approach typically recommend the use of a standard or fixed battery of tests, in which the same set of instruments is used for each individual tested, regardless of the referral question. By utilizing a

Table 1.2

BRAIN-BASED AREAS THAT SHOULD BE FORMALLY AND INFORMALLY ASSESSED AS PART OF A NEUROPSYCHOLOGICAL EVALUATION

1. **Perceptual/Sensory**
   - Visual
   - Auditory
   - Tactile-kinestetic
   - Integrated

2. **Motor Functions**
   - Strength
   - Speed
   - Coordination
   - Lateral preference

3. **Intelligence/Cognitive Abilities**
   - Verbal functions
     - Language skills
     - Concepts/reasoning
     - Numerical abilities
     - Integrative functioning
   - Nonverbal functions
     - Receptive perception
     - Expressive perception
     - Abstract reasoning
     - Spatial manipulation
     - Construction
     - Visual
     - Integrative functions

4. **Executive Functioning/Attention**
   - Sustained attention
   - Inhibition
   - Shifting set
   - Problem solving

5. **Memory**
   - Short-term memory
   - Long-term memory
   - Working memory
   - Retrieval fluency

6. **Communication/Language Skills**
   - Phonological processing
   - Listening comprehension
   - Expressive vocabulary
   - Receptive vocabulary
   - Speech/articulation
   - Pragmatics

7. **Academic Achievement**
   - Pre-academic skills
   - Academic skills
     - Reading decoding
     - Reading fluency
     - Reading comprehension
     - Arithmetic facts/calculation
     - Social studies
     - Language arts
     - Science
     - Written language

8. **Personality/Behavior/Family**
   - Adaptive behavior
     - Daily living
     - Development
     - Play/leisure
   - Environmental/social
     - Parental/family
     - School environment
     - Peers
     - Community
   - Student coping/tolerance
   - Family interpersonal style

9. **Educational/Classroom Environmental**
   - Learning environment fit
   - Peer reactions
   - Community reactions
   - Teacher/staff knowledge
   - Learner competencies
   - Teacher/staff reactions
   - Classroom dispositions

Sources: Adapted from D'Amato et al. (1999); Rhodes et al. (in press).

standard test battery, practitioners ensure that all significant domains are addressed, thus avoiding the possibility of overlooking deficits that may better account for or contribute to the patient's presenting problem. The use of standardized techniques allows for calculation of reliability and validity information for these batteries (Fletcher-Janzen, 2005; Rhodes et al., in press). Critics of the quantitative approach have cited its failure to collect information beyond normative comparisons. Such information could illuminate unique differences in how a patient approaches a task or provide rich information to guide intervention efforts. From a quantitative perspective, some have argued that the essence of the patient can be lost (e.g., Fletcher-Janzen, 2005; Rhodes et al., in press). Others have indicated that administering an entire battery may be excessive given specific referral concerns.

Traditional examples of the most commonly used fixed batteries include the Halstead-Reitan Neuropsychological Battery (HRNB) and the Luria-Nebraska Neuropsychological Battery. The HRNB was developed to address Halstead's insight that the then-current measures of intelligence did not account for an organic basis of intelligence and failed to link assessments to brain functions (Davis, Johnson, & D'Amato, 2005). Years later, research indicating that measures of neuropsychological functioning overlap a meager 10% with traditional IQ tests supported his early theories that these tests fail to capture the full range of human cognitive functioning (D'Amato, Dean, & Rhodes, 1988; D'Amato, Gray, & Dean, 1988; Sattler & D'Amato, 2002). The current HRNB was designed to differentiate patients with and without brain injuries through 10 subtests that are intended to be used as part of a complete battery including the age-appropriate Wechsler scale and a comprehensive personality assessment. A more complete description of the HRNB can be found in chapter 5 of this text.

Early on, some have argued that the Luria-Nebraska Neuropsychological Battery (LNNB) was the second most common neuropsychological test battery, although it has received quite mixed reviews (Golden & Freshwater, 2001). The LNNB was developed for use with individuals 15 years of age and older. However, a children's version, the Luria-Nebraska Neuropsychological Test Battery–Children's Revision, was later developed for use with children ages 5 through 12 (Golden, 1987). Like the HRNB, this battery was designed to diagnose cerebral impairments often overlooked by other techniques. The battery claims to be grounded in Luria's theories of brain functioning and yields

8 localization scales, 5 summary scales, and 28 factor scales providing information about specific sensory and cognitive functions (Davis et al., 2005). Some have argued that the LNNB does not accurately utilize Luria's approach and is a failed attempt at best (Davis et al., 2005). Detailed information about the LNNB is provided in chapter 6.

More recently, two additional standardized batteries, the NEPSY-II and the Dean-Woodcock Neuropsychological Battery, have gained popularity (Davis & D'Amato, 2005). Although these batteries may be classified as fixed quantitative approaches, they may also be used as part of a flexible battery. The original NEPSY: A Developmental Neuropsychological Assessment was the first to attempt to measure neuropsychological functioning specifically for children, rather than slightly modifying or renorming adult measures (Kemp, Kirk, & Korkman, 1998). The NEPSY-II, the most recent revision to the original NEPSY, was designed to assess neuropsychological development in children and adolescents ages 3 to 16 (Korkman, Kirk, & Kemp, 2007). To suit a variety of diagnostic needs, examiners may select from subtests organized to assess functioning across six domains: (1) attention/executive functions, (2) language, (3) visual-spatial processing, (4) sensorimotor, (5) memory and learning, and (6) social perception. Titley and D'Amato provide a detailed review of the NEPSY-II in chapter 7.

The Dean-Woodcock Neuropsychological Battery consists of the Dean-Woodcock Sensory-Motor Battery, the Dean-Woodcock Emotional Status Examination, and the Dean-Woodcock Structured Neuropsychological Interview. These measures may be used alone or in conjunction with the Woodcock-Johnson Tests of Cognitive Abilities and the Woodcock-Johnson Tests of Achievement for a comprehensive measurement of an individual's functioning. Used in this fashion, the Dean-Woodcock Neuropsychological Battery can provide useful data, including pathognomic signs of cerebral dysfunction as well as neuropsychological functioning across sensory, motor, personality, and emotional domains (Davis & D'Amato, 2005). Davis provides a detailed description of the Dean-Woodcock battery in chapter 8.

Qualitative Approaches

Advocates of the qualitative neuropsychological assessment approach recognize the range of diversity in individual performance on neuropsychological tests (D'Amato et al., 1999). Luria's work relied heavily on case studies representing a classic example of how informal and formal procedures can be used together to identify unique patterns and processes used by patients. Practitioners using this approach may be more interested in the process patients use to solve formal and informal assessment tasks than any resulting outcomes. For example, careful behavioral observations may identify whether factors such as the nature of the stimuli (e.g., visual, verbal, tactile), the method of presentation (e.g., visual, verbal, concrete, social), the type of response demand (e.g., verbal, motor, constructional), and the response time allowed (e.g., timed or untimed) contributed to the individual's performance (Cooley & Morris, 1990; Luria, 1973, 1980).

It is assumed that analyzing clinical observations of the client's process of approaching various tasks may provide valuable information to contribute to the development of appropriate interventions. Another popular qualitative approach developed by Edith Kaplan based on the Lurian tradition is known as the Boston Process Approach (Semrud-Clikeman, Wilkinson, & Wellington, 2005). In this and similar techniques described as the process approach, quantitative and qualitative performance on various tests are used to sample domains of functioning. These methods emphasize the importance of considering the process the client uses to solve the tests and the use of testing limits procedures to assess the client's abilities given various response demands and conditions (Fletcher-Janzen, 2005). The emergence of tests such as the Wechsler Intelligence Scale for Children–Fourth Edition Integrated (WISC-IV Integrated) represents efforts to quantify this processing approach and may signify increasing recognition of its potential contribution to the assessment process.

Practitioners using the qualitative approach may opt to use a flexible battery to assess only select domains assumed to underlie the presenting concerns. Alternatively, a mixed battery approach allows practitioners to supplement a core set of subtests with additional techniques to address specific concerns. Skeptics of this approach note that it is heavily dependent on the examiner's clinical skills in selecting and interpreting appropriate assessment techniques. Additionally, critics caution that one may easily place too much emphasis on the significance of observed behaviors (D'Amato et al., 1999). Some concerns have been raised regarding the reliability and validity of a battery assembled from multiple sources and the difficulty validating the use of a flexible battery approach to neuropsychological assessment that is inherently variable across practitioners and individual clients.

Approaches to Neuropsychological Rehabilitation and Intervention

Current approaches to neuropsychological rehabilitation are strongly grounded in the field's rich history. The most commonly used intervention strategies generally target environmental modifications, compensatory strategies, or restorative approaches (Lee & Riccio, 2005; Mateer, 2005; Work & Choi, 2005). Because brain injuries often affect multiple systems, intervention most often includes a variety of these approaches. In all situations, engaging the client and his or her support system (i.e., family) in a collaborative relationship to develop meaningful, measurable functional goals is critical (Conoley & Sheridan, 2005; Mateer, 2005).

Environmental modifications typically are used to adjust elements of the client's environment to reduce the impact of the impairment. Often these modifications involve strategies for making the environment safe or minimizing overstimulation (Ducharme, 1999; Mateer, 2005). Other environmental modifications may target reducing the effects of fatigue (e.g., a shorter school or work day) and memory impairment (e.g., labeling cupboards, using checklists). D'Amato et al. (1999) provide an example of a useful framework for modifying the educational setting to appropriately meet the needs of students with brain injuries. Their SOS model suggests that intervention for students with brain injuries returning to school settings should address structure, organization, and strategies.

Techniques utilizing a remediation approach typically emphasize reinforcing, rehabilitating, or strengthening previously learned skills (Lee & Riccio, 2005; Mateer, 2005). These strategies typically emphasize the use of direct, systematic instructional activities that target improvement of a particular cognitive skill underlying the functional behavior (Lee & Riccio, 2005; Mateer, 2005). Mateer (2005) outlines several strategies for teaching new skills that have some empirical support. Direct instruction relies on a number of sound instructional principles to systematically deliver an academic curriculum designed to teach and maintain academic skills (Mateer, 2005). Errorless learning, a technique providing correct answers or strong clues to guide clients toward correct answers to avoid memory confusion, has demonstrated effectiveness in work with clients with severe memory impairments (Wilson, Baddley, Evans, & Shiel, 1994). In their treatment plans, clinical neuropsychologists also frequently incorporate the use of procedural memory, or memory for experiences or learning that occurs over time through repetition (Mateer, 2005).

Finally, compensatory approaches typically attempt to bypass damaged functions by emphasizing the use of unaffected skill areas or adopting strategies that will circumvent difficulties frequently encountered as a result of brain damage (Mateer, 2005; Work & Choi, 2005). For example, when confronted with memory impairments, clients are often taught to use compensatory memory devices such as handheld calendar systems, alarm clocks, or memory books for keeping track of essential information and task checklists.

There are several additional factors to consider when one is determining an appropriate rehabilitation approach. Research has indicated the value of gathering information regarding the client's level of self-awareness regarding his or her current cognitive and physical functioning and its impact on the client's life (Mateer, 2005; Prigatano, 2005). Understanding the client's level of self-awareness can help gauge whether the client has enough self-regulation and capacity to initiate strategies for particular techniques to be effective and whether the teaching of these skills should be incorporated in the intervention plan (Mateer, 2005). In addition, assessing and designing a rehabilitation plan to address the client's emotional needs may be critical to any plan's success. In an innovative study, Gisi and D'Amato (2000) evaluated anger, social desirability, and forgiveness in individuals with traumatic brain injuries. They found that clients who had been forgiving showed a more positive mental health profile than those who had not. Even in cases when emotional ramifications are not predicted based on the client's brain injury, many clients may develop fears, anxiety, and frustration related to the impact of a brain injury that should be addressed as part of the treatment plan.

THE FUTURE: FACTORS DRIVING THE FUTURE OF NEUROPSYCHOLOGY

Several influences will likely continue to shape the future of neuropsychology. Scientific advancements in neuroimaging and psychopharmacology have already dramatically affected the scope and role of neuropsychological practice. In addition, rehabilitation neuropsychologists are faced with increasing pressure to demonstrate that their practices are empirically based, valid for unique populations, and ecologically valid (Traughber & D'Amato, 2005). Advancements in psychopharmacology, neuroimaging, and adaptive technology have already had a tremendous effect on the practice of neuropsychology. These advancements have altered our understanding of many psychological and behavioral disorders, such as autism and depression, that were once presumed to be environmental or functional. Neuroimaging and psychopharmacology have illuminated the neurodevelopmental and neurochemical basis of many of these disorders (Hartlage & D'Amato, 2007; Teeter & Semrud-Clikeman, 2007).

With this understanding of the neurological basis of many behaviors, our intervention options have expanded. New pharmacological advancements have emerged in the prevention and treatment of pathology. For example, a growing body of research has investigated the effectiveness of medication in slowing or preventing Alzheimer's disease. In addition, more than ever before, medication is being used to mediate the effects of impairments in mood, attention, memory, and impulse control (Whyte, 2002). As a result, practicing neuropsychologists must remain informed about new psychopharmacological interventions and their expected effects (Dunn & Retzloff, 2005). This understanding is essential because psychopharmacological treatments generally interact in complex ways with the brain's neurotransmitters and therefore may be expected to have varying impacts on functional behaviors that are often used to monitor the effectiveness of the drug treatment (Whyte, 2002). Clinicians must be capable of drawing upon their understanding of psychopharmacology as well as causal relationships with complex functional behaviors and an individual's environment to develop hypotheses regarding why a particular psychopharmacological intervention was or was not effective (Whyte, 2002).

In addition to pharmacological advances, the advancement of neuroradiological techniques since the 1970s has had a tremendous impact on neuropsychological practice. Since the advent of the CAT scan, this technology has become increasingly sophisticated, with notable advancements in both structural imaging techniques (i.e., magnetic resonance imaging, quantitative magnetic resonance imaging, and diffusion tensor magnetic resonance imaging) and functional imaging techniques (i.e., positron emission tomography, single photon emission computed tomography, and functional magnetic resonance imaging). These quick and effective techniques have enabled physicians and neurologists to diagnose many neurological impairments (e.g., lesions, aneuryisms, strokes). Because of their widespread availability and relative cost-effectiveness, these techniques have supplanted the neuropsychological assessments that, prior to the advent of this technology, were frequently used to identify impairments. As a result, neuropsychologial practice has shifted toward refining practices that allow neuropsychologists to provide information that these tests cannot. For example, many of these neuroradiologic tests are still not as good as a comprehensive neuropsychological battery at recognizing diffuse axonal damage and identifying its potential impact on the client's functional behavior (Long, 1998). In light of advancing technology, neuropsychology has adopted the challenge of seeking to understand the complex interaction between brain anatomy, cognition, and behavior to identify the potential functional impact of structural impairment as indicated by data collected through sources other than these functional and structural imaging techniques (Long, 1998; Provencal & Bigler, 2005).

In addition to shaping the role of neuropsychologists, these scientific advancements have provided researchers and practitioners with new techniques to study developmental changes in the brain and to understand plasticity and reorganization (Provencal & Bigler, 2005). This has led to the development of the Kennard principle. According to this principle, evidence supports the brain's ability to reroute and develop even around a large lesion (Finger & Wolf, 1988) and has contributed to the new understanding that damage in infancy may cause more severe deficits than once thought by affecting the development of various systems (Duval, Dumont, Braun, & Montour-Proulx, 2002; Webb, Rose, Johnson, & Attree, 1996).

Technology has also provided new techniques for measuring the ability of the brain to reorganize in response to intervention. B. A. Shaywitz and her colleagues (2002) utilized imaging techniques to demonstrate neurobiological changes in the brains of dyslexic children, which were reorganized to activate areas more similar to normal readers' brains following intervention targeting phonological processing. This use of technology may provide the most sophisticated and powerful indicator of the effectiveness of interventions. Some argue that the field is advancing toward diagnosing disorders by relying exclusively on behavioral imaging techniques (e.g., S. Shaywitz, 2003). In the future we will see further attempts to use imaging to identify neuroanatomical and neurofunctional markers of particular disorders and most probably to evaluate treatment efficacy (Provencal & Bigler, 2005).

Ecological Validity

Technological advancements have inevitably altered the role of neuropsychology to answer new referral questions regarding a client's ability to function in different contexts. Clinical neuropsychologists are frequently asked to provide information regarding the effectiveness of cognitive retraining and to identify what compensatory strategies may be necessary for a client to be successful in various environments (Lee & Riccio, 2005; Long, 1998). In order to answer questions regarding their clients' functional skills or potential for rehabilitation, appropriate treatment options, or living arrangements, neuropsychologists are required to draw multifaceted inferences from their data (Long, 1998; Sbordone, 1998). These recommendations are often based largely on informed clinical opinion, which means that neuropsychologists must recognize and appropriately acknowledge the limitations of their competency and training. Furthermore, the ability to draw inferences regarding a client's functional skills mandates that practitioners remain well versed in research that might be of assistance in drawing inferences based on similar clinical groups (Long, 1998; Traughber & D'Amato, 2005).

The ability to evaluate the complex interactions between cognitive, emotional, social, and situational influences will be required for neuropsychologists to make predictions regarding clients' abilities to function in a particular environment. The critical importance of these abilities or disabilities highlights the new directions in rehabilitation neuropsychology research that will be needed. Although informed clinical opinion may never be entirely removed from this process, research must explore and identify the boundaries of inferences that can be appropriately drawn from available tests, and new tests must be designed to answer these complex questions (Long, 1998). Research investigating the ecological validity of assessments—that is, whether tests actually reliably measure the intended functional skills and assist in making valid predictions about clients' behavior within various environments—will likely continue to drive the field of neuropsychological rehabilitation.

Cross-Cultural Aspects of Neuropsychological Services

The task of ensuring the ecological validity of neuropsychological assessment and intervention efforts proves even more daunting in the context of a diverse client base. The population of the United States has become increasingly culturally and linguistically diverse as a result of surges in immigration over the past decade. The influence of this diverse population has begun to affect assessment practices as well as intervention approaches. Research has indicated that consideration of ecological contexts is critical in work with clients from different cultural backgrounds (Hess & Rhodes, 2005). Much of this understanding comes from research with school-age children, which demonstrates the likely relationship between the overrepresentation of children from different cultural groups in special education and the disproportionate numbers of minority children who fall below the poverty line. These children are at risk for cognitive and emotional delays due to factors such as low birth weight, poor nutrition, and exposure to toxins (Hess & Rhodes, 2005; McLoyd, 1998; National Research Council, 2002). Rates of brain injury are also higher among minority youths and adults (Bruns & Hauser, 2003). In addition, fetal alcohol syndrome rates are excessively high among Native American populations (Myers, Kagawa-Singer, Kumaniyika, Lex, & Markides, 1995). It seems that individuals from minority cultural and linguistic backgrounds demonstrate greater variability in the quality of their educational experiences. Even those educated primarily in the United States, particularly those attending schools populated by large numbers of low-income minority children, may have distinctly different educational opportunities as a result of lower per-pupil expenditures that are common in these schools (Darling-Hammond & Post, 2000; National Research Council, 2002). This is significant when one considers findings that education can account for up to 15% of the variance in scores on particular neuropsychological assessments among adults (Dick, Teng, Kempler, Davis, & Taussig, 2002).

In addition to these contextual variables, cross-cultural assessment is complicated by cultural and linguistic factors. Neuropsychological assessment of language disorders among individuals from non-English linguistic backgrounds must take into account the individual's language facility in both English and his or her native language. Language proficiency should not be assumed based on the client's informal conversational skills (i.e., Basic Interpersonal Communication Skills), as several neuropsychological tests tap academic language (i.e., Cognitive Academic Language Proficiency), which may not be familiar to an individual educated in another country (Rhodes, Ochoa, & Ortiz, 2005). As the use of translated tests is contraindicated by research, neuropsychologists may be hard pressed to find suitable techniques for assessing the verbal skills of individuals from varying linguistic backgrounds (Artiola i Fortuny & Mullaney, 1997). There is a growing demand to develop reliable techniques for assessing language functioning among non-English-speaking populations.

Practitioners are encouraged to utilize culturally sensitive assessment techniques that take into consideration potential cultural differences that may account for behaviors otherwise perceived as unusual (Hess & Rhodes, 2005; Rhodes et al., 2005). In addition, because acculturation has been shown to affect psychological functioning, it is important to assess the individual's level of acculturation—the individual or family's process of adapting to a new social and cultural environment (Berry, Trimble, & Olmedo, 1988; Rhodes et al., 2005).

Neuropsychologists have advocated a variety of approaches to appropriately serve individuals from different cultural and linguistic backgrounds. Some have advocated the practice of making demographic corrections to current instruments based on education and ethnicity (Lamberty, 2002). Others have asked for the creation of a neuropsychological test battery that may be useful across different populations, such as the Cross-Cultural Neuropsychological Test Battery (Dick et al., 2002). While the question of which tools and techniques are most appropriate for work with clients from different cultural and linguistic backgrounds continues to be debated within our field, the efforts of neuropsychology to meet the needs of an increasingly diverse population will likely continue to drive contemporary practice.

Evolution of an Evidence-Based Science

Neuropsychologists are faced with different referral questions than they were 50 years ago when the field was evolving and primarily dealt with questions regarding the ability to detect brain damage. Tests that were used to detect brain damage were empirically validated for that purpose. Today, neuropsychologists are under increasing pressure to demonstrate that their assessment tools and methods continue to be valid when addressing more complex questions such as predicting a client's ability to function in a particular context. Given the increasing diversity of the population, neuropsychologists must also address whether particular techniques are valid for individuals from different cultural and linguistic backgrounds in various contexts.

Although most neuropsychologists agree that important information can be gleaned from observation and clinical skills, the field is placing greater emphasis on data-based decision making (Lamberty, 2002). At a time when neuroimaging techniques have in many ways surpassed the ability of neuropsychological assessments to accurately and economically indicate structural brain damage, neuropsychology's livelihood may depend on its ability to demonstrate its effectiveness in accurately diagnosing subtle or diffuse impairments that cannot be detected by these techniques. Certainly, neuropsychology's future also depends on its ability not only to accurately assess impairment but to reliably identify appropriate, effective, and inventive interventions. Thus, neuropsychologists are striving to develop data-based practices that emphasize sound scientific methodology. Empirically based practices include selecting appropriate assessment tools for a given purpose, designing new assessment tools to face complex questions asked in today's referrals, and demonstrating the efficacy of interventions (Traughber & D'Amato, 2005). As Prigatano (2005) pointed out, within the context of the economics of health care, not only must neuropsychologists demonstrate the efficacy of treatment, but practitioners must also be able to demonstrate the cost-effectiveness of treatment.

Ethical Considerations

Neuropsychology is a field that has grown rapidly, in part due to advancements in related fields such as neurology, medicine, and technology. Because of this rapid growth, neuropsychologists in various settings are faced with unique situations in which the correct course of action may not be clearly defined by professional ethics. As previously noted, rehabilitation neuropsychologists must maintain competency and practice only within the boundaries of their competence. In addition, practitioners must be aware of the limitations of their assessments; for example, they must understand an assessment's validity for a particular population and limitations pertaining to its predictive utility. As noted in Bush (2005), factors unique to rehabilitation neuropsychology that may present professional and ethical challenges include the interdisciplinary nature of traditional rehabilitation settings, the severity of the clients' brain injuries, the existence of multiple comorbidities, informed consent, the degree of family involvement, and confidentiality within multidisciplinary settings. In recognition of the unique situations that may commonly arise in particular neuropsychology specialties, some subspecialities such as forensic neuropsychology have opted to develop their own standards of practice to supplement the American Psychological Association's code of ethics (Bush, 2005). The credibility of the field depends largely upon individual practitioners' careful application of ethical standards to their unique settings and practices.

Neuropsychology is an applied science that studies brain-behavior relationships. The profession of neuropsychology is grounded in a rich history of empiricism and is constantly influenced by advancements in related fields. While technology seems to have virtually supplanted neuropsychology's historical role in identifying localized brain impairments, the practice of neuropsychology has greatly expanded to assume equally important new roles. Neuropsychologists with an understanding of the interactions between physical and psychological processes and individuals' social environments are uniquely positioned to integrate information across disciplines in an effort to understand each client's central nervous system functioning. Concomitantly, neuropsychologists must develop and monitor the effectiveness of individually tailored, functionally related treatment plans. The enduring contributions of neuropsychology into this century will likely remain contingent upon each individual's commitment to ethically based, empirically focused practice; continuing education; and scientific discoveries. The challenge to clinical neuropsychologists will be to meet the needs of an increasingly diverse population by providing evidence-based ecologically valid interventions.

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2

Introduction to Neuropathology and Brain-Behavior Relationships

LAWRENCE J. LEWANDOWSKI AND BENJAMIN J. LOVETT

INTRODUCTION AND SUMMARY

The purpose of this chapter is to provide a context from which to understand the focus of clinical neuropsychology. First, we review historical concepts about brain knowledge, recognizing that our knowledge is always incomplete, often inaccurate, and constantly evolving. We then discuss recent scientific progress and current thinking about brain-behavior relationships, followed by a section on theoretical conceptualizations of brain function, with primary emphasis on Luria's influential model. From this point we turn to characteristics and types of brain pathology that call for neuropsychological assessment for treatment planning.

EARLY THEORIES

The history of beliefs about the workings of the human brain is both humorous and enlightening. For example, Aristotle and other early Greek thinkers suggested that the heart was the central control organ in the body that directed human behavior. Centuries later this viewpoint gave way to Galen's ventricular hypothesis. Galen, as well as others after him, argued that the internal chambers or ventricles of the brain were warehouses for the development of psychic spirits, which were necessary for energizing and executing behavior. This view went virtually unchallenged for over a thousand years, until scientists began to take a closer look at brain matter itself (Clarke & Dewhurst, 1972). From the Renaissance to the beginning of the 19th century, many different thoughts about brain structure and function were ventured. One viewpoint that experienced strong popularity but was short lived was that of phrenology. Phrenology was a practice advocated by Gall and Spurzheim (ca. 1820) that encouraged predictions about an individual's psychological faculties based upon the shape of his or her skull. The underlying premise was that brain areas underneath certain skull protrusions were more highly developed in certain people. Correlations were made between people with similar skull protrusions and psychological characteristics. Before long, phrenologists were identifying different areas of the skull with various psychological faculties. Dozens of phrenology maps were developed, each new one more complex than the last. It was this undisciplined practice of relating brain area to psychological function that fueled the strict localization movement.

Throughout the 1800s, the issue of whether the brain was highly localized was debated. In 1861, Broca presented clinical evidence that the function of speech was localized in the third frontal convolution of the left hemisphere. In 1870, Fritsch and Hitzig reported a landmark paper on the electrical excitability of the cerebrum. Applying electrical stimulation to the cortex of dogs, they successfully mapped the sensory and motor cortex in both hemispheres. Their secondary finding indicated that when the remaining two-thirds of the cortex was stimulated, no measurable behavioral change resulted. Quite naturally, the remaining two-thirds of the cortex were referred to as "silent areas." Since that time considerable research in medical and behavioral science has been conducted in an attempt to determine what goes on in those "silent areas."

It should be clear from this brief history that beliefs about brain function have been erroneous much of the time and for hundreds of years at a time. But despite all the misinterpretations and controversies, scientific discoveries have advanced brain science greatly, particularly over the last 100 years. Our present knowledge of brain anatomy, function, and pathology is more extensive and accurate than one would have projected in 1900. Yet history has taught us that there is much to learn about the workings of the brain, and the pursuit of scientific fact will remain a slow, evolving process.

SCIENTIFIC PROGRESS

Over the past 20 years, we have experienced significant advances in neuroscience research. Technological breakthroughs in neuroimaging, neurochemistry, and genetics have allowed scientists to delve more deeply than ever into the inner workings of the brain. As a result, neuropsychology, the study of brain-behavior relationships, is at the heart of a paradigm shift, a shift that now recognizes the contributions of the nervous system to all aspects of human behavior. Every week, research articles are published correlating activation in a brain area to a pattern of thought, feeling, or behavior, to the point that such correlations are no longer newsworthy (Bloom, 2004). We are beginning to understand that most forms of mental illness reflect biological dysfunction related to brain processes, which in some ways mirrors physical illnesses of the brain (e.g., tumors, strokes, infections, head injuries). Neuropsychologists make it their business to study these interactions, realizing that psychopathology and neuropathology have neurobiological underpinnings.

LURIA'S THEORY

There are a variety of theories dealing with how the brain is organized and how it operates. For example, Hebb's (1949) cell assembly theory and MacLean's (1978) theory of the triune brain attempt to explain brain function from both a micro- and a macroscopic perspective. However, no theoretical account of brain function is as complete as that proposed by Alexander Luria. Luria's views on brain function are widely quoted and have been useful in conceptualizing both research and clinical work. He derived his ideas from investigations of adults with brain pathology, and his ideas are highlighted primarily in two books, *Higher Cortical Functions in Man* (1966) and *The Working Brain* (1973).

Rather than advocating a strict localization view of brain structure and function, Luria proposed a more dynamic conceptualization. He suggested that conscious behavior is guided by an interaction of activities across various areas of the brain. He called this complex composition of brain activities a "functional system." In other words, a function such as speaking or writing is mediated by a coordinated set of brain activities. An inability to speak or write would indicate a breakdown somewhere within the functional system. One would need to do further assessment in order to determine what part of the functional system has been compromised. Luria also suggested that no specific brain area completely controls a given function. Therefore, if a particular brain area is damaged, a variety of behavioral disruptions may result, and similarly non-damaged brain areas may be able to assume some of the functioning that is compromised. Consequently, any given brain area may be involved with a variety of behaviors. This phenomenon is referred to as "pluripotentiality," and it highlights the interdependence and communication between various brain structures.

Units of the Brain

Luria proposed that the human brain is made up of three main blocks, or functional units, and that all mental activity draws from these three units. He described functional systems that operate along a vertical organization (lower to higher), a longitudinal organization of the brain (front-back), and a lateral organization (left-right).

Arousal Unit

The first unit described by Luria is the arousal unit. This unit is comprised of a network of diffuse structures at the brain stem and thalamic levels, also referred to as the reticular activating system. The arousal unit is primarily involved in filtering sensory input and adjusting the arousal level or tone of the cortex. It is crucial to one's ability to attend or respond to stimuli. Dysfunction in this unit can cause disorders of sleep or consciousness, difficulties in screening incoming stimuli, hyper- or hypo-responsiveness to situations, and lack of attention or concentration. Structures in the arousal unit are linked hierarchically to other brain areas, particularly the prefrontal cortex. Ontogenetically, this first brain unit develops very early. Damage to this unit in an adult may greatly affect vegetative functions and the ability to attend and adapt sufficiently to the environment. Developmental disturbances to this unit within the first year of life may have less drastic effects on the individual but seem to cause problems of attention, hyperactivity, and inadequate filtering of information. This lower brain unit is often on the front end of functional systems, managing the early information processes such as attending to, detecting, filtering, and acquiring sensory input.

Sensory Reception and Integration Unit

The second unit of the brain is the sensory reception and integration unit. This unit coordinates activity of cortical brain areas posterior and inferior to the central sulcus (temporal, parietal, and occipital lobe function). Within this second unit, Luria describes a suborganization that is hierarchical in nature. This same suborganization is applied to each of the parietal, temporal, and occipital lobes. The foundation of this unit is the primary zone, or primary projection area, within each of these three lobes in both hemispheres. The primary zone of the parietal lobe, for example, is located along the post-central gyrus and is chiefly responsible for the reception of somatosensory input, including touch, pain, temperature, and proprioception. The primary zone of the temporal lobe is located along the superior temporal gyrus. This is the primary projection area for auditory information. The primary zone of the occipital lobe is located in the posterior portion of each hemisphere. This zone is the primary projection area for incoming visual stimuli. Note that these primary zones within each lobe are modality specific. The specificity of cells in these primary zones has been well detailed elsewhere (e.g., Hubel & Wiesel, 1963). Interestingly, stimulation to these primary cortical areas induces rather meaningless sensory experiences (e.g., hearing sounds) or uncoordinated movements. More complicated and coordinated behaviors within each lobe are subserved by association areas.

The secondary zone within each lobe is located adjacent to the primary zone. Here there is less modal specificity (e.g., the association areas of the temporal lobe are involved with vision as well as hearing), and the structure is composed of neurons that associate with other brain areas, including homologous areas of the contralateral hemisphere. In general these secondary zones, or association areas, are involved in the analysis, coding, and storing of information. For example, within the function of vision, the secondary (association) area in the occipital lobe seems to be involved in temporal, spatial, and feature-related analysis of the visual stimulus. In the parietal lobe, the secondary (association) area is involved in gnostic tactual functions (e.g., knowing what an object is by feeling it, and also knowing where one's arm is located in space from the perception of moving it). Similarly, the association area in each temporal lobe serves to analyze auditory information. At this secondary zone level, one begins to see an increase in hemispheric differentiation. The secondary zone of the left temporal lobe is more involved in the perception of speech sounds, while the right hemisphere appears to be more involved in the analysis of nonspeech sounds, particularly aspects of rhythm, pitch, and tone. In general, these secondary zones or association areas are involved with the ability to recognize incoming stimuli, detect and analyze the information, and associate the information to previous experience.

Another zone within this second brain unit is the tertiary zone, located at the juncture of the parietal, occipital, and temporal lobes in each hemisphere. In this zone, data from different sensory sources are integrated. There is much less modal specificity. In fact, this zone has been identified as multimodal (Pandya & Yeterian, 1990) or cross-modal in function. The principal role of the tertiary zone is information organization, particularly as it relates to the simultaneous processing of information. It is in this zone that one achieves a high degree of analysis of incoming information. Here information from a particular modality, such as visual information, can be related to tactual or auditory input, and all information can be converted to symbolic representations. Disruption of the tertiary zone in either hemisphere tends not to produce overt sensory deficits but instead yields deficits in higher levels of perceptual and cognitive functions, such as those associated with reading, writing, mathematics, and spatial behavior. It should be pointed out that the three zones within this second brain unit are both developmental and hierarchical in nature. Whereas the primary zones develop early in life and deal with the reception of modality-specific information, the secondary and tertiary zones mature later in life and are involved in more complex, less modality-specific mental operations.

Execution of Output Unit

Luria referred to the third unit of the brain, essentially the left and right frontal lobes, as the execution or output unit, or the unit that is involved with programming, regulation, and verification of activity. While this brain unit receives orienting and sensory information from the other two brain units, it is essentially involved with motor output, planning, and evaluation of behavior. It, too, is described in terms of a suborganization. The primary zone of this unit is the motor cortex, located anterior to the central sulcus. This area of the brain is known to exert major control over motor impulses sent to the contralateral side of the body. The secondary zone, or premotor area, lies anterior to the motor strip. It is involved with preparing motor programs by analyzing, organizing, and sequencing motor acts and then applying spatial and temporal analysis to ongoing movement. The tertiary zones of this third brain unit lie in the most anterior part of the brain, the prefrontal cortex, and are also modality nonspecific. In fact, the prefrontal cortex has many efferent and afferent connections with the other brain areas. Luria (1973) and others have suggested that this brain region plays an important role in the formation of intentions and programs, as well as in planning and regulating the most complex forms of human behavior. In addition to planning, executing, and evaluating behavior, the prefrontal lobes are involved with selective attention, concentration, mental flexibility, and personality functioning, such as the regulation of mood, judgment, and drives. Once again, this brain unit has both a hierarchical and developmental organization. The primary motor cortex is fully functional quite early in life, while the tertiary zones in the frontal lobe subserve much more complex functions and seem to develop gradually throughout childhood and adolescence.

Luria's theoretical formulation is rather macroscopic in nature. For example, he does not describe the functions of the nerve cell or the specific pathways and projections that comprise a particular functional system. Luria's theory, although dated and imperfect, still provides us with a useful heuristic for understanding much of brain functioning. His approach relies heavily on the notion of serial processing in a hierarchical manner, with each level (arousal unit → primary zone of reception unit → secondary and tertiary zones of reception unit → output and planning unit) adding functional complexity. Brain science over the past 30 years has informed us that brain activation is much more dynamic and parallel in real time than Luria described. We now have a greater appreciation for more widely distributed patterns of neural connectivity in the brain, including feedback mechanisms within functional systems and reciprocal connections among interconnected processing streams. For a more in-depth overview of such complex brain models, the reader is referred to Bechtel and Abrahamsen (2002) and Felleman and van Essen (1991).

CEREBRAL SPECIALIZATION

Discussions of the brain's hierarchical structure or parallel processing nature are relatively recent compared to the long-standing interest in the operation of the cerebral hemispheres. For hundreds of years, various scholars speculated on the relative similarities and differences between the right and left hemispheres. After years of investigation and many false hypotheses, discoveries of the last 50 years have indicated that the two cerebral hemispheres, and certain relative areas within them, seem to be specialized for the execution of specific psychological functions. Although the research is far from conclusive, some of the widely held views regarding hemispheric specialization merit discussion.

Anatomic and Functional Differences

Perhaps the most popular area of research in neuropsychology has to do with the investigation of anatomic and functional differences between the hemispheres. Studies involving split-brain subjects, hemispherectomy patients, sodium amytal testing, blood-flow analysis, evoked-potential recording, magnetic resonance imaging, dichotic listening, visual half-field presentation, lateralized lesions, and simple sensory and motor functions (i.e., handedness) have all yielded converging evidence regarding certain aspects of hemispheric functioning. Space does not permit a description of each research method and related findings, so we will briefly summarize some of the key points in this area (see Springer & Deutsch, 1997, for a review of this topic).

In the most general sense, the left hemisphere is the speech-producing hemisphere for most people, while the right hemisphere has been linked to certain nonspeech functions, such as visual ideation and visual-spatial organization. It is important to keep in mind that lateralization of functions is a relative, not an absolute, concept. It appears that both hemispheres are to a large extent capable of handling functions that may be better executed by a particular hemisphere. In fact, there are some who think that the hemispheres of the brain start out as equipotential and that left hemispheric language specialization is imposed on brain organization (Moscovitch, 1977). In addition to the question of how the hemispheres become specialized, there is considerable debate as to *when* the hemispheres become specialized (see Kolb & Wishaw, 2008). Some investigators, such as Lenneberg (1967) and Bryden and Allard (1978), have argued that increasing development in hemispheric specialization occurs as a child ages. Others, such as Kinsbourne and Hiscock (1977), have suggested that hemispheric specialization is essentially determined at birth and only changes qualitatively with age. Despite these controversies, few people would argue that anatomic and functional differences do exist between the hemispheres.

Functional Hemispheric Specialization

Many of the asymmetries found between the right and left hemispheres are subtle and not particularly relevant to the clinician. These include anatomical differences in cell organization and the size of a brain area, as well as individual differences related to one's gender or handedness. Of greater interest are the functional differences between the hemispheres that emerge in research studies and in patients with cerebral lesions. Roger Sperry was a pioneer in demonstrating the virtual independence in functioning of the cerebral hemispheres. Figure 2.1 summarizes much of what we know about the brain hemispheres.

As was mentioned above, the left hemisphere is the language-producing side of the brain. It is logical and analytical in nature. In most people, it is involved in sequential solutions to problems, and it seems to be more concerned with detail and more directly associated with skilled fine motor movements. In contrast, the right hemisphere is more ideational and more pictorial than verbal in nature. It prefers a mode of simultaneously synthesizing and integrating information. The right hemisphere seems to be less concerned with details than it is with getting the big picture. The right hemisphere is more musically inclined and more apt to take governance in gross motor activities, particularly how the body arranges itself in space. Its approach to problems tends to be more impulsive and holistic. Obviously these cognitive styles of each hemisphere are exaggerated. It is doubtful that even individuals with only one hemisphere would manifest all the above-mentioned characteristics to a great degree. However, studies have indicated that people vary in terms of these hemisphere styles, and present custom finds clinicians referring to people as left-hemisphere and right-hemisphere individuals.

Effects of Lateralized Lesions

In addition to the summary of lateralized functions shown above, it may be illustrative to provide some of the clinical findings that result from unilateral lesions (see Feinberg & Farah, 2003, for review). At the level of primary zones, the two hemispheres are relatively symmetrical in structure and function. That is, the somatosensory and motor strips in one hemisphere are the mirror images of those in the other hemisphere in terms of structure and function. The neurological design in these primary zones is highly specific, such that a stroke or similar trauma to the left hemisphere motor strip will result in a right-sided hemiparesis. In

Left Hemisphere Control	Right Hemisphere Control
Movement of right side of body	Movement of left side
Feeling on right side of body	Feeling on left side of body
Language abilities	Visual-spatial abilities

Reading, writing, verbal math	Music and art
Logical thinking	Creativity
Detail processing	Holistic processing
Right visual field	Left visual field

Figure 2.1 Lateralization of left and right hemisphere brain functions.

a similar manner, trauma to the right hemisphere motor strip will result in a left-sided hemiparesis. Damage to the entire primary zone of the left occipital lobe will result in a right visual field loss, while damage to the entire primary zone of the right occipital lobe will result in a left visual field loss. Damage to the primary zone in the left parietal lobe will result in sensory loss (i.e., disturbance in touch, numbness, temperature sensation) on the right side of the body, while damage to the right parietal primary zone will result in sensory loss on the left side of the body. Impairment to the primary auditory cortex in either temporal lobe, however, will only result in a mild sensory hearing loss in the contralateral ear. The sparing of auditory function under these conditions is due to a greater degree of bilateral neural representation for audition.

The secondary zones in the four lobes of the brain are more diffusely organized neurologically. Because of this diffuse organization, there is more functional asymmetry between the hemispheres. These secondary zones are still, for the most part, modality specific; thus, the secondary zone of the occipital lobe receives information from the primary zone of the occipital lobe. The function of this secondary zone includes the perception of visual information. The task of the secondary zone is to synthesize visual stimuli into a recognizable whole. Disturbances in this part of the brain have been known to result in visual agnosia, that is, an inability to recognize such things as simple objects, colors, or faces (Williams, 1970). Such agnosias are fairly rare and usually involve damage to the subcortical white matter and/or corpus callosum in addition to the occipital cortex. It appears that the inability to name objects, colors, or people is more apt to result from a left occipital lesion, whereas difficulty in pictoral recognition is related to right occipital damage. Lesions involving the secondary zone of the parietal lobes tend to produce an inability to recognize objects from touch. In terms of the right parietal secondary zone, a lesion will tend to produce astereognosis with the left hand; tactile recognition errors, particularly with the left hand (Semmes, Weinstein, Ghent, & Teuber, 1960); constructional apraxia; and loss of knowledge or sense of one's own body. In addition, right parietal lesions are known to cause contralateral neglect of the left side of the body or left space. Left parietal lesions are associated with deficits in right-side tactile errors, right-hand astereognosis, ideomotor apraxia, and handwriting.

Damage to the secondary zones of the temporal lobes tends to result in disorders of auditory perception. These disorders include disabilities in differentiating acoustic stimuli and in processing different combinations of sounds. The left hemisphere seems to be more involved with the synthesis of speech sounds and the linguistic aspects of auditory input, such as phonemic and semantic qualities, whereas the right temporal association areas seem to be more involved in the acoustic properties of music, as well as nonverbal memory (Luria, 1973). Both temporal lobes have been shown to be involved in aspects of visual perception as well as emotion. The most discussed function of the temporal lobes involves the language processing of the left hemisphere. Damage to the association areas of the left hemisphere may produce a variety of auditory-language problems, including verbal memory loss, poor comprehension, and certain aphasic conditions.

The areas of the temporal, parietal, and occipital lobes that border one another are referred to as tertiary zones. Information of all forms is synthesized in these cross-modal areas. In the left hemisphere, damage to the posterior tertiary zone could impair reading, writing, calculating, visual-motor construction, and language processing. Damage to the right tertiary zone is apt to result in visual-spatial difficulties in drawing, building, dressing, and spatial awareness. In addition, disturbances of memory and personality are found frequently with tertiary-zone damage.

The premotor region of the frontal lobes includes an area known as Broca's area. Broca's area has been identified as the principal site of the motor control for speech. Other areas of the premotor region are involved in complex body movement. These areas that generate motor programs are refined by the extrapyramidal system. Lesions to the prefrontal regions, or tertiary zones of the frontal lobes, will affect motor programming and inhibit complex motor behavior. Damage to the left side may induce rigid, inflexible, or stereotypic behaviors, as well as problems with verbal fluency and attention. Damage to the prefrontal regions also has been related to personality changes; specifically, lesions of the left prefrontal lobe have been linked to symptoms of depression, apathy, reduced sexual interest, and decreased verbal output, while lesions to the right prefrontal lobe have been related to such symptoms as immature behavior, lack of tact and social judgment, coarse language, inappropriate sexual behavior, and increased motor output.

One must not assume that the frontal lobes exclusively serve the most complex aspects of human behavior. In fact, higher-level mental functions, such as memory, thought, reasoning, and emotion, have been difficult to pinpoint from a neuroscience perspective. Because these functions are so easily disrupted with lesions in any part of the brain, it is safe to say that elaborate networks, or "functional systems" as Luria would call them, are involved in the execution of complex functions.

CHARACTERISTICS OF BRAIN PATHOLOGY

It is an understatement to say that the relationship between the brain and behavior is very complex. The overview presented above is far too simple to characterize the diverse effects of brain pathology. Clinicians are often reminded that neurological patients do not behave in accordance with the textbook. There are many reasons why an understanding of the behavioral effects of brain damage is not straightforward. Lezak (2004) mentions a number of diagnostic issues that are important in assessing a patient with neurological problems. The first issue to consider is the type or nature of the neuropathology. The type of pathology can include such things as a space-occupying tumor, a penetrating laceration of tissue, a hemorrhagic insult, or even a biochemical deficiency. Circumscribed damage to cortical tissue will tend to produce specific deficits, while widespread tissue disease, including that of white matter, will yield a greater range of behavioral impairment, particularly if chemical and electrical activities are disrupted. Another diagnostic variable to be considered when one is studying neuropathology is the extent or severity of the disorder. Obviously, there are differences between a minor head injury, such as one sustained from hitting one's head on a door, and a severe head injury from a car accident, in which the skull is fractured and unconsciousness results. Similarly, vascular accidents, tumors, and disease processes can all vary in extent or severity. In many cases, the more brain tissue is damaged or diseased, the more extensive the functional impairment. The presence of prolonged coma, rapid deterioration, and disturbance of vegetative functions are other indications of the extent and severity of neuropathology.

An important consideration in assessing the effects of neuropathology is the location of the brain damage. A large tumor in the right frontal lobe may impair activities of daily living only to a small degree, whereas a small lesion around Broca's area in the left hemisphere may severely affect speech and right-sided motor functions. As previously discussed, damage in particular parts of the brain often results in predictable types of behavioral impairment. Therefore, knowing the location of a lesion may help the clinician understand a patient's weaknesses and aid in future management. Of course, location is of utmost concern to the neurosurgeon, particularly when working near speech centers, the visual cortex, or motor-control areas.

A diagnostic variable that is important for the patient's outcome is the velocity of the neuropathology. Velocity refers to the rate of onset of the pathology, its present status, and its eventual course. Certain types of pathology, such as cerebral palsy, originate at or before birth and are static disorders, in which no further neuropathology occurs. In other examples of neuropathology, such as a stroke, the trauma occurs suddenly but the damage resolves over time, some more quickly than others. Certain types of tumors and degenerative diseases, such as Parkinson's disease, multiple sclerosis, and Alzheimer's disease, are progressive in nature. Once again, the rate of progression is variable and often difficult to assess in terms of a patient's prognosis. Another significant diagnostic consideration is the difference in neuropsychological outcomes between congenital and acquired neuropathology. For example, there are qualitative differences in functioning between children who are born with hydrocephalus, cerebral palsy, or other brain anomalies and children (particularly after age five) and adults who acquire brain injury later in life. In general, congenital neuropathology tends to exert less specific effects on behavior than acquired neuropathology does. Others have written extensively on this subject (see Kolb & Gibb, 2007; Spreen, Tupper, Risser, Tuokko, & Edgell, 1984).

The variables discussed thus far are very important in determining a patient's overall impairment and outcome. However, one cannot overlook other patient variables that affect the recovery from neuropathology. Some of these patient variables include age and sex, family medical history, and present and previous health status. Other factors that contribute to the overall picture of a patient with neuropathology and that combine to determine a patient's resulting functional status may include intelligence, degree of education, socioeconomic status, personality, motivation, and family support. Perhaps this is why the assessment and treatment of patients with neuropathology is such a challenging endeavor. In order to understand better the interactions of these clinical variables, as well as the brain-behavior relationships previously discussed, it is worthwhile to review some major neuropathological disorders and their characteristics.

TYPES OF NEUROPATHOLOGICAL DISORDERS

Vascular Disorders

Cerebrovascular disorders are not only the most common underlying disease process in those disabled by neuropathology, but also one of the leading causes of death in the Western world (Zillmer & Spiers, 2001). All cerebrovascular disorders lead to an interruption of sufficient blood flow to the brain. This interruption can be very brief (ischemia), leading to temporary neurobehavioral deficits, or long enough to lead to neuronal death (infarction) and its more permanent consequences. Here we focus on the most common of these disorders, the cerebrovascular accident (commonly called a stroke), which has a diverse set of underlying physical causes, including thrombosis, embolism, and hemorrhage.

More than half of strokes are thrombotic, resulting from the gradual occlusion of a cerebral blood vessel by the buildup of fat deposits in the vessel wall (atherosclerosis). Over time, these fat deposits recruit connective tissue and blood cells to their site, hardening the vessel wall and increasing its risk of rupturing. Because this is a progressive process, strokes of this kind are often preceded by transient ischemic attacks (TIAs or "mini-strokes"), which cause neurological symptoms that resolve within 24 hours. TIAs, then, usually serve as indicators of the occlusion process and are excellent predictors of future strokes (Skilbeck, 2003).

About a quarter of strokes are embolic, occurring when a piece of a blood clot, fatty deposit, or other material from another area of the circulatory system travels to the cerebral arteries and lodges in one, interrupting blood flow (Hannay, Howieson, Loring, Fischer, & Lezak, 2004). This underlying pathophysiology generally leads to a sudden onset of symptoms, without such warnings as TIAs. However, indicators of poor cardiac health, including prior heart attacks, can be used to predict occurrence of embolic strokes.

The least common strokes, hemorrhagic strokes, are the most dangerous, with a one-month mortality rate of up to 50% (Hannay et al., 2004). Here the rupture of an aneurysm, a weakened area of vessel wall, is the most common cause, with hypertension, space-occupying tumors, and congenital malformations of cerebral blood vessels all contributing to the weakening process. As in embolic strokes, symptom onset is sudden, but the symptoms of hemorrhagic strokes usually include an alteration of consciousness, with small amounts of blood loss leading to disorientation and large amounts leading to coma.

The behavioral presentation of stroke is highly variable and dependent upon the location of the ischemia or infarction. Given the nature of the cerebrovascular network, the stroke may affect a fairly large area of the brain, although usually only in one hemisphere. It is for this reason that strokes often impair motor functioning on the side of the body contralateral to the damage. Moreover, consistent with our understanding of hemispheric specialization, left hemisphere strokes usually lead to aphasic conditions, whereas right hemisphere strokes lead to problems in spatial perception. Emotional changes tend to follow hemispheric divisions as well; left hemisphere strokes often lead to depressed affect, whereas right hemisphere strokes can lead to indifference and even euphoria. It should be noted that left hemisphere strokes tend to be diagnosed more rapidly because their impairment is easier to recognize, but victims of right hemisphere strokes actually have a somewhat poorer prognosis, at least as measured by the longer amount of time that they remain in rehabilitation facilities (Zillmer & Spiers, 2001).

Traumatic Brain Injury

Traumatic brain injury (TBI) is becoming an increasingly common form of brain damage and is currently the most common form in children and young adults (Langlois, Rutland-Brown, & Thomas, 2006). The causes of individual cases of TBI are almost always known and most frequently involve vehicular or industrial accidents. Two types of head trauma are differentiated in the TBI literature. In closed-head injuries, the brain is accelerated and decelerated quickly, but the brain is not exposed to the environment. In open-head injuries, the skull is broken, either through penetration by a foreign object or crushing under pressure. In general, open-head injuries are more likely to lead to focal brain lesions and circumscribed cognitive deficits, whereas closed-head injuries tend to lead to diffuse pathology (via edema, increased intracranial pressure, etc.) and less predictable deficits.

There are several ways to assess the severity of TBI and predict patients' outcomes. Emergency medical personnel typically measure the depth of the individual's coma using the Glasgow Coma Scale (Teasdale & Jennett, 1974) or a similar instrument. The Glasgow Coma Scale codes for the individual's best motor response (ranging from no response to obeying commands), best verbal response (ranging from no response to carrying on a meaningful conversation), and conditions of eye opening, yielding a composite score that has been shown to predict mortality as well as functional recovery. Other assessment methods include measuring the duration of especially meaningful symptoms, such as loss of consciousness or amnesia.

One of the more interesting areas in current TBI research is that of mild TBI, or concussion. Typically, individuals who experience concussions report little or no loss of consciousness, and neuroimaging methods fail to detect pathophysiological changes. However, about half of these individuals go on to experience post-concussive syndrome; a wide assortment of symptoms, including irritability, dizziness, poor concentration, sleep problems, memory problems; and sensitivity to light and noise (King & Tyerman, 2003). While the majority of individuals with concussion will normalize in 1–2 weeks, a small percentage will experience persistent and sometimes life-altering symptoms. Currently, we cannot predict who will sustain long-term post-concussive syndrome, but it appears that patients' personality traits, their levels of premorbid functioning, and even their level of psychosocial stressors before the head trauma may contribute to the eventual outcomes of TBI (Hannay et al., 2004).

Intracranial Neoplasms

Another category of neuropathology is tumor. Intracranial tumors, or neoplasms, appear in many varieties (for a comprehensive treatment, see Schiff & O'Neill, 2005). Several distinctions help to explain the large number of tumor types. First, some scholars distinguish between primary or "true" brain tumors, which originate in brain tissue, and secondary tumors, which travel from metastatic tumors in other areas of the body. Secondary tumors have typically been developing for a longer time when neurological symptoms are first noted and are associated with a poorer prognosis. Another distinction may be made between infiltrating and non-infiltrating tumors; infiltrating tumors are enmeshed with normal brain tissue and often destroy it directly, whereas non-infiltrating tumors are clearly differentiated from other brain tissue but occupy enough space to compress surrounding tissue.

Many brain tumors arise from abnormal development of supporting cells (glia) rather than actual nerve cells (neurons). These resulting gliomas account for about half of all brain tumors in adults. Perhaps the most dangerous glioma is the glioblastoma multiforme, a rapidly growing and malignant tumor that occurs most frequently in middle age. Glioblastoma multiforme symptoms depend on the location of the tumor and sometimes do not appear at all until the tumor is quite large. Prognosis is poor, and standard treatment leads to a median survival length of 14 months and a 5-year survival rate of under 10% (Stupp et al., 2005).

Other intracranial tumors come not from brain tissue per se but the layers of protective covering making up the meninges. Mengingiomas account for about 20% of brain tumors and are generally benign, exerting their neurobehavioral effects by expanding between the brain and the skull, and compressing the brain tissue at various locations on the cerebral cortex (Hannay et al., 2004). Due to their non-infiltrating nature, neurosurgical removal is easier for meningiomas than for other tumors, but meningiomas often recur and require a second removal.

Secondary or metastatic tumors usually arise from carcinomas in some other part of the body, usually in the lung, breast, thyroid, or gastrointestinal tract. These tumors generally metastasize within the brain itself such that treatment at best postpones the inevitable outcome. When multiple tumor sites exist, especially in both hemispheres of the brain, the assessment task is particularly complicated. However, in such cases, rapid mental deterioration is the rule, obviating the need for a comprehensive neuropsychological assessment designed to detect subtle deficits.

In general, the presence of a tumor may initially give rise to subtle affective, cognitive, sensory, or motor dysfunction. Due to the space-occupying nature of tumors, intracranial pressure increases, leading to headache and nausea, sometimes the first signs of tumor. Tumors tend to produce focal effects in terms of both motor and cognitive deficits. Seizures represent a common problem, both before and after treatment. Finally, the treatment itself, whether radiation or chemotherapy, has been shown to cause generalized cerebral atrophy as well as a variety of specific cognitive impairments, making the effects of tumor therapy difficult to distinguish from those of the tumor itself (Anderson-Hanley, Sherman, Riggs, Agocha, & Compas, 2003).

Degenerative Diseases

There are many degenerative diseases of the central nervous system. Among these are various forms of dementia, neuromuscular disorders, and demyelinating diseases. The best-known degenerative disease is Alzheimer's disease, a progressive disorder that over a period of several years brings older adults from a state of good neuropsychological function to death (Relkin & Caporaso, 2004). The underlying pathology involves the atrophy of cortical structures (especially in the association cortex areas of the parietal and temporal lobes) as well as selected subcortical structures, most notably the hippocampus. This anatomical perspective leads to a predictable neuropsychological presentation in which memory is the cognitive function most obviously affected. Individuals with Alzheimer's typically forget information within minutes of when it is presented (global anterograde amnesia), which makes past events and occurrences inaccessible. However, Alzheimer's deficits are also evident in other neuropsychological domains, including language, visual/spatial processing, executive functioning, and emotion.

Two well-known subcortical dementias, Parkinson's disease and Huntington's disease, exert their primary effects on the brain's motor systems (Paulsen, Nehl, & Guttman, 2004). In Parkinson's disease, the substantia nigra in the midbrain degenerates, leading to a decline in the dopamine available to coordinate fluid movement of the body. Consequently, individuals with Parkinson's disease make slow, small, rigid, and robotic movements, all with a resting tremor. Cognitive functioning in Parkinson's disease is highly variable, with the most robust cognitive deficits being in the areas of executive functioning and language. In Huntington's disease, rather than a paucity of movement, uncontrollable jerky movements, also called chorea, are the problem. The underlying pathophysiology involves the deterioration of inhibitory neurons that would otherwise make movements more controlled. The neurocognitive profile includes deficits in attention, spatial processing, and memory retrieval, but more unique to Huntington's disease are psychiatric symptoms such as severe emotional lability, aggressiveness, and even delusions.

Demyelinating diseases, most notably multiple sclerosis, represent another category of neurodegenerative disease. In MS, the immune system attacks the neuroglia that myelinate axons, creating axons that cannot effectively transmit information within and beyond the central nervous system. Initial symptoms are often transient and localized to one neural system (e.g., vision, motor control), which leads many patients to be misdiagnosed with somatoform disorders (Arnett, 2003). About half of MS patients have cognitive deficits; memory and attention/concentration are the most commonly affected areas, followed by executive functioning, visual/spatial processing, and, least commonly, language. The course of the disease is extremely variable, often consisting of repeated periods of waxing and waning symptoms.

Infectious Diseases

Infections of neural tissue represent another category of disease process that neuropsychologists may encounter (Roos, 2004). One of the classic instances of neuropathology leading to behavioral and cognitive effects is that of an infection: herpes simplex encephalitis. Most of those who survive this rare disease have lost substantial amounts of brain tissue in the frontal and temporal areas of the cortex, as well as several subcortical structures. The behavioral manifestations of this pathology include poor impulse control, lack of goal-directed activity, and inappropriate social behavior (all expected outcomes of frontal lesions) as well as memory disturbances. Of more recent interest are prion diseases, the best known of which is Creutzfeldt-Jakob disease. Creutzfeldt-Jakob disease is poorly understood at this time but is generally thought to be caused by a virus-like protein that incubates over a period of many years before destroying brain tissue. Emotional symptoms may be the first to be noticed, but the defining symptoms are in the motor domain, specifically ataxia and verbal apraxia.

Toxic Conditions

We conclude our survey of neuropathology with toxic conditions. The list of substances that are toxic to neural tissue is seemingly infinite, but relatively few of these substances cause neuropsychologically discrete symptoms. Perhaps the best known of these latter substances is alcohol, which, when taken in excess for an extended period of time, can lead to Korsakoff's syndrome. This syndrome is chiefly a memory disturbance that results from the degeneration of certain thalamic nuclei, leading to an inability to consolidate, retrieve, and utilize new information. Metallic substances are also known for their effects on brain functioning (Hannay et al., 2004). Lead exposure, for example, has long been known to lower IQ, but it also has effects on memory, processing speed, and motor coordination, among other cognitive domains. Similarly, mercury exposure exerts neurotoxic effects, with selective preference for the cerebellum, basal ganglia, and occipital cortex; this pathophysiological profile leads to deficits in the areas of visuospatial construction and coordination.

CONCLUSIONS

In this chapter an attempt has been made to present an overview of past and present thoughts about brain function. A theoretical framework borrowed from Luria was described and used as a basis for explaining brain-behavior relationships. At a more specific level, findings regarding hemispheric specialization and regional specialization of function were discussed. Each of the lobes within a cerebral hemisphere was described in terms of primary, secondary, and tertiary zones as defined by Luria. It was pointed out that, generally, the more complex the function, the more complex is the neurological substrate that executes the function. Therefore functions such as memory, thought, reasoning, and emotion tend to be diffusely organized in the brain, and lesions in many places throughout the brain may disturb these functions. This issue became more clear in a discussion of brain pathology characteristics associated with tumors, dementia, head injury, stroke, and demyelinating diseases. Also, major variables that clinicians must consider in assessing patients were discussed. The interaction of these variables as exemplified by categories of brain pathology served to illustrate how difficult neuropsychological assessment can be and how much research is still needed in this area.

The study of neuropsychology has gone beyond the "strip-mining" stage. Scientists and clinicians are digging deeper to unravel mysteries of the human brain and its functioning. Modern medical technology, using such devices as computerized axial tomography, magnetic resonance imaging, positron emission tomography, and brain electrical activity mapping, as well as clinical experimental neuropsychological studies, continues to improve the foundation of knowledge concerning brain and behavior. Research with normal and brain-damaged humans and animals is providing converging information that has been helpful in improving our understanding and treatment of a number of neuropathological disorders. It appears that brain science will continue to make rapid growth. It is to be hoped that these new developments will replace old ideas, so that views about the brain will continue to improve rather than lie in error for centuries at a time, as was once the case.

TREATMENT PLANNING AND INTERVENTIONS

This chapter is general in nature and provides a foundation for understanding the brain's organization, basic function, and dysfunction. Rather than detail specific interventions here, it seems more appropriate to discuss some general treatment implications that stem from our understanding of the brain thus far. First, the complex, dynamic, and parallel nature of brain processes suggests that everyone's brain functioning is unique and moderated by variables such as sex, age, handedness, genetic endowment, environmental experience, development, and health. Such wide variation in the normal brain is multiplied when we consider the various insults that can occur to the brain. As noted above, there are many different types of neuropathology that affect brain functioning in various ways and to various extents. Considerable variation exists between types of neuropathology (e.g., stroke versus traumatic brain injury) as well as within types of pathology (e.g., mild versus severe TBI). It should be obvious from this discussion that no two patients, even two with the same brain pathology, will display the same behavioral and neuropsychological profile. The implied treatment lesson is that every patient is different and therefore requires individualized management. Whether a patient requires surgery, medication, rehabilitation, counseling, vocational training, or speech or physical therapy will depend on a myriad of variables. It is little wonder that most of this work is conducted in medical centers, where teams of professionals including neuropsychologists pool their assessment findings and expertise to create individualized treatment plans for patients. Treatment plans often involve intervention in multiple systems (i.e., family, school, work, medical care) across multiple domains of function (i.e., physical, mental, emotional, social, vocational). Therefore, it is common for treatment packages to be multi-focused and highly individualized. The idiosyncratic nature of treatment in this field is a necessity; however, it has virtually negated our ability to conduct large-scale treatment studies. Thus, the field of neuropsychology is noted for its prowess in the areas of clinical research and assessment, yet criticized for its lack of treatment efficacy studies.

A second general treatment implication drawn from our understanding of brain organization is a focus on both rehabilitation and compensatory treatment methods. There often is recovery from many of the brain disorders (e.g., stroke, tumor, TBI, infection), and this recovery is enhanced by various treatment regimens, including physical and speech therapy, cognitive retraining, counseling, occupational therapy, medication, and life management consultation. While these interventions tend to improve recovery, it is often the case that the brain is permanently damaged and some behavioral impairment will persist. In these cases, treatment must focus on bypassing the area of deficit and emphasizing the remaining strengths of healthy brain areas. This might mean making adjustments in one's job, family responsibilities, and even daily routines to accommodate one's weaknesses and optimize one's strengths. There may be a diminishing return on treatment efforts that focus on restoring lost function due to significant brain damage. There are times when the loss of function must be accepted, and treatment efforts geared toward healthy areas of functioning. Some have described this as focusing on the donut, not the hole.

The last implication we want to highlight is simply that the best treatments tend to be the treatments most informed by competent neuropsychological assessment. We recommend a comprehensive multidisciplinary assessment conducted by professionals with extensive brain-behavior expertise that informs multi-system and multi-modal treatment packages employing evidence-based interventions for both short-term recovery and long-term management. Ideally, the management plan is carefully monitored, evaluated, and modified as needed to facilitate the best treatment outcomes possible.

CLINICAL RECOMMENDATIONS FOR PROFESSIONAL PRACTICE

This chapter deals primarily with foundational rather than applied knowledge, so the recommendations for practice are rather general. The messages from this chapter are to stay abreast of scientific discoveries; be skeptical of what we think we know about the brain; continue to further your training in areas of neuroscience, neurochemistry, genetics, neurology, and neuropsychology; and draw on this up-to-date knowledge of brain function and dysfunction when assessing and treating individuals with neuropathology.

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3

The Neurological Examination as It Relates to Neuropsychological Issues

KIMFORD J. MEADOR, GLEN R. FINNEY, AND FENWICK T. NICHOLS

The medical specialty with which neuropsychologists have the closest interface is neurology. Whether the neuropsychologist evaluates patients on referral from neurologists or wishes to obtain neurological evaluations on patients already evaluated with neuropsychological procedures, it is important to be aware of the context and content of the neurological examination, which differs from the neuropsychological evaluation. Even when there is overlap, the focus is on different issues. Compared to the neuropsychological examination, the neurological examination may be lacking in precise quantitative measurement of diverse aspects of cognition, but it provides information relative to non-cognitive functions not covered by the neuropsychological examination. Further, the neurological examination addresses issues of etiology, such as infections, genetic disorders, metabolic problems, and a variety of other phenomena that are not addressed by neuropsychological assessment procedures. Thus, the issue is not which examination approach is the most sensitive to central nervous system problems, but to what extent neurological and neuropsychological assessments contribute to understanding a given patient in that medical-social milieu.

HISTORICAL PERSPECTIVE

The neurological examination has developed from a series of observations linking specific cerebral lesions with associated patterns of deficits (i.e., signs and symptoms). The first recorded observation of this type was approximately 5 millennia ago. The Edwin Smith surgical papyrus translates the writings of an Egyptian physician from about 3500 B.C. This narrative probably represents the first report not only of aphasia, but also of a seizure:

> A man having a wound in his temple . . . perforating his ternporal bone . . . ; if thou ask of him concerning his malady, he speak not to thee. . . . Copious tears fall from both his eyes, . . . if thou puttest thy fingers on the mouth of the wound . . . , he shudders exceedingly. (Qtd. in McHenry, 1969).

Hippocrates noted the importance of the brain in cognitive function, referring to the brain as the organ of "intellect" and the "guiding spirit" (qtd. in Luria, 1980):

> Men ought to know that from the brain, and from the brain only, arise our pleasures, joys, laughter and jests, as well as our sorrows, pains, griefs and tears. Through it, in particular, we think, see, hear, and distinguish the ugly from the beautiful, the bad from the good, the pleasant from the unpleasant. . . . It is the same thing which makes us mad or delirious, inspires us with dread and fear, whether by night or by day, brings sleeplessness, inopportune mistakes, aimless anxieties, absent-mindedness, and acts that are contrary to habit. (Qtd. in McHenry, 1969)

Hippocrates also reported the association of right hemiparesis and aphasia:

> A woman . . . became unable to articulate and the right arm was paralyzed. (Qtd in. McHenry, 1969)

However, the brain was not appreciated as the seat of cognitive functions until many, many years later. This helps explain the persistent allusions in our language to the association of the heart with the emotions. If the views of Hippocrates had been accepted earlier, a different organ might be revered on St. Valentine's Day.

In the second century A.D., Galen made one of the first crude attempts to localize mental phenomena in the structures of the brain. According to his theory, the frontal lobes were the seat of the soul and the source of animal spirits. Vital bodily humors from the liver were transported in the blood to the rete mirabile, where they were converted into psychic humors as they entered the brain. Throughout the Middle Ages, the belief that cognition was localized in the substance of the brain vied with the belief that psychic humors in the ventricles controlled mental function. This idea of ventricular localization was probably derived from Homophiles (ca. 300 B.C.) and persisted well into the Renaissance. Leonardo da Vinci depicted this ventricular/humeral theory in a drawing of the human head.

The genuine scientific beginnings of functional localization in the brain awaited the 19th century. At times it reached ridiculous proportions in the school of phrenology, which assigned a variety of complex cognitive functions (e.g., wit, love of parents, prudence, sexual love) to specific portions of cerebral gyri. On the opposite extreme, the holistic view contended that the brain functioned as a single unit. By the end of the 19th century, the localizationists held the higher ground through a series of striking observations.

In 1861, Paul Broca described a man with a lesion centered in the left frontal operculum, which extended beyond Broca's area proper. In all likelihood, the lesion was produced by a series of infarctions secondary to meningovascular syphilis. The patient is referred to by the eponym of "Tan" because the extent of his verbal output was "Tan-tan." In this setting of severe motor aphasia, the patient's comprehension was remarkably intact. This observation led Broca to conclude that the motor engrams for language were seated in the posterior one-third of the left inferior frontal gyrus. Thirteen years later, Carl Wernicke described another patient who was the antithesis of Broca's case. Wernicke's patient exhibited a severe comprehension deficit combined with intact verbal fluency. The lesion was in the region of the posterior one-third of the left superior temporal gyrus. Wernicke concluded that the sensory engrams for language were located in this region. Ferrier's demonstration of the differential patterns of motor movement produced by electrical stimulation of the cortex furthered the concept of localized function. In the later 19th century, Golgi and Cajal demonstrated that the brain was not a homogenous mass, but made up of discrete cellular elements. Later, the full spectrum of cerebral cytoarchitectural differentiation became apparent, suggesting regional differences in function.

These and other observations provided strong support to localizationism and laid the foundation for the modern neurological examination. In the early 20th century, the balance of opinion between localizationist and holistic views swung back toward the holistic view under the weight of experimental evidence of diffuse distribution of certain functions (e.g., Lashley's experiments on localization of memory), but in the latter half of the 20th century, opinion swung once more toward localizationism. As is often the case when two schools of scientific thought mount strong conflicting arguments, the truth lies somewhere in between. Any theory of brain function is at best metaphorical. Each is valid in its predictive capacity and ability to explain and offer insights into brain mechanisms. Each is inadequate in its failure to explain all brain mechanisms and the degree to which it focuses attention away from certain aspects of brain function. The fallacy of strict localizationism is that externally observed behavioral symptoms occurring in association with focal cerebral lesions are used as a basis for assigning specific complex behavioral functions to discrete anatomical locations. As Hughlings Jackson so aptly pointed out, the localization of a symptom associated with a lesion in a circumscribed area of the brain is not synonymous with localization of the particular function. Sir Charles Sherrington also viewed brain function as a dynamic process across a distributed neuronal network. His description of 80 years ago echoes the current view:

> It is as if the Milky Way entered upon some cosmic dance. Swiftly the brain becomes an enchanted loom where millions of flashing shuttles weave a dissolving pattern, always a meaningful pattern though never an abiding one; a shifting harmony of subpatterns. (Qtd. in Jastrow, 1983)

BASIS OF THE NEUROLOGICAL EXAMINATION

Our present concept of brain mechanisms views neurobehavioral function as an analysis and synthesis of information coded as specific temporospatial patterns of neural activity occurring across a network of neural assemblies. Neural activity encompasses not only propagated electrical discharges, but also postsynaptic potential and neurochemical, membrane, and cellular (DNA/RNA/protein) changes. While the brain's highly differentiated cytoarchitecture and a mass of experimental data strongly suggest individual cellular columns and local neural assemblies performing different processing roles, overt behavior is always the function of the activity in a network of neurons including both cortical and subcortical structures. A lesion at any one point in the network may shut down the processing capacity of the entire network. Furthermore, lesions at different points in the network may produce similar behavioral deficits. A single neuron or a group of neurons may be involved in many neuronal networks, depending on the task demands. The symptoms, signs, and behavioral deficits produced by a discrete lesion are the product of a pattern of deficits produced by overlapping networks that are functionally unable to "rewire" around a common set of damaged neuronal tracks and analyzers. That pattern is the key to the neurological exam. Through an analysis of the pattern of deficits (i.e., signs and symptoms), the physician is able to localize the lesion, generate differential diagnoses, provide prognosis, and direct therapy.

More than any other portion of the physical examination, the physician's performance of the neurological examination varies with the individual patient and disease state. The physician uses a neurological examination based on a core framework that is shaped and expanded depending on the patient's history and the results of the ongoing examination. Starting with the presenting complaint or symptom, the physician begins to generate a potential list of differential diagnoses and asks questions to restrict or refine the list. In addition to the patient's medical history, his or her family and social history may contribute to the diagnosis. It is important that the patient's education and work history be obtained in order to allow interpretation of the mental status exam. Throughout the neurological examination, the process of refining the differential diagnosis continues as the examiner searches for the specific pattern of deficits. The physician is constantly searching for performance discrepancies, pathological signs, and neurological asymmetries that can be fitted into a pattern of deficits consistent with known brain mechanisms and specific disease states. In this chapter, the neurological examination is described as it relates to neuropsychological issues and disease.

GENERAL PHYSICAL EXAMINATION

The general physical exam is an important accompaniment to the neurological exam in patients with altered mental status. For example, systemic diseases such as hypoxia, hypertension, hypoperfusion, uremia, and liver failure can all affect cognition. Vital signs may give clues to possible organic causes of altered mental status.

Pulse. Tachycardia and bradycardia may impair cerebral perfusion, while arrhythmias (e.g., atrial fibrillation) may impair perfusion as well as predispose an individual to embolic phenomena. Pulsus paradoxus may be seen with severe obstructive pulmonary disease or in pericardial effusion with tamponade.

Blood Pressure. Elevated blood pressure suggests the possibilities of malignant hypertension, intracerebral hemorrhage, and increased risk of cerebral infarction. Orthostatic hypotension may produce mental clouding, dizziness, and symptoms of vertebrobasilar insufficiency.

Respiration. Tachypnea may be seen with hypoxia, other pulmonary problems, sepsis, or severe liver disease. Hypoventilation may accompany severe brain injury or respiratory failure of other causes. Cheyne-stokes respiration is commonly due to central nervous system causes but may also be seen in older patients and in congestive heart failure. Kussmal respirations may result from an acidosis (especially diabetic ketoacidosis). Apneustic breaching is seen with brain stem dysfunction.

Temperature. Elevation of temperature suggests a possible infectious process that may directly involve the brain (e.g., meningitis, encephalitis, brain abscess) or secondarily affect the brain (e.g., sepsis, pneumonia, subacute bacterial endocarditis). Hypothermia may be seen in patients suffering from exposure, hypothyroidism, and drug intoxication.

The skin should be examined for cyanosis or edema as evidence of cardiopulmonary disease. The presence of petechiae suggests abnormal platelet function and an increased hemorrhagic risk. Splinter hemorrhages suggest embolic phenomena. The stigmata of phakomatoses (e.g., telangiectasia, facial angiomas, ash-leaf spots, café-au-lait spots, and neurofibromas) might indicate specific intracerebral structural abnormalities. The skin, especially of the head, should be examined for evidence of contusions, which suggest direct brain injury or subdural/epidural hematomas.

Auscultation of the head and neck should be performed. Cranial arterial bruits may be indicative of an arteriovenous malformation. A venous bruit anterior and inferior to the external auditory canal raises the possibility of increased intracranial pressure. The bruit is abolished by light pressure over the ipsilateral jugular vein or by valsalva maneuver. A bruit over the carotid suggests the presence of stenotic vascular disease.

The ears are examined for the presence of otitis media, which raises the possibility of associated brain abscess, and for the presence of blood behind the tympanic membrane (i.e., Battle's sign), which frequently accompanies basilar skull fractures.

Examination of the nose includes checking for the presence of cerebrospinal fluid rhinorrhea (which predisposes an individual to recurrent meningitis) and for neoplastic sources (which may directly invade the brain). Pain on percussion over the frontal or maxillary sinuses may suggest sinusitis and the possibility of associated brain abscess.

Examination of the mouth and throat may reveal infectious or neoplastic sources. Paleness of the mucous membranes will be present in severe anemia.

The neck should be examined for suppleness; a stiff neck suggests meningeal irritation such as is seen with infection or subarachnoid hemorrhage. The size of the thyroid gland should be assessed, as both hyperthyroidism and hypothyroidism may produce abnormalities in cognition and behavior.

Auscultation and percussion of the chest may reveal pulmonary dysfunction such as pneumonia, congestive heart failure, obstructive airway disease, tumor, and effusions. The cardiovascular exam should assess rate, rhythm, rubs, clicks, murmurs, cardiac size, and function in order to rule out hypoperfusion, hypoxia, and/or embolic sources (e.g., subacute bacterial endocarditis and other valvular diseases).

The abdominal exam should specifically check liver size, as an enlarged liver raises the possibility of metastatic disease, alcoholic hepatitis, or infectious hepatitis with resultant hepatic failure and encephalopathy. Gastric resection or malabsorption may predispose the patient to dementia secondary to nutritional deficiencies (e.g., Korsakoff's syndrome). The abdominal exam may also reveal neoplastic sources.

Examination of the extremities should include symmetry, range of motion, and arthritic changes, and evidence of congenital malformations. Left/right asymmetries in size may indicate damage early in brain development of the cerebral hemisphere contralateral to the smaller limbs.

THE NEUROLOGICAL EXAMINATION

The Mental Status Examination

The first item of the mental status exam is the level of consciousness, which is rated as alert, somnolence or lethargy (i.e., sleepy but maintaining an awake state with interaction), stupor (i.e., depressed but arousable), semicoma (i.e., responds to pain or other noxious stimuli, but not to the point of responding to commands), or coma (i.e., no response other than reflexive). In addition to these general labels, it is always preferable to state specifically the patient's response (e.g., "Responds to pain with purposeful movement"). Orientation to person, place, and time should be noted. Again, it is preferable to record the patient's specific answers. For instance, a patient disoriented only to the month would be at a much higher level than a patient who thinks that the year is 1936.

The assessment of memory is divided into three parts: (1) immediate memory, which is primarily a measure of attention; (2) recent memory, which is the capacity to learn or make new memories, and (3) remote memory, which represents the long-term memory store. Remote memories go through a process called consolidation that continues over hours, months, or even years. As a result of consolidation, there is a more distributed, resilient representation of this type of memory. Remote memories are relatively resistant to disease and may be spared to a large degree, whereas recent memory is impaired in a variety of diffuse encephalopathies or early in idiopathic degenerative dementias (e.g., Alzheimer's disease). However, a retrograde amnesia affecting remote memories may occur in a gradient fashion such that more recent remote memories are impaired but distant remote memories are spared. This form of retrograde amnesia can be seen in conditions such as extensive damage to both medial temporal lobes, head trauma, and later stages of Alzheimer's disease. A recent memory disorder may exist in relative isolation following focal lesions in the mesial temporal lobes, septal nuclei, retrosplenial cortex, or dorsomedial thalamus. Immediate memory and cognitive capacity to some degree can be assessed by digit spans. In general, a normal person should be able to repeat seven random digits forward and five digits backward (i.e., recall five digits in reverse of the order given). The physician may assess recent verbal memory at the bedside by giving the patient three objects to remember (e.g., horse, apple, table). The patient should repeat the three objects to ensure that he or she has understood the test items. Other verbal items in the examination are then presented and serve as a distracter. Three to five minutes following verbal distraction, the patient is asked to recall the three objects, and the number correctly remembered is recorded (e.g., "Two of three objects at 5 minutes") along with the number of false positive errors. If the patient fails to recall the objects, then a second trial with cueing (e.g., providing the first letter or phoneme of the words) or recognition (e.g., giving multiple choices) may be given to further delineate the deficit. A failure of memory that improves markedly with cueing or recognition may represent a retrieval problem and localize more to frontal executive areas, whereas a memory deficit that does not improve with cueing or on a recognition trial is more a problem associated with encoding and most classically seen in diseases such as Alzheimer's disease. Although recent verbal memory may be disordered in a variety of diffuse disease states, it may be specifically impaired by lesions of the left (i.e., dominant) temporal lobe. In contrast, lesions of the right temporal lobe may preferentially decrement visuospatial recent memory. When the diagnosis or exam suggests right temporal pathology, physicians may test the encoding of visuospatial memories at the bedside in patients with otherwise intact visuospatial skills by having them copy a figure such as intersecting pentagons and then reproduce it immediately and again after 10 minutes. Alternatively, a more difficult visuospatial memory test may be used. For example, the Rey-Osterrieth Complex Figure Test (Lezak, Howieson, & Loring, 2004) is a very sensitive measure for right frontal temporal dysfunction. Remote memory may be assessed to a large degree via details in the personal history. If a more objective measure is desired at the bedside, one might ask the patient to name the last five presidents. However, the socioeducational pitfalls of using this single question as a measure of remote memory must be borne in mind.

In the vast majority of patients, the left cerebral hemisphere is dominant for propositional language. Thus, assessment of propositional language may be thought of essentially as a measure of left cerebral function. This is true for the vast majority of dextrals (i.e., right-handers) and will even hold true for most sinestrals (i.e., left-handers) and ambidextrous individuals, although to a lesser extent. Non-dextrals will tend to show an increase of mixed cerebral dominance, and, in a small minority, right cerebral dominance for language. The distribution of various functions may vary with an individual, especially if there is a prior history of cerebral damage in childhood or personal/family history of sinestrals.

At least six components should be tested in the language assessment area: naming, repetition, comprehension, fluency, reading, and writing. Physicians can test naming by having the patient name several common objects (e.g., watch, shirt, door) and parts of objects (e.g., watchband, sleeve, pen clip). Physicians can test repetition by having the patient repeat a phrase such as "No ifs, ands, or buts." This phrase is particularly difficult because of the string of prepositions. If the patient is unable to repeat the sentence, then a simpler sentence or single words may be tested. Comprehension is assessed to a large degree when the history is taken and during other components of the exam. Comprehension is best tested by the use of multistep commands or sentences with complex syntax, such as "Point to the door after you point to the ceiling." In some cases, aphasics who are unable to comprehend commands external to the body will be able to carry out midline body commands, such as "Close your eyes" or "Stick out your tongue." One should be careful not to give visual cues when giving these commands. Speech fluency may also be assessed when the history is taken and during other components of the exam. Specific testing for fluency may include the Benton Word Fluency Test, in which the patient is asked to write or say as many words beginning with a certain letter (excluding proper names) as he or she can in 1 minute. The letters commonly used are *F*, *A*, and *S*, and the patient should be able to name at least 10 words in the 1-minute time span for a single letter. This type of testing assesses the executive search ability of the prefrontal lobes as much as it does language function. Assessment of naming, repetition, comprehension, and fluency will allow the examiner to classify the patient's aphasia according to standard nomenclature. When all four functions are severely impaired, the patient's deficit is classified as a global aphasia. A motor (i.e., Broca's, anterior, or nonfluent) aphasia is characterized by impaired fluency and repetition with relative sparing of comprehension and, perhaps, naming or at least the ability to pick out verbally named objects. If speech output is not completely impaired, the remaining speech will be effortful and lacking connecting words such as prepositions, giving the speech output a telegraphic quality. While Broca's area is the posterior one-third of the inferior frontal gyrus, a classical Broca-type aphasia actually requires a larger lesion. Lesions restricted to Broca's area proper produce an acute marked decrease in speech output from which the patient usually recovers in the course of a few days or weeks. A permanent motor aphasia requires a lesion extending beyond Broca's area to include the underlying white matter and adjacent perisylvian cortex. Broca aphasia is most commonly the result of occlusion of the anterior/superior division of the middle cerebral artery, which also usually supplies the motor strip, so that in addition to the aphasia there is an associated severe contralateral hemiparesis.

A sensory (i.e., Wernicke's, posterior, or fluent) aphasia typically spares speech fluency. Comprehension, naming, and repetition are impaired. Speech output flows effortlessly with normal rhythm. In the more severe forms, the patient becomes incomprehensible, juxtaposing meaningless phrases and neologisms to form a "word salad." In contrast to Broca's aphasia, a contralateral hemiparesis is typically absent or minimal. Wernicke's is usually the result of occlusion of the inferior/posterior division of the middle cerebral artery, which does not supply motor cortex, so that there is no associated weakness; the patient may be agitated, speak gibberish, and not follow commands. As a result, the patient with Wernicke's aphasia is at times misdiagnosed as a psychiatric disorder. Such a mistake can be avoided by careful observation for neurological signs frequently associated with lesions in the left cerebral hemisphere (i.e., apraxia, right visual field deficits, and subtle neurological deficits such as a slight facial weakness, drift, reflex asymmetries, or pathological reflexes).

Although repetition is impaired with lesions anywhere in the primary language area (i.e., perisylvian region of the dominant hemisphere), repetition is most severely impaired relative to other language functions with lesions of the arcuate fibers connecting Wernicke's and Broca's regions (i.e., the so-called conduction aphasia) or more commonly with lesions of Wernicke's area. Repetition is relatively intact in the transcortical aphasias, which spare the primary language area. Such a condition may exist following a cardiopulmonary resuscitation that results in infarction of the watershed areas. If comprehension and naming are spared along with repetition, the language deficit is classified as a transcortical motor aphasia. This isolated loss of fluency may be present in diffuse neurodegenerative diseases (e.g., Parkinson's disease), akinetic states, or lesions of either frontal lobe (left more than right). If fluency is spared along with repetition, the deficit in comprehension and naming is classified as a transcortical sensory aphasia, which is typically produced by lesions posterior to the primary language area. Naming may be disrupted in relative isolation with lesions in the vicinity of the temporoparietal-occipital junction on the left. It may also be disordered in diffuse disorders or dementias such as Alzheimer's disease.

One should remember that the standard aphasia classifications are based on aphasias produced by chronic cortical lesions (i.e., late after the stroke). The patient examined in the acute phase may not fit classical patterns and may evolve over time into a more classic picture. Subcortical lesions (e.g., thalamic) may also produce aphasias, but these do not fit the standard localization notions.

Finally, reading and writing should be assessed separately because dissociated deficits of reading or writing may occur, as in apraxia or in alexia without agraphia. At the bedside, simple command sentences may be used in this context. Having the patient read proper names and having the patient write his or her own name are very poor measures for testing because they are diffusely represented and almost reflexively engrained. In alexia without agraphia, the lesion disconnects the primary language area from the primary visual cortex. For instance, the lesion in Dejerine's original case of alexia without agraphia involved destruction of the left calcarine cortex along with the splenium of the corpus callosum.

Apraxia is a disorder in the execution of learned movements that cannot be explained by the degree of weakness or sensory loss. Since handedness and language dominance are linked in the majority of the population, it is not surprising that apraxia would be produced by lesions to the left hemisphere. Lesions to the left parietal region are specifically prone to produce apraxia in both hands. Further, lesions of the anterior callosal fibers or in the subcortical white matter in either frontal lobe may produce an isolated left-hand apraxia. The physician should test manual apraxia by asking the patient to pantomime a task such as hammering, using a screwdriver, or flipping a coin in the air. The apraxia may improve with imitation of the examiner's movements or by use of the real object. In severely aphasic patients, the use of a real object may be the only way to test for the presence of apraxia. Buccofacial apraxia for items such as sucking on a straw or blowing out a match may be seen in cases of lesions of the left dorsolateral frontal lobe.

The constellation of findings including acalculia, agraphia, right/left confusion, and finger agnosia, which are frequently referred to as Gerstmann's syndrome, has been attributed to lesions of the left angular gyrus. This syndrome is very rarely seen in isolation, but its components may frequently accompany other deficits in cases of lesions in this region. Again, it is the pattern of symptoms that is important, in that isolated components of this syndrome might be produced from lesions in the opposite hemisphere (e.g., dyscalculia and right/left confusion).

Evaluation of right cerebral cognitive functions should include assessment of the neglect syndrome. Just as the left hemisphere may be thought of as dominant for language functions, the right hemisphere may be thought of as dominant for some attentional and intentional mechanisms. Thus, lesions to the right cerebral hemisphere may produce the neglect syndrome, which, in its severest form, includes anosognosia (i.e., absence of awareness of disease such as hemiplegia) and even denial that the individual's body part belongs to him or her. The patient may ignore all stimuli from the left hemispace. In milder forms, the patient may admit his or her weakness but show a lack of concern (i.e., anosodiaphoria). He or she may only ignore stimuli from the left hemispace when given double simultaneous stimuli from both sides (i.e., extinction). This type of neglect may be seen in any sensory modality but is most consistently present for tactile stimuli. In addition to the attention disorder, patients may exhibit an intentional disorder, especially in cases of lesions of the basal ganglia or the mesial or dorsolateral frontal lobes. They may exhibit a left hemibody akinesia or contralateral motor neglect. A modification of the test for tactile extinction is used to test for motor neglect. Instead of having the patient answer, "Left," "Right," or "Both" when he or she is touched on the hands with his or her eyes closed, ask the patient to raise the hand opposite the hand touched. In other words, the patient should raise the right hand when touched on the left, the left hand when touched on the right, and both when simultaneously touched on both hands. In motor neglect, the patient will fail to raise the akinetic arm (usually the left) when touched bilaterally. Neglect syndromes affect not only personal space, but also peripersonal and extrapersonal space as well as perception of objects. For example, the patient will bisect lines on average to the right of midline. This can be due to a number of factors, including attentional, intentional, spatial-oriented, and object-oriented factors. Also useful is a line cancellation task where several line segments are scattered on a page and the patient is asked to place a line through all of them. Hemispatial neglect will typically result in lines on the left side of the page not being cancelled. Sometimes the neglect is object centered, and then most of the lines may be struck through, but to the right side of each line. When asked to draw an object (e.g., flower), the patient with neglect may draw only the right side of the object.

Visuospatial constructional skills are frequently disordered following right cerebral lesions, even in the absence of the neglect syndrome. Having the patient draw a cube, a cross, or a square will test these skills at progressively lower levels of difficulty.

The higher cortical sensory functions of stereognosis and graphesthesia may be disordered following parietal lesions (right > left). Stereognosis is the ability to recognize objects by touch alone; graphesthesia is the ability to recognize numbers or letters written in the palm of the hand.

Prosody has to do with the intonation of language. The most universal use of prosody in speaking is emotional prosody, and the physician may test this by having the patient produce and identify the emotional intonation of emotionally neutral sentences, with vocal emotional tones such as happy, sad, mad, and indifferent. The areas of the right hemisphere subserving prosody tend to parallel those in the left hemisphere involved in language. Problems with the production of emotional prosody are seen in right frontal lesions, and deficits in the comprehension of emotional prosody most often are seen in parietotemporal lesions. Prosody may be impaired in cases of right cerebral lesions and specifically spared in aphasics with left cerebral lesions.

Outside of professional musicians, disturbances in the ability to appreciate and produce the elements of music, called amusia, can also be seen in lesions of the right hemisphere. Right frontal lesions typically impair the production of song, and right temporal lesions disrupt the perception of music.

One last language function that localizes to the right hemisphere rather than the left hemisphere is the production of “overlearned” speech. An example of overlearned speech is prayers that are repeated regularly over the course of a lifetime. Overlearned speech such as this can be spared in cases of damage to the left hemisphere where the patient is otherwise aphasic and, conversely, can be impaired without other language impairments when damage is in the right hemisphere.

Frontal lesions produce the paradox of a patient who has both difficulty initiating tasks (e.g., akinesia or decreased word fluency) and difficulty stopping or alternating tasks (e.g., perseveration). Due to the plasticity of the frontal lobes, frontal lesions can be particularly silent, especially in cases of a slowly progressive or chronically static process. Luria figures, go/no-go tasks, fist/edge/palm tasks, and cross response inhibition are sensitive to frontal dysfunction. An example of Luria figures is the copying of repeated *M*'s and *N*'s or other alternating repetitive figures. Typically the patient will perseverate and lose the pattern. A common go/no-go task would be to ask the patient to raise two fingers in response to the examiner's raising one finger, and to raise a fist when the examiner raises two fingers. The examiner then gives random alternating strings of the two signals. In the fist/edge/palm task, the patient repeatedly performs the sequence of alternately placing his or her hand in the fist, edge, and palm positions. For the cross response inhibition task, the patient is asked to close his or her eyes, and they are touched on the left or right hand in a random sequence; he or she is asked to raise the hand opposite the one touched, similar to the motor neglect task. Frontal patients have a great deal of difficulty maintaining such tasks and alternating the responses at the appropriate times. For example, they cannot consistently inhibit the hand touched in the cross inhibition test. One should keep in mind that these “frontal” signs may be produced not only by focal frontal lobe lesions, but also by diffuse dementias or by focal subcortical lesions (e.g., thalamus).

Finally, the mental status exam should include assessment of the patient's affect and thought processes. A flat affect may be seen in diffuse encephalopathies, frontal lobe pathology, and disorders of the ascending dopaminergic tracts (e.g., Parkinson's disease). This flat affect may be part of a symptom complex known as abulia. Abulia is characterized by flat affect, inertia, akinesia, apathy, and sometimes bradykinesia. Most dramatically, there is slowness of response and lack of spontaneous motor or cognitive activity. Depression may produce cognitive dysfunction or be the result of neurological disease. At times a catastrophic depressive response may be seen following left cerebral lesions, and a euphoric, inappropriately jocular affect, or "laissez-faire" affect may occur in cases of right cerebral lesions. Psychotic symptoms in an adult without prior psychiatric history are particularly suggestive of an organic process, especially if visual hallucinations are present or if the thought disorder does not fit a typical schizophrenic pattern. An organic psychosis may be the result of metabolic disorders, diffuse dementias, or focal brain lesions (e.g., right frontotemporal or midline lesions). Acute confusion and delayed psychosis have been reported separately in patients with focal right-hemispheric lesions. In conjunction with other experimental evidence, the association of focal right-hemispheric lesions with psychosis and with aprosody suggests a unique role for the right cerebral hemisphere in interaction with the limbic system for the processing of emotional stimuli.

CRANIAL NERVE EXAM

A complete listing of the cranial nerve exam is in the exam outline (Table 3.1). Cranial nerve deficits in conjunction with ataxia and crossed motor/sensory deficits are helpful in localizing lesions to the brain stem. Since the brain stem is supplied by posterior circulation, the combination of abrupt onset of cranial nerve findings and crossed motor/sensory suggests a stroke in the posterior circulation. Nystagmus in the primary position and vertical nystagmus (if present in the absence of drugs such as anticonvulsants, benzodiazepines, and ethanol) are particularly suggestive of a process in the posterior fossa.

Defects in eye movements may point to a specific diagnosis in a dementing disease. For example, impaired upgaze is seen in Parinaud's syndrome, and impaired vertical or horizontal gaze (especially downward) is typical of progressive supranuclear palsy. A combination of a

Table 3.1

OUTLINE OF THE NEUROLOGICAL EXAMINATION

GENERAL PHYSICAL EXAMINATION:

Skin: without lesions (e.g., petechiae, cyanosis, neurofibromatoses)

Head: no deformities, masses, tenderness, or bruits

Neck: supple without masses or bruits

Spine: straight without tenderness

Chest: clear to auscultation and percussion

Cardiovascular system: regular rate and rhythm without murmurs or gallops

Abdomen: soft without masses

Extremities: symmetric, full range of movement, warm to touch, and good distal pulses

MENTAL STATUS EXAMINATIONS:

Level of consciousness and orientation:

Alert and oriented times three

(alert, lethargic, stupor, semicoma, coma)

(oriented to person, place, and time)

Memory:

Recent: Memory for recent events intact

Recalled 3 of 3 objects on immediate and delay (e.g., after 5 minutes) recall without false positives

Remote: Memory for general and personal history intact

Left cerebral:

Language intact to naming, repetition, comprehension, fluency, reading, and writing

Note paraphasic errors

Word fluency greater than 10 in 1 minute

(*Continued*)

Table 3.1

	Praxis normal (ideomotor limb and buccolingual)	
	Gerstmann's syndrome absent (i.e., acalculia, agraphia, finger agnosia, right/left confusion)	
Right cerebral:		
	No neglect (e.g., anosognosia, extinction, line bisection, visuospatial neglect, hemi-akinesia)	
	Visuospatial construction intact	
	Prosody intact	
Frontal:		
	Task alternation intact: Luria figures, cross response inhibition, go/no-go tasks, fist/edge/palm task	
	No personality or behavioral changes (e.g., environmental dependency, perseverations)	
Parietal:		
	Stereognosis and graphesthesia intact	
Psychological:		
	Thought processes intact	
	No predominate affect	
Cranial nerves:		
	Cranial nerves I–XII intact (see below)	
	I	smell intact bilaterally
	II	PERRLA (pupils equal round reactive to light and accomodation)
		VFs full OU (visual fields full in both eyes)
		Fundi benign with spontaneous venous pulsations
	III, IV, VI	EOMs full (extraocular movements full); no nystagmus
	V	facial sensation, corneals, and masseters intact
	VII	facial musculature symmetric; taste intact

(*Continued*)

Table 3.1

OUTLINE OF THE NEUROLOGICAL EXAMINATION *(Continued)*

	VIII	hearing intact in both ears (AU)
	IX, X	gag intact; uvula midline
	XI	sternocleidomastoids and trapezii (0–5 rating)
	XII	tongue midline
Motor:		
	Normal bulk, tone, and strength in all groups (0–5 rating)	
	Coordination intact to finger to nose, heel to shin, rapid alternating movements and tandem gait	
	Gait normal	
	Dexterity and speed intact	
	No tremors or other involuntary movements	
	No retropulsion	
Reflexes:		
	DTRs 2+ (deep tendon reflexes) and symmetric (rated 0–4)	
	No pathological reflexes:	
	Hoffman	
	Frontal release: grasps, Meyerson's sign, snout, root	
	Babinski (Plantars downgoing, equivocal Babinski, or Babinski present)	
Sensory:		
	Intact to pinprick, light touch, vibration, and position	
	Romberg negative	

recent memory disorder with gaze or nerve palsies raises the possibility of Wernicke's encephalopathy (i.e., thiamine deficiency) or perithalamic injury secondary to top of the basilar artery embolic infarction. Deficits in the cranial nerve exam may also point to hemispheric lesions. For example, gaze preferences (toward destructive lesions and away from active seizure foci), visual field defects (e.g., a superior quadranopsia with contralateral temporal lobe lesions or an inferior quadranopsia with parietal lesions), or facial weakness with a central pattern (i.e., predominately lower facial weakness opposite the brain lesion) may result from hemispheric lesions.

Particular attention should be given to the fundiscopic exam for evidence of vascular disease (e.g., hemorrhages, exudates, and arteriovenous crossing defects, which results from compression by an artery as it crosses the vein in patients with chronic hypertension) and increased intracranial pressure (i.e., papilledema). If papilledema is questionable, spontaneous venous pulsations at the disk indicate the presence of normal intracranial pressure as long as glaucoma is absent. If spontaneous venous pulsations are not seen, no specific statement concerning intracranial pressure can be made in the absence of papilledema, as spontaneous venous pulsations may be absent in normals.

The examination of the pupils should assess size, reactivity, and symmetry. Both pupils are normally the same size. While up to 15% of normals may have asymmetric pupil size, anisocoria (difference in the size of the pupils) should prompt further evaluation. If one pupil is large and unreactive, there may be a third cranial nerve palsy (such as may be seen with expanding intracranial masses) or parasympathetic nerve injury. If one pupil is smaller and less reactive than the other, the lesion may involve the sympathetic nervous system (i.e., Horner's syndrome), raising the possibility of brain injury, superior thoracic lesions (e.g., Pancoast tumors), or carotid artery occlusion or dissection. If both pupils are large and minimally reactive, there may be anticholinergic intoxication or brain stem injury. If the pupils are small and minimally reactive, narcotic intoxication or pontine injury may be present.

MOTOR EXAM

Muscles should be evaluated on the basis of bulk, tone, and strength. Tone may be decreased (as in lesions of peripheral nerves, the cerebellum, or acute lesions in the cortex) or increased. Important forms of hypertonicity include "lead-pipe" rigidity in the contralateral extremities with chronic lesions of the motor cortex; "cogwheel" rigidity, as seen in parkinsonism; spasticity (or clasp knife rigidity), as seen in cerebral palsy; and paratonia, gegenhalten, or frontal rigidity (i.e., a fluctuating hypertonia seen in frontal lobe disease or diffuse dementias). Another form of paratonia, facilitory paratonia or mitgehen, is also seen and is usually associated with frontal dysfunction. A good general screen of muscle strength in the extremities would include examination of the deltoids, biceps, triceps, wrist extensors, handgrip, interossei, hip-flexors, quadriceps, hamstrings, and dorsal and plantar flexors of the foot. Strength should be graded on a 0–5 rating scale in the following manner: 0 for absence of movement, 1 for trace movement, 2 for movement across gravity but inability to move against gravity, 3 for movement against gravity but lack of resistance, 4 for weakness but movement against gravity with resistance, and 5 for normal strength. Obviously the grade 4/5 encompasses the largest group, and ratings of 4 may be subdivided into 4− and 4+ in order to better denote the degree of weakness or to indicate asymmetries. Minimal weakness may be best demonstrated by a downward or pronator drift of the outstretched arms. Coordination should be tested by finger-to-nose, heel-to-knee or shin, and rapid alternating movements. If possible, routine gait and tandem gait should also be tested. Coordination is typically thought of as a cerebellar test, but it may be disordered in a variety of cortical and subcortical lesions. Motor speed should be observed for slowed initiation of movement (i.e., akinesia) and slowed movement after initiation (i.e., bradykinesia). The two symptoms commonly occur together and may result from dysfunction in frontal, striatal, or dopaminergic systems. Subcortical dysfunction as seen in Parkinson's disease can also cause retropulsion, where the patient is propelled backward, taking several steps or even falling either spontaneously or with mild pushing or pulling backward by the examiner.

EXAM OF REFLEXES

Deep tendon reflexes (DTRs) should be elicited at the biceps, triceps, brachioradialis, patellar, and Achilles' tendons. Deep tendon reflexes should be graded on a four-point scale in the following manner: 0 for no reflex, 1 for trace movement, 2 for normal reflex, 3 for hyperactive reflex, and 4 for the presence of clonus. Asymmetries in reflexes should be noted. Testing of pathological reflexes should include the Babinski, Hoffman, Meyerson's sign (i.e., failure to inhibit blinking in response to glabellar tap), grasp, and snout reflexes. If present, the Babinski indicates dysfunction in the corticospinal tract, and the Hoffman simply indicates hyperreflexia. The remaining reflexes (i.e., grasp, snout, and Meyerson's sign) are the so-called frontal lobe reflexes, which actually are more commonly seen in diffuse diseases such as senile dementia of the Alzheimer's type. Meyerson's sign is striking in Parkinson's disease where patients exhibit reptilian stare (i.e., lack of spontaneous blinking).

SENSORY EXAM

Examination of sensation should include pinprick, light touch, vibratory, and position-sense testing. While cortical lesions may produce hypesthesia, the sensation of pain will be maintained with lesions above the thalamus. Sensory deficits that exactly divide the midline are rare and may indicate a conversion reaction; however, subcortical lesions (e.g., thalamic lesions) may produce such a pattern. Deficits in vibratory and position sense are most commonly produced by peripheral neuropathies (e.g., diabetes neuropathy) or lesions of the posterior columns (e.g., B12 deficiency or syphilis). When testing for vibratory loss in peripheral neuropathy, the examiner can use his or her own sense of vibration as a control as it will be transmitted through the finger or toe of the patient during the test and is useful since there may be a symmetric diminution of vibratory sense that otherwise would not be obvious. Unilateral loss of position sense in the presence of normal vibratory sense may indicate a cortical parietal lesion.

SUMMARY

In closing, one should remember that no single sign or symptom is diagnostic or even localizing in and of itself. The pattern of deficits helps the examiner determine the location of the lesion and ultimately points to the etiology. The search for the pattern begins with the history and continues throughout the exam. Formal neuropsychological testing can complement the neurological examination by confirming a suspected pattern of cognitive dysfunction, detecting subtle deficits, and further delineating the neurobehavioral deficits and documenting in detail the pattern of capacity and incapacity. The results not only have a role in legal and rehabilitative perspectives but also can assist in difficult diagnostic problems.

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4 Neuropsychology and Neuroimaging: Integrating and Understanding Structure and Function in Clinical Practice

CHAD A. NOGGLE, ANDREW S. DAVIS, AND MARK BARISA

In the past 30 years the neurosciences have yielded substantial advances in neuroimaging techniques that provide sophisticated images of the human brain through non-invasive methods. These advances in medical science have had profound implications for the clinical practice of neuropsychology. Neuroimaging has provided an increased ability to connect neuroanatomical structure and function with clinical presentations. This has refined the understanding of the roles neural regions and circuitry play in specific neurocognitive and behavioral tasks, which in turn has lead to improvements in clinical practice. The field of clinical neuropsychology has undergone parallel changes with the advent of the improved ability to localize and determine lesions and structural anomalies. Many of the traditional neuropsychological instruments were originally designed to localize impairment or determine the presence or extent of brain damage. The improvements in neuroimaging have mandated change in the process of neuropsychological assessment to focus on the determination of functional implications of injury/illness and design of effective interventions and recommendations for rehabilitation. This chapter will present some of the neuroimaging advancements and explain how the field of neuropsychology can utilize this information to guide clinical practice and direct rehabilitative intervention.

HISTORY OF INTEGRATING BRAIN MORPHOLOGY AND CLINICAL PRACTICE

The field of clinical neuropsychology grew out of a need to localize cerebral lesions and determine the extent of neurological impairment through non-intrusive methods. In regards to working with the medical fields and assisting in rehabilitation, 30 years ago, neuropsychologists were primarily responsible for localizing lesions and determining the lateralization of impairment. Early neuropsychologists used both direct and indirect observation. Indirect observation included observing visible neurological impairment and extrapolating to observable behaviors (e.g., the case of Phineas Gage) and using neuropsychological test instruments that measure behavior as supposedly correlated to specific neural processing areas. Direct measurement was not possible until autopsy, as in the case of Paul Broca examining the brain of his famous patient with expressive aphasia after death. Despite neuropsychologists' success using indirect measurement, it is difficult to argue that direct measurement of functions is the future of the field. Indirect measurement and estimation of localization of impairment suffer from the fact that neuropsychologists are not really measuring a neurological region; they are measuring behavior that they *believe* is related to a specific neural processing area based on research or anecdotal evidence. The advent of the imaging techniques discussed in this chapter led to the current ability to directly measure and localize deficits in living patients; however, it is important for any field to understand its history, and this chapter will briefly review the history of localization of impairment and the understanding of the biological basis of behavior.

Humans have long been aware of the brain-behavior relationship, and the search for information and treatment extends back thousands of years. Archeologists have discovered several thousand skulls that show evidence of humans having survived trephination, the ancient practice of removing pieces of the skull, designed to relieve swelling of the brain (Zillmer & Spiers, 2001). The ancient Greeks produced the first written records of brain-behavior relationships. Pythagoras and other scholars developed the idea of the brain hypothesis, which stipulated that the brain is the source of all behavior (Zillmer & Spiers, 2001). Hippocrates, largely credited with founding modern medicine, held that the brain was the site of cognitive processes, sensations, and emotions. He also postulated that psychological disorders were caused by neurological trauma, which challenged the commonly held belief that neurological disorders, especially seizures, were the result of divine interventions. Plato (420–347 B.C.) wrote that the soul, responsible for rational thought, was located in the brain and noted that head trauma will result in impairment in reasoning (Robinson, 1970). Aristotle (384–322 B.C.), postulated that the heart was the seat of all mental processes. He argued that as the heart is warm and active, it was the seat of emotions such as love and anger. The brain works to cool the hot blood that rises from the heart. This viewpoint was called the cardiac hypothesis (Zillmer & Spiers, 2001). The ideas of the Greek philosophers, although anatomically wrong on many counts, provided the foundation upon which the study of neuropsychology was built, and future philosophers and physiologists may not have made their contributions without the advances of these philosophers.

Galen's (130–201 C.E.) observations of the human body came from his work as a surgeon who was appointed to gladiators (Finger, 1994b). Galen wrote that the functioning of the body and brain results from the combination of the four elements, qualities, and humors (May, 1968). Galen's view of humors became so ingrained that physicians barely elaborated on the role of the brain for the next thousand years. During the 16th century, Galen's anatomic mistakes began to be corrected. René Descartes (1596–1650), a French philosopher and mathematician, is an important figure in the history of neuropsychology in that he proposed a division between mental and physical processes. He viewed the human body as a material entity that functioned like a machine, where the mind was free to carry out the functions of consciousness. This idea is now referred to as interactive dualism (Benjamin, 1997).

As the 18th century approached, more accurate representations of the brain and its functions were being developed. Emanuel Swedenborg (1688–1772) was likely the first to generate a theory of cortical localization of behavioral functions. Swedenborg wrote that separate areas of the brain were necessary to prevent psychological chaos and charted his ideas of discrete areas for vision and hearing based on his studies of pathology and anatomy (Finger, 1994a). Although ahead of his time, his ideas were not published until the end of the 19th century, when localization theory was broadly accepted. It was with the idea of brain localization in mind that Franz Gall (1758–1828) promoted the science of phrenology. Phrenologists believed that the brain consists of a number of separate organs that are independently responsible for some aspect of behavior or personality. They proposed that variations in brain functions among individuals led to variations in the shape or size of that organ of the brain. Hence it was possible to detect variations in brain functions by looking for differences in the shape of the skull. Although today phrenology is referred to with contempt and humor, the advocates of phrenology made many important contributions to the study of the brain and how it affects behavior.

Paul Broca (1824–1880), a French surgeon-anthropologist, was able to identify specific functional areas within the cerebrum. He is best remembered for identifying an area we now commonly call Broca's area, which is related to expressive speech and produces a speech disorder. Broca is also responsible for introducing a belief held for many decades that the left hemisphere was the dominant hemisphere. After performing an autopsy on his famous patient Leborgne (also called Tan), who was suffering from a degenerative ability to produce speech, Broca was able to identify the area of the cerebrum responsible for the damage, which now bears his name. On an autopsy, Broca was able to identify several areas of the brain that were destroyed, which led him to conclude that the area of the brain that bears his name was responsible for causing the expressive language problem. Another 19th century researcher, Carl Wernicke (1848–1904), postulated that the ability to understand spoken language had a specific localization site in the brain, in the posterior half of the left superior temporal gyrus. The disorder now known as Wernicke's aphasia is characterized by defective comprehension of spoken words, and fluent yet incoherent speech. Wernicke's findings cast a realistic shadow on 19th century proponents of brain localization theory who hypothesized that functions had one specific location.

Hughlings Jackson (1835–1911) was an English neurologist who hypothesized that higher mental functions are not discrete actions unto themselves but are combinations of a series of simpler mental processes. He disagreed with localization theorists who proposed that the brain has a single speech center. For example, he viewed speech as a sequence of simple mental abilities, such as hearing, fine motor movements, and kinesthetic control of the mouth. Thus, if there is an injury to the brain that results in loss of speech, it does not necessarily occur in Broca's or Wernicke's area since the injury could disrupt any one of the many processes that are necessary to create speech. Jackson was not interested in answering the question of where language is located; he wanted to know what each region's contribution to language is (Harris, 1999).

Alexander Luria (1902–1977), a Russian neuropsychologist, built on Jackson's theories to become one of the most prominent neuropsychologists of the 20th century. Luria did not view any complex higher cortical functions as products of a particular tissue or organ, but as the coordination of several different brain areas. Luria combined elements of localization, equipotentiality theory, and the work of Hughlings Jackson to create a conceptualization of a normally functioning brain as three units. The first unit regulates activation, muscle tone, and vigilance and consists of the reticular formation, limbic system, and mesial basal frontal lobes. Injuries to the first unit can result in lethargy and apathy, which will impair higher cortical systems, even though the areas related to higher cortical functions may remain intact. The second unit is responsible for registration, analysis, and the storage of sensory information and is comprised of the temporal, parietal, and occipital lobes. The third unit regulates complex mental activity, such as planning, abstract thought, and organization. This unit is dependent upon the integrity of the frontal lobes. All activities depend upon the cooperation of all three units. Luria hypothesized that when a functional system ceases to operate correctly as a result of an injury, it is not obvious which cerebral structure in the brain is impaired. For example, a brain-injured patient may not be attending (Unit 1), he may not be able to analyze relevant stimuli (Unit 2), or he may not be actively trying to use the information; all three of these possibilities will have similar functional presentations (Gouvier, Ryan, O'Jile, Parks-Levy, Webster, & Blanton, 1997). No single unit or area of the brain is solely responsible for the execution of any activity. In order to assess which system is impaired, Luria proposed testing a series of hypotheses by calling upon each unit to sequentially demonstrate its integrity. Luria's idea of harmonious processing remains very relevant today, decades after he first published his ideas. His ideas have directly influenced modern neuropsychological tests such as the Luria-Nebraska Neuropsychological Test Battery (Golden, Purisch, & Hammeke, 1985) and the NEPSY: A Developmental Neuropsychological Assessment (Korkman, Kirk, & Kemp, 1998). More importantly, Luria's idea of harmonious processing demonstrates some of the weaknesses of modern neuroimaging. Although functional neuroimaging is adept at showing regional processing, more widely used measures of static functioning (e.g., MRI, CT) only identify a lesion site and do not provide evidence of functional impairment. Thus, while the field of neuropsychology is likely to undergo significant changes in the next several years, the identification of functional implications and the interaction of the neurological impairment, behavior, and the environment are likely to remain the domain of the neuropsychologist.

Through modern neuroimaging analyses, we have been able to confirm the ideas proposed by Luria and Jackson regarding the overlapping of functional systems in producing behavior. As suggested by Luria

(1964, 1966) the brain is best characterized as having harmonious functional systems that interact with one another to varying degrees to carry out all behavior and function. For example, clinically, a patient may present with dysnomia (i.e., difficulty in naming); however, this manifestation may originate from at least eight different sites of neuroanatomical impact (Broca's area, Wernicke's area, arcuate fasciculous, perisylvian region, anterior border zone, posterior border zone, angular gyrus, anterior and posterior border zone) (Filley, 2001). Assessment of additional domains of language functioning (e.g., spontaneous speech, auditory comprehension, repetition) may better establish regional differentiation; however, imaging can more accurately achieve this same differentiation when a lesion is viewable via imaging, which the neuropsychologist may then use to guide his or her understanding of the individual's functional presentation. This understanding is of particularly great importance because although the functional aftermath of two very different lesions may be similar, their responsiveness to methods of intervention will differ according to regional origin (see Crosson, Bacon Moore, Gopinath, White, Wierenga, et al., 2005). Given this, it stresses the importance of utilizing neuroimaging findings in neuropsychological practice. The following section will explain the mechanical and scientific underpinnings of modern neuroimaging techniques.

COMPUTED TOMOGRAPHY

Modern imaging techniques' roots can be traced back to the 1970s, when computed tomography (CT) was introduced. The introduction of this method was a dramatic leap forward in terms of clinical and scientific practice. Prior to this, lesion identification and differentiation mostly relied upon techniques similar to current neurobehavioral examinations and neuropsychological assessments. Findings from these modes of assessment not only were used for differential diagnosis of traumatic events (e.g., cerebral vascular accidents, head injuries) but also guided neurosurgical intervention (Haeger, 1988). In cases such as head injury, prior to CT traditional X-ray technology was used; however, this would only reveal skull fractures and was unable to identify affliction to brain tissue. As a result, X-ray data rendered could actually be misleading, as a fracture of the skull in one region may be responsible for some of the etiology of the brain damage; however, a countercoup affliction of opposing tissue may be missed. The development of CT was thus able to greatly improve diagnostic accuracy and better guide subsequent intervention and rehabilitation. Interestingly, CT is built upon the same scientific principles of traditional X-ray; it is simply utilized in a different manner. This technology is based on the principle that X-ray energy is disproportionately absorbed depending on the density of the material, in this case bone and tissue, through which it is passed (Blumenfeld, 2002). In standard X-ray, beams of energy are administered at very few degrees; thus there is lesser energy to be absorbed and only the densest material can be viewed. For example, if a bone was fractured or broken, an X-ray would reveal the bones that were most distinctly defined, while dense surrounding tissue and muscle could be faintly detected to a much lesser degree. The low clarity of this tissue is directly related to the amount of X-ray energy exposure and the angles at which it is applied. Based on this principle Allan M. Cormack, a South African physicist, and Sir Godfrey Hounsfield, a British engineer, developed the first CT in 1971 (Haeger, 1988). Based on their understanding that the clarity of material on X-rays is based on the amount of energy it is able to absorb, Cormack and Hounsfield theorized that numerous beams of X-ray energy applied at numerous angles will allow tissue of even the lowest density to absorb enough energy to be visible (Raichle, 1987). This principle, in combination with computer technology that could compute and analyze gathered data via mathematical applications, made it possible to view the structural aspects of the brain. Since its initial development, the technical properties of CT have been improved such that it is able to provide highly sophisticated and refined imagery of finite neuroanatomical structures and features (Zillmer & Spiers, 2001).

In modern CT scans, the patient's head is placed in the center of the scanner, and the X-ray scan is revolved around the head, which allows the energy to exit the other side, where it is picked up by detectors that then relay the information to a computer in which the data are mathematically analyzed and images are rendered based on how much energy was absorbed in different areas, thus showing the density. As a result of the application of X-ray energy at varying angles and degrees, CT can discriminate variance in density as minute as 1% that is grossly related to discriminating density as small as 2 millimeters in diameter (Zillmer & Spiers, 2001).

Once data are computed and the image is rendered, a neuroradiologist will interpret the findings. In doing so, he or she looks for expected symmetries of the brain as well as areas of hyperdensity and hypodensity that may speak to structural integrity. Specifically, evaluation of these characteristics provides insight into any neuroanatomical abnormalities. For example, asymmetries can suggest an underlying abnormality that would require further investigation via additional imaging techniques. In regards to density, the more dense the tissue, the lighter it appears on the rendered scan. Consequently, dense white matter regions will be much lighter on imagery than will less dense gray matter and cell bodies (Blumenfeld, 2002). Cerebrospinal-filled regions (i.e., ventricles) will be quite dark.

Neuroradiologists' understanding of the expected density and consistency of how neuroanatomical regions appear allows them to identify abnormal appearances and, based on their density, determine their likely etiology and type. A tumor or hemorrhage will appear brighter, as both create hyperdensity of the tissue/region they affect. In contrast, hypodensity may suggest an ischemic infarction or an old infarction. In regards to the latter, the infarction may initially present as hyperdense in nature, due to a mild buildup of blood. After a period of resolution, these regions may become isodense (i.e., appearing close to baseline density) but may eventually become hypodense as a result of necrosis—death of the tissue due to prolonged absence (usually greater than 1–5 minutes) of blood, oxygen, and additional nutrients required to sustain activity. Overall, as a result of the refinement of the technical aspects of CT and the images rendered, in conjunction with its relatively rapid output and generally low cost compared to other imaging methods, CT is likely the most used of all neuroimaging techniques and generally the first used in diagnostic workups.

MAGNETIC RESONANCE IMAGING

As the popularity of CT grew and the scientific community realized the potential of the ability to produce accurate images of the living brain through non-invasive practices, attention was directed toward the development of similar technologies. Two such technologies that arose from this technological movement were magnetic resonance imaging and positron emission tomography.

Magnetic resonance imaging (MRI) was first developed in the early 1970s based on the research of Felix Bloch and Edward Purcell (Raichle, 1987). The functional principle underlying MRI is that hydrogen protons, which are present in all atom nuclei, react to magnetic applications in such a way that their reaction may be measured and calculated in order to yield an image of their structural alignment. More specifically, when an individual is placed in an MRI scan, he or she is subjected to an intense magnetic field that acts upon the hydrogen protons, magnetizing them and, in turn, causing them to align in relation to the magnetic field. Once aligned, a strong radio frequency signal is applied at an angle to the magnetic field, which causes a swing from one extreme of electricity to another (i.e., from a maximum to a minimum). Upon removal of the radio frequency, the hydrogen protons spin back to their original magnetized alignment. This spin back, in combination with a small radio frequency, generates a small magnetic projection that can then be measured and analyzed. The degree of magnetic projection originating from a region is proportionately related to the amount of hydrogen protons within that region and, consequently, the density of the tissue in which they are stored. In other words, data recorded and analyzed and a three-dimensional visualization of hydrogen responsiveness demonstrate the density of regions and structures throughout the brain. As a result, images rendered can be analyzed much like those of CT in that asymmetries, hyperdensities, and hypodensities can be seen. In contrast, however, to images yielded by CT, MRI's ability in spatial detection of data in three-dimensional space provides images of neuroanatomical structures superior to that rendered by CT, thereby providing for more accurate and finite diagnosis of underlying pathology (Pykett, 1982). As a result of this superiority and increased availability, MRI is being used clinically much more frequently. However, as a result of its much greater cost in comparison to CT, the latter is still used much more frequently in diagnostic practice.

POSITRON-EMISSION TOMOGRAPHY

Similar to MRI, the use of positron-emission tomography (PET) has increased as the connection between metabolic processing and the brain has been revealed. This is not a new idea; indeed, the connection between cerebral hemodynamics and brain processing was suggested in the 19th century (Roy & Sherrington, 1890). Raichle (1987) described PET as a view of the brain not simply as a statically represented structure, but rather as an entity whose composition can only be truly understood and appreciated through an investigation of its dynamic properties. More specifically, PET allows for the visualization of specific underlying physiological factors related to the metabolic and vascular integrity of the brain as it relates to neurocognitive actions. The procedure requires an injection of a radionuclide tracer, which, based on its composition, bonds with specific components within the blood (e.g., glucose), which is then taken up by brain tissue. The organization of radionuclides is such that they are unstable. As a result, once the radionucleotide decays within the system, it emits a stray positron that interacts with an electron. Due to this interaction, two photons are repelled in opposing directions. This repelling creates a small yet traceable amount of energy that can subsequently be measured. Once data are computed and analyzed, images can be rendered that demonstrate chemical utilization (e.g., glucose uptake) during specific tasks, which suggests activation, and subsequently the extent to which that region is involved in that function. Overall, utilization of glucose and oxygen, as well as increased blood flow, are indicative of the extent of activation. As a result, the greater the requirement of a brain region on a specific task, the higher the amount of glucose uptake within that region on PET should be. In contrast to CT and MRI, where structure is the focus, PET's focus is functional.

Given the technical aspects of PET and the results it yields, it has been primarily used as a research tool to expand the understanding of regional involvement in particular functions; however, clinically there remains utility. Specifically, in various neurological presentations, PET can identify areas of suppressed metabolic activity, thereby demonstrating the functional impact of these manifestations. Furthermore, in some cases where pathology is not clear, PET can help determine whether tissue is active or non-active, which may help determine the appropriateness of surgical intervention. Overall, not only does PET have a lot to offer as a research device, but as PET becomes less expensive and more available, we will likely see increased clinical utility.

ELECTROENCEPHALOGRAPHY

Similar to PET in that it reveals the underlying physiological actions of the brain, electroencephalography (EEG) is a commonly used technique in neuroscience research and clinical practice. Whereas PET investigates the metabolic activity of the brain, EEG investigates the electrical activity. This is based on the principle that during varying states of arousal, corresponding brain wave patterns demonstrating changes in polarity, shape, and frequency can be seen. Irregularities may speak to underlying pathology (Knight, 1985, 1997). For example, a patient with frontotemporal dementia may be expected to demonstrate relative slowing of electrical activity within these regions secondary to degeneration. In fact, slowing represents one of the two primary abnormalities seen on EEG, the other being the presence of epileptiform activity. Although there are possibilities in differentiation, the primary clinical utility of EEG is to assist in the diagnosis of seizure activity and disorders, sleep disorders, and level of coma or presence of brain impairment. As a result of its ability to plot electrical activity, EEG remains the primary tool in the diagnosis of epilepsy and assisting in determining the type and origin of the seizure activity. Whereas PET can demonstrate changes in activation based on cognitive tasks and region utilized, similar changes or at least alterations to the same degree cannot be seen on EEG (Knight, 1997).

FUNCTIONAL MAGNETIC RESONANCE IMAGING

Whereas traditional MRI looks at magnetically structured/organized hydrogen protons to determine density, and PET investigates underlying cerebral metabolism, functional magnetic resonance imaging (fMRI) incorporates both of these techniques. Functional magnetic resonance imaging focuses on wider metabolic factors in the context of a three-dimensional and spatially related origin. The technique works along similar principles as traditional MRI; however, methods of computation and calculations differ as a result of the understanding that hydrogen protons react to varying degrees based on the amount of uptake of specific metabolic factors, such as glucose and oxygen (Heiss, Thiel, Winhuisen, Mulberger, Kessler, & Herholz, 2003). It is referred to as functional because these changes can be viewed as they occur in relationship to brain activity (Cohen, Noll, & Schneider, 1993). This is achieved essentially in overlapping the functional/metabolic findings and structural renderings similar to those of the standard MRI, which yields a three-dimensional pattern of activation in relationship to task performance. Although this appears quite similar to PET, it differs in two key ways. First, PET is not as structurally defined as fMRI (Cohen et al., 1993). Secondly, fMRI does not require radiation exposure as do PET and CT (Blumenfeld, 2002).

Overall, the advancements of neuroimaging techniques have made the investigation of neuroanatomical integrity related to functionality that more refined. These techniques allow for more accurate diagnosis and are constantly providing new information regarding brain-behavior relationships. Recognition of their utility and scientific underpinnings makes incorporation and utilization of these tools in neuropsychological practice possible, particularly as they apply to neuropsychological rehabilitation. However, this only begins with an understanding of the defined neuroanatomical-neurocognitive correlates.

CLINICAL RECOMMENDATIONS FOR PROFESSIONAL PRACTICE

In regards to clinical neuropsychology, imaging techniques are relied upon to guide the refinement of knowledge of neuroanatomy as it relates to functionality. As noted by Damasio and Damasio (1989), neuroimaging involves not only the identification and characteristics of a lesion, but also how it relates to functional outcomes and how best to assist in recovery. Neuropsychologists are often given referrals to assist members of the medical practice team in differential diagnosis, determining functional capacity, and assisting with intervention and treatment planning. When working with medical disorders which result in visible brain lesions or anomalies, it is critically important for neuropsychologists to be aware of the research-based findings regarding the connections between lesion location and functional outcomes. For example, neuroimaging data are critical in work with patients who have experienced a traumatic brain injury with visible lesions. Being able to understand the connection between the results of the neuroimaging and functional presentation greatly facilitates the selection of test instruments depending upon the location of the infarct, which can greatly reduce testing times and improve the validity of assessment results. This section will review some key findings linking neuroimaging to clinical practice. It is important to note that this is merely a selection of some findings; there are untold numbers of research articles available on neuroimaging and neurobehavioral correlates. The interested reader is encouraged to try some medical and psychology search engines.

One of the basic tenets of clinical neurosciences is that the brain is divided into two separate hemispheres that, although similar in appearance, differ significantly in regards to neurofunctioning (e.g., Robichon, Levrier, Farnarier, & Habib, 2000; Xu et al., 2001). This is critical and basic information for individuals engaging in the practice of clinical neuropsychology. Indeed, cerebral lateralization of dysfunction is often one of the starting points of a neurobehavioral examination, and understanding the specialization of each hemisphere should be the starting point in the integration of neuroimaging with clinical practice. Table 4.1 provides a basic breakdown of some of the key functions of each hemisphere. It is important to note that this differential presentation of each hemisphere is not consistent for every individual. For example, language is lateralized to the left hemisphere for about 95% of right-handed individuals and for about 70% of left-handers (Springer & Deutsch, 1998). Thus, most individuals have similar lateralized abilities, but it is still critical to perform a test to determine laterality.

As can be seen in Table 4.1, language is primarily a left hemisphere function. Language assessment is a key component of neuropsychological assessment, whether conducted for differential diagnosis or for

Table 4.1

LATERALIZED COMPLEX COGNITIVE FUNCTIONS OF THE LEFT AND RIGHT HEMISPHERES

FUNCTION	REFERENCE
Right Hemisphere	
Processing Modes	
Simultaneous	Sperry (1974)
Holistic	Sperry (1974); Dimond & Beaumont (1974)
Visual/nonverbal	Sperry (1974); Savage & Thomas (1993)
Imagery	Seamon & Gazzaniga (1973)
Spatial reasoning	Sperry (1974); Poizner, Bellugi, & Klima (1990)
Nonverbal Functions	
Depth perception	Carmon & Bechtoldt (1969)
Melodic perception	Shankweiler (1966)
Tactile perception	Boll (1974); Coghill, Gilron, & Iadarola (2001)

(*Continued*)

Table 4.1

LATERALIZED COMPLEX COGNITIVE FUNCTIONS OF THE LEFT AND RIGHT HEMISPHERES (*Continued*)

FUNCTION		REFERENCE
	Nonverbal sound recognition	Milner (1962)
	Motor integration	Kimura (1961)
	Visual constructive performance	Parsons, Vega, & Burn (1969)
	Pattern recognition	Eccles (1973)
	Language Pragmatics	Berman, Mandelkern, Phan, & Zaidel (2003)
Memory and Learning		
	Nonverbal memory	Stark (1961)
	Face recognition	Milner (1967); Hecaen & Angelergues (1962)
Left Hemisphere		
Processing Modes		
	Sequential	Sperry, Gazzaniga, & Bogen (1969)
	Temporal	Mills (1977)
	Analytic	Morgan, McDonald, & McDonald (1971); Eccles (1973)
Verbal Functions		
	Speech	Blank, Scott, Murphy, Warburton, & Wise (2002)
	General language/Verbal skills	Friedman, Kenny, Wise, Wu, Stuve, Miller, et al. (1998); Gazzaniga (1970); Smith (1974)
	Calculation/Arithmetic	Reitan (1955); Eccles (1973); Gerstmann (1957)
	Abstract verbal thought	Gazzaniga & Sperry (1962)
	Writing (composition)	Sperry (1974); Hecaen & Marcie (1974)
	Complex motor functions	Dimond & Beaumont (1974)

(*Continued*)

Table 4.1

FUNCTION	REFERENCE
Body orientation	Gerstmann (1957)
Vigilance	Dimond & Beaumont (1974)
Learning and Memory	
Verbal paired associates	Dimond & Beaumont (1974)
Short-term verbal recall	Kimura (1961)
Abstract and concrete words	McFarland, McFarland, Bain, & Ashton (1978); Seamon & Gazzaniga (1973)
Verbal mediation/rehearsal	Dean (1983); Seamon & Gazzaniga (1973)
Learning complex motor function	Dimond & Beaumont (1974)

Sources: Much of this table was reproduced from Dean & Anderson (1997); Davis & Dean (2005).

treatment planning and rehabilitation. Language can be affected in a multitude of neurological disorders that require rehabilitation, such as cerebral vascular accident (CVA) or traumatic brain injury (TBI). Although it is tempting to conclude that language is solely a function of the left hemisphere, research has indicated the damage to the right hemisphere can also affect language functioning. For example, Berman, Mandelkern, Phan, and Zaidel (2003) used neuroimaging to determine that while the left hemisphere is specialized for the semantic and phonetic elements of spoken language, the right hemisphere is specialized for language pragmatics (social aspects of language). There are even gender differences in the localization of language; females may have more bilateral organization of language (Shaywitz, Shaywitz, Pugh, Constable, Skullarski, & Fulbright, 1995), which may make it easier for them to recover from conditions such as CVA or TBI.

As mentioned, there is not nearly enough space in a single chapter to discuss the functional neuroanatomy as revealed by neuroimaging for every condition neuropsychologists encounter. For example, neuroimaging is an essential component of work with patients with CVAs, since the location of the infract directs the neuropsychologist to select certain test instruments, change the nature of the neurobehavioral examination, and, in the absence of positive findings, give more credence to a somatoform disorder. However, to illustrate the utility of functional neuroimaging for research and clinical practice, a few findings from different disorders will be briefly discussed.

Autism is a much discussed disorder that is an excellent example of an area for which neuroimaging may hold a bright future to aid in differential diagnosis and treatment planning as more research is conducted. Autism is a very difficult disorder to diagnose due to its overlapping symptomology with other disorders (e.g., fragile X syndrome, Asperger's disorder) and differential presentation (e.g., intelligence ranging from mental retardation to average). What is particularly troubling is that early diagnosis for autism is critical, since early interventions are generally more effective (e.g., Bryson, Rogers, & Fombonne, 2003). Neuroimaging has suggested that multiple brain areas may be involved in the etiology of autism, including the amygdala, basal ganglia, hippocampus, planum temporale, and temporal lobes (Rojas, Smith, Benkers, Camou, Reite, & Rogers, 2004), although a definitive pattern has yet to emerge. An interesting finding regarding the ability of neuroimaging to assist in differential diagnosis in the future is pattern of differential brain growth, which is seen in children with autism. Children with autism seem to be born with normal brain volumes, but by ages 2 to 4, 90% have larger brain volumes than their same-age peers, and then there is a relative decrease in growth by age 12 (Acosta & Pearl, 2004). Since children with autism may demonstrate this different pattern of brain growth prior to the onset of observable clinical symptoms (Courchesne, Carper, & Akshoomoff, 2003), improvements in neuroimaging and our understanding of the neurological progression of autism may one day allow for an earlier and more accurate diagnosis.

A disorder in which neuroimaging can greatly assist in clinical practice is multiple sclerosis. Multiple sclerosis is an insidious progressive neurological disorder associated with the presence of plaques in the brain that are usually detected with MRI. Although the symptomology tends to focus on white matter degeneration, many patients with MS experience deficits in higher-order cortical processes, which can greatly affect a patient's ability to interact with his or her environment. Neuroimaging is particularly helpful in tracking the progression of MS since MRI is so adept at viewing the type of lesions associated with MS; increasing frequency of lesions serves as a marker for disease progression, which may not be immediately visible via clinical signs (Miller, Barkhof, Frank, Parker, & Thompson, 2002). Although neuroimaging is an essential component of diagnosis of MS, the disorder also highlights the necessity of neuropsychological involvement with the longitudinal progression of MS. Early MS can be quite challenging to correctly diagnose, since the initial complaints of most patients are not particularly pathognomic of MS and may be neurological and neuropsychological soft signs. The overinterpretation of signal changes on the MRI is the most common reason for misdiagnosis (Rolak & Fleming, 2007). Another complicating factor is the comorbidity of multiple neurological and psychiatric disorders that mimic conditions of MS (Rolak & Fleming, 2007). Since patients with MS have been found to experience depression and neurocognitive deficits (e.g., memory and attention) that can affect functional capacity, the current best practice of treatment is a combination of neuroimaging and neuropsychological assessment.

Perhaps the most important clinical recommendation for professional practice we can make is that neuropsychologists who plan to utilize neuroimaging in differential diagnosis and treatment planning should become familiar with functional neuroanatomy. If neuropsychologists do not incorporate this information into differential diagnosis and subsequent recommendations for treatment planning, they are likely to miss critical information, which will lead to poor patient outcomes. A classic example of this is the differential diagnosis of dementia. Although it is relatively easy to identify memory deficits via neuropsychological assessment, it is much more difficult to determine the etiology of the memory deficits. The importance of this process is highlighted by the increasing demand for empirically validated interventions. If the fields of rehabilitation and neuropsychology are to adhere to this mandate, the first step of the process is the accurate differentiation among similar clinical conditions. For example, in the elderly, dementia and depression have similar clinical presentations in regards to cognitive impairments, including memory deficits (American Psychiatric Association, 2001; La Rue, D'Elia, Clark, Spar, & Jarvik, 1986). Historically, depression and dementia have been considered separate entities, and the emphasis has been on differentiating one from the other (Rabins, 1989; Stoudemire, Hall, Gulley, & Morris, 1989; Teri & Wagner, 1992). This differentiation has long been a concentration of researchers (e.g., Christensen, Griffiths, Mackinnon, & Jacomb, 1997; Murray, 2002; Pitt & Yousef, 1997). Although recent research has demonstrated improvements in this differentiation through neuropsychological assessment alone (e.g., Noggle, 2006), difficulty remains. In some instances, available data from neuroimaging can assist the clinical neuropsychologist in this differentiation (Helmith, 2002). For example, volumetric MRI has demonstrated its utility in tracking the progression of some neurodegenerative diseases by differentiating the normal cortical atrophy of aging from cortical atrophy in degenerative dementias (e.g., Mueller, Schuff, & Weiner, 2006).

Distinguishing between types of dementia as well as assessing severity can also be facilitated by neuroimaging. For example, vascular dementia and Alzheimer's disease have similar clinical presentations upon examination and are frequently comorbid in the same patient. The differential diagnosis is complicated by the fact that vascular dementia is not a single clinical condition but can arise from a stroke in a large artery, subcortical vascular problems, or other vascular lesions (Kwak, 2004). However, vascular dementia and Alzheimer's disease can have quite different clinical outcomes and emphases of treatment. Some of the medications used for treatment of Alzheimer's disease may be helpful in patients with comorbid vascular dementia, but the presence of vascular lesions can reduce the efficacy of the medication (Mueller et al., 2006). Primary prevention of vascular dementia aims at reducing risk factors to cardiovascular health such as arterial hypertension, lipid abnormalities, coronary artery disease, diabetes, and smoking, whereas secondary prevention targets stroke management and prevention (Erkinjuntti, Roman, Gauthier, Feldman, & Rockwood, 2004). Although these concerns are important in Alzheimer's disease as well, this highlights the importance of differential diagnosis of conditions in planning for treatment and rehabilitation.

The future of functional neuroimaging applications to rehabilitation settings is yet to be determined. However, early work by Crosson and others is already showing value in demonstrating shifts in function from damaged areas to other locations of the brain—including lateralization changes (Crosson et al., 2001, 2005). Additionally, his group has begun to explore using this knowledge to guide rehabilitation treatment efforts (Crosson et al., 2007). Such information may prove to be instrumental in guiding rehabilitative efforts, and this work has the potential to push functional neuroimaging to the forefront of evaluation and treatment of neurologic deficits in rehabilitation environments.

In summary, neuroimaging is an essential part of clinical neuropsychology practice for both differential diagnosis and treatment planning and intervention. Expanding technology in this area is making it possible to utilize imaging techniques to better understand recovery from acquired neurologic injuries and to potentially guide rehabilitative interventions. It is strongly recommended that the interested reader and/or beginning neuropsychologist/rehabilitation psychologist become familiar with functional neuroanatomy, which will greatly improve the integration of structure and function in clinical practice. It is exciting to contemplate what the future of neuroimaging holds in regards to the clinical practice of neuropsychology and rehabilitation. Neuroimaging and functional neuroimaging have greatly reduced the importance of the neuropsychologist in localizing impairments, and no doubt future changes await our field as medical technology continues to grow. However, knowledgeable clinicians will be prepared to utilize this new information for the betterment of patient care and ultimately patient recovery.

As a point of caution, readers should keep in mind that the utility of ever-advancing neuroimaging techniques should not decrease the need for clinical acumen and interpretation of neuropsychological data. In other words, structure does not necessarily supersede function. Experienced neuropsychologists are well aware that illnesses and injuries (even focal lesions) do not occur in isolation and the residual deficits can be quite varied between and within patients. As such, interpretation of test data should continue to play a critical role in differential diagnosis and treatment planning. It is the clinician's ability to mediate and merge all available information in the manner that best suits the needs of the patient and ultimately assists in guiding rehabilitative and recovery efforts.

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PART II

Neuropsychological Assessment for Treatment Planning and Intervention

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5 Understanding and Using the Halstead-Reitan Neuropsychological Test Batteries With Children and Adults

STEPHANIE R. SINCO, RIK CARL D'AMATO, AND ANDREW S. DAVIS

The Halstead-Reitan Neuropsychological Test Battery (HRNB) is an assessment tool developed by Halstead and his doctoral student, Reitan. The HRNB is a fixed set of tests used to evaluate complex neuropsychological abilities in relation to brain functions in individuals age 15 and older. The HRNB has been adapted for children ages 5 to 14, leading to the development of two different batteries, the Halstead-Reitan Neuropsychological Test Battery for Older Children and the Reitan-Indiana Test Battery for Children. The HRNB is a collection of separate neuropsychological tests that are used together, as opposed to most batteries, which are composed of a series of standardized subtests (Davis, Johnson, & D'Amato, 2005).

INTRODUCTION AND HISTORY

With the HRNB, Halstead (1947) sought to evaluate "biological intelligence," defined as the adaptive capacity of the brain dependent upon

This chapter is based in part on the authors' prior work, from Davis, A. S., Johnson, J. A., & D'Amato, R. C. (2005). Evaluating and using long-standing school neuropsychological batteries: The Halstead-Reitan and the Luria-Nebraska Neuropsychological Batteries. In R. C. D'Amato, E. Fletcher-Janzen, & C. R. Reynolds (Eds.), *Handbook of school neuropsychology* (pp. 236–263). Hoboken, NJ: Wiley.

its organic integrity. The HRNB is typically used to evaluate individuals with suspected cerebral dysfunction and examines a variety of brain functions, including visual and auditory processing, tactile discrimination, spatial perception, motor output, attention, concentration, memory, and problem-solving skills (Reitan & Wolfson, 1996). Among the fixed neuropsychological batteries available, the HRNB has been the most frequently used and most widely studied and validated (Horton, 1997). The HRNB can provide information regarding cause, deficit localization, lateralization, and impairment severity, as well as strengths and weaknesses across various neuropsychological functions. Although the HRNB is a comprehensive neuropsychological instrument, over the last few decades few modifications have been made to the test.

Halstead (1947) laid the foundation for the HRNB when he noted that current theories of intelligence failed to account for the organic basis of intelligence. Halstead wrote that there was a need to measure and identify intelligence in relation to brain functions. His clinical observations led him to develop a biologically based theory of intelligence based on four factors: (1) central integrative field, (2) abstraction, (3) power, and (4) direction. The central integrative field was a broad factor representing the general background and experience of the individual. Abstraction represented the basic intellectual factor, including the ability to reason and analyze, while power represented the energy source behind the production of intelligent behavior (Reitan & Wolfson, 1993). The individual's receptive and expressive functions were represented by the directional factor (Reitan & Wolfson, 1993). Although this four-factor model of intelligence has not been comprehensively evaluated, the HRNB was derived from this model (Reitan & Wolfson, 1993).

Halstead (1947) indicated that individuals with cerebral lesions could display a range of deficits, including motor problems, sensory-perceptual problems, and general or specific confusion about events and activities. He did not believe that a single test was capable of measuring and assessing this wide range of deficits (Halstead, 1947; Reitan & Wolfson, 1993). Halstead addressed this problem by creating a series of 10 tests that were based on his theory of intelligence. In creating these tests, he experimented with psychological procedures that differed from traditional evaluations in that they required examinees not only to solve problems but also to observe the nature of a problem, analyze the problem, and then define the problem (Reitan & Wolfson, 1993). Halstead's testing procedures and tests were offered to the psychological community in his 1947 text, *Brain and Intelligence: A Quantitative Study of the Frontal Lobes*.

In the 1950s, Reitan conducted numerous studies on the HRNB in order to identify the tests that were able to discriminate between brain-damaged and healthy individuals. Seven of Halstead's tests form the core of the HRNB. Through his research, Reitan solidified the clinical utility of neuropsychological tests in identifying brain dysfunction. Research during that time revealed that standard intelligence tests in isolation were not able to detect cerebral impairment, which showed the need for neuropsychological batteries like the HRNB (Hebb, 1939, 1941). More recent research has indicated that only about 10% of traditional intelligence tests overlap with neuropsychological batteries, which again shows the need to consider neuropsychological measures in planning for intervention (D'Amato, Dean, & Rhodes, 1998; D'Amato, Gray, & Dean, 1988; Sattler & D'Amato, 2002). To refine the HRNB, Reitan added tests such as the Reitan-Indiana Aphasia Screening Test, the Reitan-Klove Lateral Dominance Examination, the Reitan-Klove Sensory-Perceptual Examination, the Grip Strength Test, and the Trail Making Test (Horton, 1997). When the HRNB is administered, the age-appropriate Wechsler intelligence scale (Wechsler, 2003) and a comprehensive measure of personality such as the Minnesota Multiphasic Personality Inventory–II, are typically administered and are viewed as part of this neuropsychological battery (Reitan & Wolfson, 1993, 1996). Reitan and Wolfson argue that the assessment of behavior, personality, and affect is a crucial component of any neuropsychological evaluation.

When the HRNB was adapted for use with children and adolescents, two different batteries were developed: the Halstead-Reitan Neuropsychological Test Battery for Older Children (HRNB-C; Reitan & Davison, 1974), and the Reitan-Indiana Test Battery for Children (RITB-C; Reitan, 1969). The HRNB-C is designed for examinees ages 9 to 14 years old, and the RITB-C is designed for examinees ages 5 to 8 years old. Both children's versions were based on the subtests from the HRNB, but with altered instructions, and in some cases, different subtests have been added or deleted. The HRNB-C is similar to the adult version except that there are shortened versions of the Category Test, the Trail Making Test, the Tactual Performance Test, and the Speech Sounds Perception Test. Because of significant differences in neurodevelopment between young children and adults, the RITB-C required greater modification than the HRNB-C.

The proper use of the Halstead-Reitan requires that professionals be trained in neuropsychological test administration, scoring, and interpretation. Training for the HRNB should include multiple observations of a skilled examiner and multiple practice sessions with volunteers

(Groth-Marnat, 2000). Most authors have suggested that professionals who interpret the HRNB have graduate training and postgraduate training in neuropsychology (Davis et al., 2005; Reitan & Wolfson, 1992). In order to practice as a neuropsychologist, the National Academy of Neuropsychology recommends a doctoral degree in psychology with a focus in clinical neuropsychology from an accredited university. The National Academy of Neuropsychology also suggests that neuropsychologists complete an internship in a clinically relevant area of professional psychology. In addition, 2 years of experience and specialized training supervised by a clinical neuropsychologist are recommended, with at least 1 of the 2 years of training at the postdoctoral level in the study and practice of clinical neuropsychology (National Academy of Neuropsychology, 2001). Ethical guidelines regarding the administration of the HRNB require the examiner to be qualified in test administration and interpretation of neuropsychological instruments (Reynolds & Gutkin, 1999).

Often test manuals include a section on user qualifications that addresses who should be using the test, what training is required prior to administration and interpretation, and steps for safeguarding the testing materials. The HRNB, HRNB-C, and RITB-C do not have a comprehensive section that discusses user qualifications. Ethically, it is clear that only psychologists trained in neuropsychological test administration and interpretation, neurodevelopment, and neuropsychological assessment for intervention should use these instruments.

Examiners have encountered a number of difficulties when using the various HRNB batteries. The HRNB takes approximately 2 to 4 hours to administer and requires a highly trained examiner. Because of the lengthy amount of time necessary to complete the examination, patients may become frustrated and/or fatigued during testing (Horton, 1997). Interpreting the HRNB is also a complex process, which requires advanced training and expertise (Horton, 1997). The HRNB test is also expensive and contains various materials that are difficult to transport, such as the Category Test and the Tactual Performance Test. Another problem that researchers have pointed out is that the HRNB does not include comprehensive measures that assess functions such as memory, academic achievement, and visual-spatial skills (Goldstein & Incagnoli, 1997; Sattler & D'Amato, 2002). In order to assess these functions, supplemental tests, which require additional time and expense, may be necessary. Another difficulty with the HRNB is that research that examines the ecological validity of the measure is limited (Horton, 1997). Determining exactly what each test is measuring and linking these tests to functional activities (everyday life) has been problematic. In general, substantial evidence linking assessment findings to evidence-based treatment planning is not currently available (Traughber & D'Amato, 2005).

FIXED VERSUS FLEXIBLE BATTERY APPROACH

The HRNB is considered a *fixed* battery. In a fixed battery approach, the entire test is given in a standardized manner regardless of the presenting referral. This approach allows for a comprehensive wide-ranging assessment and standardized administration; however, a primary difficulty with this approach relates to its cost-effectiveness. The fixed battery approach requires practitioners to evaluate all areas, even areas that appear intact, which results in the collection of what some may view as excessive data (Goldstein & Incagnoli, 1997; Rhodes, D'Amato, & Rothlisberg, in press). The comprehensive Halstead-Reitan batteries cover important neurodevelopmental areas, the examination of which can lead to the development of appropriate neuropsychological interventions. The approach is extremely valuable when neuropsychological evaluation data is questioned, such as in court proceedings. This approach is also useful for beginning practitioners who may not feel comfortable selecting specific subtests and rejecting others as part of the evaluation.

The alternative to administering a fixed battery is the *flexible* battery approach, in which the reason for referral is the primary focus of the examination (Kaufman, 1990). In the flexible battery approach, tests are selected based on the needs of the examinee in an effort to address the unique referral question (Goldstein & Incagnoli, 1997). With a flexible battery approach, subtests from newer measures such as the NEPSY-II can be incorporated, and older tests eliminated, whenever adjustments are needed according to the findings of a case. For example, the HRNB Category Test and the Tactile Performance Test could be administered in tandem with specific domains of the NEPSY-II. A flexible battery approach can be especially helpful when neuropsychological processes are evaluated in an effort to offer classroom teachers instructionally relevant information (Witsken, Stoeckel, & D'Amato, in press). Additionally, flexibility in administration can lead to the modification and individualization of instructions during the assessment (Rohling, Williamson, Miller, & Adams, 2003). For instance, a child may be unable to verbally respond to an item but can point to a template. If this does not violate the intent of the measure, such a modification may be acceptable (Rhodes et al., in press). Some authors have suggested combining the fixed and flexible approaches by using flexible procedures related to the referral question to develop a 60- to 90-minute battery (Goldstein & Incagnoli, 1997).

PSYCHOMETRIC PROPERTIES

Reitan's (1964) validation study demonstrated the ability to differentiate individuals with brain damage from normal individuals (Groth-Marnat, 2000). Initially, clinical validity was documented in a study by Reitan in which 88 out of the 112 patients were correctly classified by blinded experimenters based on their HRNB scores. In another study, test-retest reliability was found to range from .87 on trail making to .59 on Tactual Performance Test localization (Klonoff, Fibiger, & Hutton, 1970). A number of authors have offered a detailed evaluation of the HRNB, as well as an analysis of recent research (Dean, 1985; Golden & Golden, 2003; Kennedy, Clement, & Curtiss, 2003; Lezak, Howieson, Loring, Hannay, & Fischer, 2004; Reitan & Wolfson, 2001).

Although the HRNB is a widely used neuropsychological instrument, the battery was never standardized on a representative stratified sample of healthy individuals (Lezak et al., 2004). Another significant limitation of the HRNB is that the manual does not provide important reliability and validity information, but instead is focused on the reason for each subtest's inclusion in the battery (Dean, 1985; Reynolds & Gutkin, 1999). Universal standard scores for the HRNB drawn from a large normative sample are still not available, although there are several groups of independent normative scores available for interpretation. It is difficult to compare results of individual tests due to the lack of standard score transformation data (Dean, 1985). However, despite these limitations, the HRNB remains one of the most researched and validated neuropsychological tests in the world (Horton, 1997).

EVALUATING TESTS FROM THE HALSTEAD-REITAN NEUROPSYCHOLOGICAL BATTERY

Individual tests comprising the Halstead-Reitan Neuropsychological Test Battery are described in this section. Table 5.1 presents the various subtests for each version of the HRNB.

Table 5.1

TESTS OF THE THREE VERSIONS OF THE HALSTEAD-REITAN NEUROPSYCHOLOGICAL TEST BATTERIES

HRNB	HRNB-C	RITB-C
Reitan-Indiana Aphasia Screening Test	Reitan-Indiana Aphasia Screening Test	Reitan-Indiana Aphasia Screening Test
Finger Tapping Test	Finger Tapping Test	Finger Tapping Test
Grip Strength	Grip Strength	Grip Strength
Sensory-Perceptual Examination	Sensory-Perceptual Examination	Sensory-Perceptual Examination
Tactile Form Recognition	Tactile Form Recognition	Marching Test
Rhythm Test	Rhythm Test	Color Form Test
Speech Sounds Perception Test	Speech Sounds Perception Test	Progressive Figure Test
Trail Making Test for Adults	Trail Making Test	Individual Performance Test
Tactual Performance Test	Tactual Performance Test	Tactual Performance Test
Category Test	Category Test	Category Test
		Target Test

Finger Tapping Test

The Finger Tapping Test, also known as the Finger Oscillation Test, is a measure of fine motor speed and coordination (Strauss, Sherman, & Spreen, 2006). On this test, the examinee is asked to tap his or her dominant index finger as rapidly as possible on a small lever or key attached to a counter. The finger tapping continues for 10 seconds across five trials and is then repeated with the nondominant index finger. The five trials for each hand are averaged to assess finger-tapping speed. Decreased performance in one hand generally indicates a contralateral hemispheric weakness. In general, dominant hand performance is expected to be about 10% better than that for the nondominant hand (Horton, 1997). The Finger Tapping Test is often thought to be one of the tests in the battery that is most sensitive and most effective for determining fine motor problems, brain impairment, and laterality of brain lesions (Reitan & Wolfson, 1996; Russell, Neuringer, & Goldstein, 1970). In administering this test, examiners must be cognizant of fatigue, which can greatly affect performance. A 1- to 2-minute rest period after the third trial may be appropriate in some cases to prevent fatigue (Strauss et al., 2006). It is also critical that the examinee only use his or her index finger, without moving the wrist, when completing this test. This can be difficult for individuals with poor motor control (Strauss et al., 2006).

Grip Strength Test

In order to assess grip strength, examinees stand with their arms at their sides and squeeze a hand dynometer as hard as they can with each hand across two trials. The score is the mean of the two trials. This test only requires a few minutes to administer and measures upper-extremity gross motor strength. Differences in grip strength have been reported across ethnicities and genders. For example, research indicates that African American women have better grip strength than White women (Strauss et al., 2006). The Grip Strength Test is sensitive to lateralized impairment in the hemisphere contralateral to a weakness observed in either hand. The test is thought to be sensitive to impairment or lesions in the motor strip and has been found to be sensitive to examinees with traumatic brain injury as well as sensorimotor difficulties and degenerative disease with motor components (Haaland, Temkin, Randahl, & Dikmen, 1994). Although this test is sensitive to a variety of disturbances, it is critical that judgments about impairment be made with support from other abnormal test results (Strauss et al., 2006).

Seashore Rhythm Test

The Seashore Rhythm Test was adapted from the Seashore Tests of Musical Ability, and its nonverbal attention format is unique compared to other assessment measures in psychology (Jarvis & Barth, 1994; Selz, 1981). This nonverbal measure requires attention and working memory skills. The Seashore Rhythm Test requires the examinee to listen to pairs of rhythmic beats and determine if the beats are the same or different.

The examinee is presented with 30 trials, and the score is the number of correctly identified items. After prolonged use, the tape may become scratched, obscuring the beats, which may threaten the validity and reliability of this test. Many neuropsychologists initially assumed that this test served as a measure of right hemispheric functioning, as nonverbal rhythmic tasks are typically thought to be housed within the right hemisphere (Davis & Dean, 2005). Yet research has demonstrated that groups with left or right hemispheric damage are equally impaired on this measure (Reitan & Wolfson, 1992). Certainly, this task serves as a measure of nonverbal auditory discrimination, auditory perception, and auditory attention (Lezak, 1995; Selz, 1981). Poor performance on this task may indicate auditory discrimination challenges or a severe impairment of attention or concentration (Jarvis & Barth, 1994).

Speech Sounds Perception Test

The Speech Sounds Perception Test measures auditory attention and perception, auditory-visual integration, and the ability to discriminate between similar verbal sounds (D'Amato, 1990; Lezak et al., 2004). It is one of the more unique measures from the battery. The Speech Sounds Perception Test is often contrasted with the Seashore Rhythm Test, which uses nonverbal cues. In this test, the examinee listens to a tape of 60 spoken nonsense words containing the *ee* sound and underlines the correct word on the response sheet. The number of errors makes up the score. Both the Seashore Rhythm Test and Speech Sounds Perception Test do not require English language proficiency and may provide helpful information for individuals who do not speak English. Research has indicated that individuals with left hemispheric impairment tend to perform poorly on this task due to the verbal comprehension component (Reitan & Wolfson, 1992, 1993, 1996). Overall, the Speech Sounds Perception Test has proved to be extremely helpful in psychoeducational diagnosis and instructional activities in classrooms (Witsken et al., in press).

Trail Making Test

The Trail Making Test is second only to the Category Test on the HRNB as a general indicator of neuropsychological impairment (Jarvis & Barth, 1994; Reitan & Wolfson, 1993, 2001; Selz, 1981). The Trail Making Test is a paper-and-pencil test that consists of two tasks: Trail Making A and

Trail Making B. Both tests examine visual attention, visual perception, inhibition, and cognitive processing speed (D'Amato, 1990; Dean, 1985; Groth-Marnat, 2000). Trail Making A requires that the examinee draw a line between 15 numbered circles in a sequential manner as quickly as possible. Examinees are quickly redirected upon making errors, and the time it takes to complete the task is recorded. Trail Making B consists of 8 sequentially numbered circles and 7 alphabetically lettered circles. The examinee is asked to draw a line from circle 1 to circle A, circle A to circle 2, circle 2 to circle B, and so on. The Trail Making Test is seen as one of the best measures of global cerebral functioning due to its focus on symbolic recognition, which is a left hemispheric task, while the visual scanning component is more of a right hemispheric function (Reitan & Wolfson, 1985, 1992, 2001). Difficulties in standardization arise due to its imprecise scoring. For example, the amount of time that passes before the examiner points out errors and the amount of time it takes the examinee to make corrections can vary greatly (Strauss et al., 2006).

Tactual Performance Test

The Tactual Performance Test examines tactile discrimination, spatial awareness, spatial memory, and motor functions. In this unique measure, the examinee is blindfolded and asked to place 10 differently shaped blocks into the appropriate places on a form board, which is situated on a table in front of the examinee. There are three trials: dominant hand, nondominant hand, and both hands. The number of correctly placed blocks and the time are recorded for each trial. After these tasks are completed, the form board and blindfold are removed. The examinee is then asked to draw the form board from memory, and the number of correctly reproduced shapes is recorded. The Tactual Performance Test requires the transfer of information across hemispheres and estimates the general efficiency of the brain (Reitan & Wolfson, 1992, 2001). The differential performance across hands is examined in order to assess lateralization of cerebral damage (Horton, 1997). The spatial memory and motor function components of this measure may relate to learning and consequently can be helpful in treatment planning.

Category Test

The Category Test requires the examinee to develop general concepts from feedback that is given on specific stimuli. In this test, the examinee is presented with a pattern of geometric designs on a screen and instructed to choose which key numbered 1 through 4 corresponds to the designs. Correct responses are indicated by a bell and incorrect responses are indicated by a buzzer. Immediate feedback allows the examinee to develop hypotheses regarding the complex problems and modulate future responding. The Category Test is made up of a large projection box that is not portable and slides that can get stuck in the machine. This test is the least user friendly and can threaten the standardization of the HRNB due to its difficult administration and complex equipment. However, this measure is unique in the field of neuropsychology and provides immediate feedback to the examinee indicating if he or she has selected the correct item (D'Amato, 1990; Dean, 1985). More portable book and computerized versions, which are receiving increasing attention by researchers, are now available (Strauss et al., 2006). Examinees with cerebral impairment can take excessive time (up to 2 hours) in completing this test; thus shortened forms have been created (Strauss et al., 2006). The Category Test is considered a classic measure of executive functioning. It measures concept formation, memory, hypothesis testing, new learning, and abstract reasoning (Gontkovsky & Souheaver, 2002; Lezak et al., 2004; Reitan & Wolfson, 1992, 2001; Selz, 1981). In general, this test allows the examinee to formulate and test hypotheses, receive immediate performance feedback, and modify hypotheses based on that feedback (Reitan & Wolfson, 1992). There are no time limits, and the score is the total number of errors across trials. The Category Test is believed to be the most sensitive Halstead-Reitan indicator of cerebral dysfunction (Horton, 1997). It also seems to be the most novel measure in the battery, and one that is helpful in rehabilitation planning and explaining the examinee's ability to learn new information (Dean, 1985).

Reitan-Klove Lateral Dominance Examination

This test is used to determine the examinee's left or right preference and dominance across the hands and feet. This measure is dated and seems to be rarely used in current clinical practice (Jarvis & Barth, 1994; Lezak et al., 2004). This test helps interpret other tests that examine bilateral performance, such as the Tactual Performance Test and the Finger Tapping Test. The examinee is asked to complete various tasks, such as pretending to throw and kick a ball, hammer a nail, and use an eraser. Reitan and Wolfson (1992) have recommended that regardless of which hand the child uses to perform these tasks, the hand with which the child writes his or her name should be the hand regarded as the dominant hand for performance on the battery.

Reitan-Indiana Aphasia Screening Test

This subtest is a modification of the Halstead-Wepman Aphasia Screening Test (Halstead & Wepman, 1949). This test assesses a wide range of gross language-related deficits, including difficulty in reading, writing, spelling, arithmetic, naming, and repeating words and phrases as well as right/left confusion (Horton, 1997). The examinee is asked to name objects, understand spoken language, identify body parts, copy simple geometric shapes, identify numbers and letters, produce spoken language, use simple mathematical skills, and discriminate between left and right. The Reitan-Indiana Aphasia Screening Test is not a comprehensive test of language ability, but a screening test used to elicit responses that are indicative of pathognomic signs of brain impairment or indications that can greatly facilitate a diagnosis. This measure has proved to be helpful in understanding basic academic abilities and also can assist in intervention planning (Reitan & Wolfson, 1992, 2001). With children, especially those suspected of academic impairment, special care must be taken to ensure that the examinee possesses the pre-academic and academic skills necessary to complete these tasks (Reitan & Wolfson, 1992, 2001).

Different approaches to scoring the Reitan-Indiana Aphasia Screening Test have been offered. Some examiners prefer to use the pass-fail model by totaling the number of errors. Another approach is to look at each task independently and gauge failures as a suspected deficit in the domain being tested. For example, difficulty in copying geometric shapes may be indicative of constructional dyspraxia (Reitan & Wolfson, 1993). This approach can lead to a high number of false positives, which is why it is important to remember to use these tasks as screening devices that may suggest the existence of a possible impairment. It is important to note that this screening measure may not be sensitive enough to identify all types of language difficulties. If pathognomic signs are present, a more thorough examination may be indicated.

Reitan-Klove Sensory-Perceptual Examination

The Reitan-Klove Sensory-Perceptual Examination investigates auditory, tactile, and visual sensory abilities, as well as how accurately examinees can perceive unilateral and bilateral sensory stimulation. Examinees are required to identify shapes without visual stimuli, identify the location of unilateral and bilateral sensory stimulation, and demonstrate their visual and auditory acuity. The auditory, kinesthetic, and visual sensory modalities are tested independently of one another (Lezak et al., 2004). Relative hemispheric function can be evaluated by comparisons of performance across each side of the body (Horton, 1997). Furthermore, examinees with lateralized lesions, or traumatic disruptions of brain tissue, can often identify stimulation when it is limited to one side of the body but may fail to recognize stimulation that occurs simultaneously on both sides of the body (Reitan & Wolfson, 1992).

INTERPRETING HRNB SCORES AND COMPOSITES

Reitan recognized the importance of using multiple methods of inference when making diagnostic decisions (D'Amato, Crepeau-Hobson, Huang, & Geil, 2005; Horton, 1997). Reitan and Wolfson (1992) provide a guide for clinical interpretation of the HRNB that involves the use of a General Neuropsychological Deficit Scale (GNDS). The GNDS can be considered an overall gauge of the examinee's neuropsychological functioning that uses cutoff scores as a guide to compare test scores to the scores of individuals with brain damage. The GNDS is comprised of 42 variables from the HRNB and is considered an accurate and efficient summary measure (Rohling, Williamson, Miller, & Adams, 2003). Reitan and Wolfson (1999) have reported that the GNDS seems sensitive to mild brain injury. In addition, Reitan and Wolfson have suggested interpreting neuropsychological data four different ways, advocating for consideration of the (1) level of performance, (2) pattern of performance, (3) pathognomonic signs, and (4) right-left differences (Reitan & Wolfson, 1993). Level of performance is an inter-individual comparison in which the examinee is compared to scores from individuals without brain impairment. Patterns of performance is an intra-individual comparison in which the examinee's scores are examined and compared to one another. Pathognomonic signs explore simple tasks that are often compromised in individuals with cerebral impairment. These tasks should be normal in individuals with no brain impairment. Research has shown that the pathognomonic signs method can be problematic because of a lack of sensitivity and thus a tendency toward underidentification of individuals with cerebral impairment (Horton, 1997). However, when any pathognomonic sign is present, this information can be helpful (Horton, 1997). Finally, right-left differences allow practitioners to compare performance from the two sides of the body to each other.

Reitan and Wolfson (1993, 2001) have explained in detail how subtests should be scored using a range of 0–3, where 0 indicates normal performance, and scores of 2 and 3 signal impaired performance. Some deficits receive higher scores because they are more indicative of brain impairment (Reitan & Wolfson, 1993). The overall GNDS score generates the following qualitative labels: normal range (0–25), mild impairment (26–40), moderate impairment (41–67), and severe impairment (68 or more). Research has indicted that the GNDS can accurately discriminate between controls and subjects with brain damage (Reitan & Wolfson, 1993).

The GNDS allows neuropsychologists to consider an examinee's performance on the HRNB from a level of performance approach, right-left comparisons, and the consideration of particular deficits. Reitan and Wolfson (1993) have also recommended that the examinee's GNDS scores be compared to scores of individuals with brain damage for the following domains: motor functions, sensory-perceptual functions, attention and concentration, immediate memory and recapitulation, visual-spatial skills, abstraction and reasoning, and dysphasia. As a final step, it is recommended that the data obtained from the GNDS scores be used as a framework from which to view the results of the other tests, namely, measures of cognitive ability, academic achievement, and personality (Reitan & Wolfson, 1993). For example, when comparing the GNDS and cognitive scores, if the cognitive scores suggest typical performance and the GNDS is in the impaired range, it is possible that the individual is experiencing an underlying neuropsychological deficit (Reitan & Wolfson, 1993). Other methods have been suggested in interpretation of the HRNB but have not shown the ability to identify cerebral impairment (Reitan & Wolfson, 2005; Yantz, Gavett, Lynch, & McCaffery, 2006). Although the GNDS and the other methods advocated for interpretation seem to be excellent general indicators, they have not shown to be particularly sensitive in localizing cerebral damage (Reitan & Wolfson, 1993). Ultimately, the ability to draw inferences regarding the type of lesion or disorder, and if it is progressive or static in nature, requires knowledge across various domains of neuropsychology, neurology, and neuroanatomy (D'Amato, Fletcher-Janzen, & Reynolds, 2005; Reitan & Wolfson, 1993).

Another summary index, the Halstead Impairment Index, is comprised of the tests that are most sensitive to cerebral damage, providing an indication of the patient's overall impairment. The scores on the Halstead Impairment Index range from 0.0 (no brain impairment) to 1.0 (severe brain impairment). This score gives an indication of possible cerebral damage but does not provide in-depth information regarding neuropsychological strengths and weaknesses or rehabilitation needs. Psychologists accustomed to interpreting tests that produce standard scores derived from subtests, as well as composite index scores, may be troubled by the lack of standardization with tests from the HRNB. Dean (1985) reported that the manual for the HRNB lacks the basic psychometric information needed for interpretation, and that interpretation is more dependent on clinical judgment than on psychometric fidelity. This lack of psychometric sophistication, combined with administration difficulties, limits the utility of all the Halstead batteries, especially since newer neuropsychological test batteries that are psychometrically sound have emerged (e.g., see the NEPSY-II). Indeed, some of the newer batteries (i.e., the Dean-Woodcock) feature classic neuropsychological and neurological tests that are very similar to the Halstead tests but include clear interpretation guidelines (D'Amato et al., 2005).

TREATMENT PLANNING IN NEUROPSYCHOLOGICAL REHABILITATION

In treatment planning, comprehensive rehabilitation has been shown to be the most important part of the recovery process (Reitan & Wolfson, 1993). Returning the individual to the highest level of functioning possible is often the goal of neuropsychological services (Goldstein & Incagnoli, 1997). In rehabilitation, if lost functions cannot be restored, the objective is to teach compensatory strategies in these problem areas (Semrud-Clikeman, 2001). The process of neuropsychological assessment involves interviews, observations, review of previous data, administration of psychological and neuropsychological measures, scoring and analysis of data, interpretation, and the development of treatment recommendations. Evaluating treatment outcomes is the last of these critical steps. In order to begin treatment planning, it is important to understand the examinee's history, behaviors, lost functions, and strengths and weaknesses across cognitive, social, emotional, and neuropsychological areas. When interpreting HRNB scores, the examiner can uncover the individual's strong and weak areas and then determine how these areas relate to everyday functioning (Goldstein & Incagnoli, 1997). For example, if an individual appears to be experiencing memory challenges, modifications such as wristwatch alarms, appointment books, tape recorders, and visual prompts may be helpful in compensating for the overall memory impairment (Groth-Marnat, 2000). In another example, if an individual performs poorly on the Category Test, this may indicate a challenge in learning new concepts or solving novel problems. For such individuals, breaking directions into small steps, continuously practicing the new skill, and using coaching and reinforcement may be beneficial (Groth-Marnat, 2000). Unfortunately, most rehabilitation hospitals and centers have limited rehabilitation outcome data. A lack of data makes it difficult to develop evidence-based interventions in neuropsychological rehabilitation (Traughber & D'Amato, 2005).

Reintegrating into educational or employment settings can be difficult for individuals who have experienced cerebral impairment. Individuals may have lost the functions needed to perform successfully if returning to work or school. Gradual reintegration seems to be the key to promoting successful reentry (Lezak et al., 2004). The HRNB can provide information for determining a patient's level of premorbid functioning and overall impairment. Specific brain areas or neuropsychological domains that have been compromised in the patient can be identified. Differences between abilities in the right and left hemispheres can be discovered, patient strengths and needs can be revealed, and patient processing related to environmental demands can be identified. Other important areas to consider in making treatment recommendations include the individual's energy level, frustration tolerance, emotional liability, impulse control, initiative, family support, ability to learn, and the amount of environmental structure and demands (Goldstein & Incagnoli, 1997). While some of this data can be gleaned from the HRNB, specialized life-skill activities will also need to be evaluated and taught. In the evaluation of children, data related to instructional activities in schools will need to be assembled, analyzed, and interpreted, with a focus on classroom learning and the ability to understand the unique processing needs of the student (Witsken et al., in press).

Individuals vary in how they are affected by cerebral impairment; however, individuals with brain damage often have difficulty in the areas of executive functions, memory, processing speed, and attention

(Goldstein & Incagnoli, 1997). If the individual has difficulty with divided attention, modifications to the environment that reduce distractions could be beneficial. D'Amato and Rothisberg (1996) developed the Structure, Organization, and Strategies model for interventions targeting children who have experienced a traumatic brain injury. In short, this model guides professionals in designing interventions that promote structure and organization in the environment and teach compensatory strategies or remedial activities to individuals with cerebral impairment. It is also critical to offer counseling to individuals who have suffered brain impairment. Often, individuals remember clearly how they were before an accident and have difficulty coping with their lost abilities. It is essential to keep in mind that individuals with cerebral impairments present with challenges that vary considerably across environments. Adequate rehabilitation can only be achieved after a comprehensive assessment is completed by a professional trained in neuropsychology. Once the needs of the patient are identified and understood, clear, concise, and relevant interventions can be offered.

SUMMARY

The HRNB remains one of the most widely used neuropsychological test batteries consisting of well-validated neuropsychological tasks that have proved to be good indicators of pathognomic signs and neuropsychological skills (Davis et al., 2005). Although this comprehensive battery was designed to differentiate between brain-injured and normal individuals, it offers a rich array of clinical information regarding brain-behavior relations. The HRNB can provide information regarding diagnostic decision making, deficit localization, and impairment severity, as well as demonstrating strengths and weaknesses across various functions. This chapter presented the history and development of the HRNB and also highlighted the unique qualities and treatment planning capabilities of the Halstead batteries. In terms of shortcomings, the HRNB has limited reliability and validity information, especially compared to more contemporary neuropsychological measures. Some elements of the HRNB, such as the limited portability and difficulty in administration, can be frustrating. Furthermore, interpretation of this measure is a complex process requiring advanced training and expertise. The HRNB can provide new information beyond what is typically collected in psychology, which can lead to the development of unique and appropriate interventions. New instruments developed according to the highest psychometric standards have become popular in neuropsychology. However, the majority of articles published early in the development of the field utilized the HRNB. This battery was the gold standard of neuropsychological instruments for decades. Nevertheless, significant modifications will be needed if this battery is to retain its ranking as the most widely used neuropsychological measure in our field.

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6 Understanding and Using the Luria-Nebraska Neuropsychological Test Batteries With Children and Adults

JUSTIN WALKER, RIK CARL D'AMATO, AND ANDREW S. DAVIS

The Russian neurologist A. R. Luria was a pioneering force in the field of neuropsychological assessment for rehabilitation. One of his many contributions was a battery of informal neuropsychological tasks "that he used to obtain an essentially qualitative evaluation of an individual's neurological status and integrity" (Reynolds & French, 2003, p. 54). Based on his theory of human cognitive processing, Luria (1966, 1980) proposed the presence of three functional units in the brain. The units were said to work in conjunction and are present in any type of mental process. A summary of Luria's techniques was published as *Luria's Neuropsychological Investigation* (Christensen, 1975). At that time, the psychometric measures traditionally used in clinical neuropsychology differed from the qualitative approaches suggested by Luria. Neuropsychological functioning, according to Luria, was not something that could be measured qualitatively, and he was, ironically, opposed to our fixation with standardization that focuses exclusively on scores in place of people. It is important to note that Luria reviewed the proposed

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This chapter is based in part on the authors' prior work, from Davis, A. S., Johnson, J. A., & D'Amato, R. C. (2005). Evaluating and using long-standing school neuropsychological batteries: The Halstead-Reitan and the Luria-Nebraska Neuropsychological Batteries. In R. C. D'Amato, E. Fletcher-Janzen, & C. R. Reynolds (Eds.), *Handbook of school neuropsychology* (pp. 236–263). Hoboken, NJ: Wiley.

framework that attempted to make his tasks formal tests and was less than enthusiastic about the interpretation of the tasks used to represent his theoretical paradigm (Christensen, 1975; Witsken, Stoeckel, & D'Amato, in press). However, the test battery developed by Golden (Golden, Purisch, & Hammeke, 1985) is argued by many to be based on Luria's work. This battery has been criticized by some researchers and practitioners for a variety of issues (Purisch, 2001). Neuropsychologists have asserted that the normative base of the LNNB does not align well with Luria's approach to neuropsychological assessment (Adams, 1980a, 1980b). Although his name appears in the title of the current standardized measure, Luria's contributions to the LNNB are not clear. In fairness, it would seem difficult to modify informal qualitative tasks into a psychometrically standardized test such as the Luria-Nebraska. Luria advocated a theory-driven, observation-oriented, and flexible process approach to assessment (Witsken et al., in press). This was in stark contrast to the more psychometric, objective, product-oriented approach used in the United States. Table 6.1 contrasts Lurian's qualitative approach to the North American quantitative approach.

HISTORY OF THE LURIA-NEBRASKA

The first publication of the Luria-Nebraska Neuropsychological Battery (LNNB) was in 1978 (Golden, Hammeke, & Purisch, 1978) and was followed by another version soon after (Golden et al., 1985). Qualitative approaches such as Luria's were conjoined with the more traditional quantitative approaches of testing. Critics argued against this blending of methods (Chittooran & D'Amato, 1989; Lezak, Howieson, Loring, Hannay, & Fischer, 2004), and the test received mixed reviews (Golden & Freshwater, 2001). Purisch (2001) maintains that the LNNB is "an application of Luria's item pool, not an attempt to fuse qualitative/flexible and quantitative/standardized approaches" (p. 276). Despite the criticisms of the methodological approach, early research identified the LNNB as having potential as a quantitative standardized battery (Stambrook, 1983). However, it is critical to understand the state of the field of neuropsychology in the 1980s and 1990s. At that time, the psychometric foundation of all neuropsychological batteries was clearly lacking (Davis, Johnson, & D'Amato, 2005). Because of this problem, authors in the field argued for better standardization of all neuropsychological measures (Rhodes, D'Amato, & Rothlisberg, in press). To answer this call, the NEPSY-II neuropsychological battery (Korkman,

Table 6.1

CONTRASTS BETWEEN LURIAN'S EASTERN QUALITATIVE APPROACH AND NORTH AMERICAN/WESTERN QUANTITATIVE APPROACH TO NEUROPSYCHOLOGICAL SERVICES

LURIAN/EASTERN APPROACH	NORTH AMERICAN/WESTERN APPROACH
Theory driven	No overall a priori theory–data driven
Attempts to support or confirm a theory	Attempts to disconfirm specific hypotheses
Synthetic	Analytical
Observation oriented	Evaluation oriented
Single-case oriented	Group-comparison oriented
Describes behaviors	Evaluates behaviors
Subjective	Objective
Looks for patterns of functioning	Looks for differential diagnosis
Qualitative in nature	Quantitative in nature
Flexible	Fixed
Process oriented	Product oriented
Focuses on individualized activities	Focuses on multiple tests/procedures
Links behavioral data to functioning	Links psychometric data to diagnosis
Considers the functional system	Considers discreet brain-related areas
Clinical-theoretical	Actuarial-standardized

Sources: Adapted from Brinkman, Decker & Dean, 2005; Davis et al. (2005); Tupper (1999); Witsken et al. (in press).

Kirk, & Kemp, 2007; discussed in chapter 7) and the Dean-Woodcock Neuropsychological Battery (Dean & Woodcock, 2003; discussed in chapter 8) as well as some neuropsychological processing measures such as the Test of Memory and Learning (Reynolds & Bigler, 1994) were developed.

Another edition of the LNNB, which is the battery in use today, was released in 1985. The LNNB has since been used as a screening mechanism and as a more comprehensive diagnostic tool. The purpose of the LNNB was to help determine and diagnose cognitive deficits as well as localization and lateralization of brain impairments. Indeed, many neuropsychologists who use the LNNB may refer to the ability of the battery to "localize" deficits; the test interpretation section of the manual relates difficulty or failure of some test items to specifically measure areas of neurological processing. Furthermore, the LNNB was designed with rehabilitation in mind, since the results are meant to aid in developing services for children and adults (Golden, Hammeke, & Purisch, 1978; Golden et al., 1985). In fact, the proposed ability of the LNNB to relate behavioral functioning to localized areas in the brain may appeal to rehabilitation psychologists since they may be interested in examining an area of the brain that was affected by a sudden-onset neurological condition, such as a stroke or traumatic brain injury. However, it is important to keep in mind the harmonious processing of the functional units in the interpretation of the results of the LNNB (i.e., recognizing that any behavior is the result of multiple areas of the brain working in harmony).

APPLIED RESEARCH WITH THE BATTERY

Items were chosen to be on the LNNB if they could discriminate between patients with neurological disorders and individuals with no medical conditions (Golden et al., 1978). Results were replicated with patients representing additional disorders (Moses & Golden, 1979). Some researchers have been critical of the fact that the items were selected because they differentiated between groups, not because they were relevant to the current knowledge of brain-behavior relationships (Crosson & Warren, 1982; Delis & Kaplan, 1982). While the method of item selection used on the LNNB has made it an adequate measure in diagnosing brain damage, this method leads one to question the test's utility as a comprehensive tool for assessing neuropsychological strengths and weaknesses. The LNNB has been used in numerous studies using patients with disorders with a purported neurological etiology. Early studies differentiated between patients with schizophrenia and patients with traumatic brain injuries (Moses & Golden, 1979; Purisch, Golden, & Hammeke, 1979). Similarly, significant differences were found on 9 of the 11 clinical scales for patients with epilepsy (Berg & Golden, 1981). These results could not be replicated, which leaves researchers and practitioners questioning the test's reliability and validity (Hermann & Melyn, 1985). Related problems were discovered in patients with multiple sclerosis. Golden (1979) stated that patients with MS performed better on some items of the LNNB than others with brain injuries. In fact, Golden claimed that the LNNB discriminated between patients with MS, normal subjects, and patients with brain injuries, although some have questioned the data used to differentiate between groups (Stanley & Howe, 1983).

Some researchers have argued that the LNNB may not be a useful tool in assessing patients with language disorders, specifically aphasia (Crosson & Warren, 1982; Delis & Kaplan, 1982). Many items appear to rely on the use of expressive and receptive language skills, which would make distinguishing aphasic disturbances and other related disorders difficult (Crosson & Warren, 1982; Delis & Kaplan, 1982; Spiers, 1981). Moreover, the test has been called biased against patients with deficient language skills (Franzen, 1989; Goldstein, 1986). An issue that some see as a strength and others as a problem is the fact that patients with brain damage whose language skills are intact can score in the normal range on some LNNB scales (Fields, 1987; Goldstein, Shelly, McCue, & Kane, 1987). Indeed, in some cases, patients with discrete localized damage (e.g., right parietal damage from a stroke) have completely intact receptive and expressive language scales on the LNNB, which can help in a rehabilitation setting. On other studies evaluating patients with aphasia, the LNNB failed to differentiate between individuals with different types of aphasia (Ryan, Farage, Mittenberg, & Kasprisin, 1988). One study considering brain localization in patients with aphasia failed to accurately classify patients with aphasia due to temporal lobe damage and misclassified these individuals as having frontal lesion damage (Mittenberg, Kasprisin, & Farage, 1985). Studies seem mixed when indicating if the LNNB can adequately differentiate between different types of patients.

While some research has shown that the Luria-Nebraska Neuropsychological Test Battery–Children's Revision (LNNB-C; Teeter, Boliek, Obrzut, & Malsch, 1986) can discriminate between children with and without a learning disability, other studies have not been as clear (Davis et al., 2005), Pfeiffer, Naglieri, and Tingstrom (1987) found that elevated LNNB-C scales helped to correctly identify most students with learning disabilities. Similarly, some researchers have shown that when two or more scales of the LNNB-C are above the critical level, most children can be correctly classified as having a learning disability (Teeter et al., 1986). When comparing children with mild and more severe learning disabilities, Snow, Hynd, and Hartlage (1984) found significant differences on the LNNB-C scales, which accurately differentiated those children. However, other studies failed to use the LNNB-C to differentiate between students with learning disabilities (Morgan & Brown, 1988; Snow & Hynd, 1985). In some research, the LNNB-C seems to have been a poor predictor of children with ADHD (Schaughency, Lahey, Hynd, Stone, Piacentini, & Frick, 1989) and average learners when used for diagnostic activities. From a psychometric standpoint, these mixed findings suggest that the LNNB-C must be used cautiously.

In addition to investigating populations of patients with learning disabilities, the academic achievement of children with psychiatric disorders has been explored with the LNNB. Hooper (1995) investigated the correlation between the LNNB and the Woodcock-Johnson Tests of Achievement–Revised with school-age children. He found that scores on the two tests were significantly correlated. However, younger children achieved scores with a higher correlation than did older children. Despite difficulties in child and adolescent differentiation, the LNNB has been a frequently used instrument because of its clinical efficiency and its usefulness in identifying patients with and without brain damage (Hynd & Semrud-Clikeman, 1990).

LURIA-NEBRASKA TEST DESCRIPTIONS

Originally designed for individuals 15 and older, the LNNB was then used with 13- and 14-year-olds. The administration time for the instrument is usually between 1½ to 2½ hours. This shorter administration time is cited as an improvement over other neuropsychological batteries such as the Halstead-Reitan (Davis et al., 2005; Golden, Hammeke, & Purisch, 1980). Original items were derived exclusively from Christensen's (1975) work. The LNNB comes in two forms—Form I (introduced in 1980) has 269 items and Form II (introduced in 1984) has 279 items—both of which assess motor and cognitive skills using a qualitative and quantitative scoring system. These two forms have 84 items in common. Although the forms produce similar information (Golden et al., 1985), a distinction between forms is that Form II can be computer scored. Form I has 11 clinical scales, while Form II has 12 clinical scales; Form II also has a memory scale. Another difference between the two forms is the set of stimulus cards used. (See Table 6.2.)

Table 6.2

SUBTEST OF THE LURIA-NEBRASKA NEUROPSYCHOLOGICAL TEST BATTERY AND THE LURIA-NEBRASKA NEUROPSYCHOLOGICAL TEST BATTERY–CHILDREN'S REVISION

LNNB	LNNB-C
Motor (C1)	Motor (C1)
Rhythm (C2)	Rhythm (C2)
Tactile (C3)	Tactile (C3)
Visual (C4)	Visual (C4)
Receptive Speech (C5)	Receptive Speech (C5)
Expressive Speech (C6)	Expressive Speech (C6)
Writing (C7)	Writing (C7)
Reading (C8)	Reading (C8)
Arithmetic (C9)	Arithmetic (C9)
Memory (C10)	Memory (C10)
Intellectual Processes (C11)	Intellectual Processes (C11)
Intermediate Memory (C12)	

Source: Adapted from Davis et al. (2005).

The LNNB and LNNB-C have somewhat different scale structures than other instruments. This is because the scales on the LNNB are "not asked repeatedly at different levels of difficulty" (Golden & Freshwater, 2001, p. 61). For example, many tests of cognitive processing use an approach of administering similar items with increasing difficulty. The LNNB differs in that multiple skills are assessed within the same scale with significantly fewer items per skill. For example, the Motor Scale has items that assess motor planning, kinesthetic praxis, dyspraxia, and motor sequencing. Although this has the advantage of assessing multiple areas within the same domain, it increases the chance that an attention or receptive language error could present as pathognomic of impairment of a motor skill. The battery actually is comprised of over 700 discrete tasks, many of which are considered simultaneously in the scoring of individual items. Items of the LNNB-C are scored in a similar fashion to the items on the LNNB. Items are scored either as 0 (normal performance), 1 (borderline performance), or 2 (abnormal performance). These scores are totaled and then converted into T-scores for each scale. This scoring method has been criticized by several researchers (e.g., Chittooran & D'Amato, 1989; Reynolds & Fletcher-Janzen, 1997).

SCALES ON THE LURIA-NEBRASKA BATTERY

The following scale descriptions are adopted from Davis et al. (2005), Golden et al. (1985), Lezak et al. (2004), Reynolds and Fletcher-Janzen (in press), and Teeter and Semrud-Clikeman (2007).

Motor (C1)

The Motor Scale is comprised of items that measure the motor abilities of both the right and the left hands. This scale contains items that assess sequential motor-related tasks such as touching each finger with the thumb of the same hand in sequence. Many of these tasks are quite simple, and most clients are able to complete them. Some of the tasks resemble those that are found in a neurological exam (Allen, Hulac, & D'Amato, 2005). At one point, the client is blindfolded and asked to complete a number of tasks. The examiner can alter directions in order to communicate with the client. This scale is the longest scale on the LNNB and is considered the most useful (Golden et al., 1985). Indeed, some practitioners may wish to use this scale in isolation if they suspect or wish to quantify a motor deficit.

Rhythm (C2)

With the exception of two items, the Rhythm Scale items are presented on an audiotape. Items are intended to evaluate the examinee's ability to listen to musical tones and rhythmic patterns, and sometimes to reproduce these tones and patterns. Some items require the examinee to discriminate between tones, while others have the examinee repeat words or lines in a song or tap a rhythm he or she has heard. For the most part, verbal instructions are not evaluated on this scale. The patient needs to pay more attention to complete these items than for items on the previous scale, and thus failure or difficulty on these items may indicate an attention problem.

Tactile (C3)

Many items are conducted when the client is blindfolded. The examiner may touch the client's body with a pencil eraser or pin with varying degrees of pressure. Other items ask the examiner to draw figures on the back of the examinee's wrist and ask him or her to identify the figures. This scale is considered to be the most difficult scale to administer, and this affects the scale's reliability and validity (Golden et al., 1985). Again, attention and concentration are key to this scale since many items cannot be repeated. This scale is particularly useful in rehabilitation settings due to its sensitivity to tactile perception and discrimination errors, such as those seen in astereognosis, agraphesthesia, and sudden-onset neurological conditions.

Visual (C4)

The purpose of the Visual Scale is to elicit the patient's visual and visual-spatial skills without the use of motor skills, which are assessed on C1. Indeed, this scale is useful in delineating the visual component observed in visual-spatial and visual-motor integration problems. On this scale, the patient responds verbally to questions. Tasks may include the naming of objects and pictures. Forms 1 and 2 differ considerably on this scale with respect to stimuli. However, the procedures and questions are identical across the two forms.

Receptive Speech (C5)

This scale measures the patient's comprehension of speech. Some items ask the examinee to point to pictures, while others have the examinee pick a sentence that makes the most sense. Some later items ask the examinee to follow multistep directions, while the earlier items focus on gross receptive language skills. Although directions can be repeated, paraphrasing and repetition of the actual item content are not allowed.

Expressive Speech (C6)

The Expressive Speech Scale evaluates the patient's ability to make verbal statements. The examinee repeats words and sentences and may retell a story. Some reading items on this scale measure expressive fluency (Golden et al., 1985). This represents a potential confound for patients with reading problems; thus, it is important to independently assess reading skills if failure on one of these items has been noted. This scale does not evaluate the meaningfulness of statements but rather evaluates the patient's fluency and articulation skills.

Writing (C7)

Items on this scale include spelling words and writing via motor skills. Examinees are evaluated on their ability to count letters in words, correctly spell words, and copy as well as write letters. Two optional scales are included to increase interpretability of these items: O1 (Spelling) and O2 (Motor Writing). Basic writing and spelling skills are evaluated up to a seventh-grade level (Golden et al., 1985).

Reading (C8)

The Reading Scale evaluates the accuracy of basic reading skills up to a seventh-grade level. This scale does not measure expressive fluency skills, which can be better accounted for on C6. The items on C8 ask examinees to identify letter sounds and read single letters, words, sentences, and paragraphs. One major problem with this scale, and all scales that rely on visual stimuli, is that patients who do not see well have more difficulty completing this subtest. This scale was designed to measure basic reading skills that could be affected by an acquired or developmental condition. It should not be used to measure ipsative reading strengths in strong readers. A standard reading achievement test should be used to measure significant reading strengths (Rhodes et al., in press).

Arithmetic (C9)

Reading and writing of numerical numbers and simple calculation skills are measured on the Arithmetic Scale. Examinees are asked to subtract a specific number and count backwards. The C9 scale is considered the most sensitive scale for evaluating patients with brain injuries, meaning that it is difficult for patients with traumatic brain injuries to complete. For these patients, it may be the most difficult scale on the LNNB. Like the other academic scales of the LNNB, C9 measures basic skills up to the seventh-grade level.

Memory (C10)

The Memory Scale assesses both verbal and nonverbal memory. Items may or may not include interference. The client is asked to repeat a series of words back to the examiner, use picture memory with and without delay, and repeat a rhythm with the hand or voice. Stimulus repetitions on this scale are not allowed. The client must attend to the stimulus if he or she is to purposefully complete the item.

Intellectual Processes (C11)

Several items on this scale resemble those included on traditional measures of intelligence and executive functioning measures. Tasks include describing pictures and answering questions about a story. The sequencing of pictures task is similar to the Picture Arrangement subtest of the Wechsler scales. The task where the examinee describes how two objects are alike is similar to the Similarities subtest on the Wechsler, and examinees must solve word problems much like the Arithmetic subtest of the Wechsler scales. This scale yields an estimate of intellectual functioning (Golden et al., 1985). This scale provides a good example of how caution must be used in interpretation of the battery. Essentially, caution should be used in gauging the overall T-score on C11 since the scale is composed of many different types of items. For example, a patient may obtain only a slightly elevated T-score but may be presenting with salient processing problems. Item analysis should be used in order to ascertain the true nature of the problem.

Intermediate Memory (C12, Form II Only)

This scale contains verbal and nonverbal items and requires retention and recognition of material found in previous sections of the test. Not all the items on this scale involve the remembering of information the examinee was asked to learn and recall. The scale has been called a measure of "delayed, unwarned recall and incidental memory" (Franzen, 1999, p. 2). The delay in presenting items usually ranges from 30 minutes to 2 hours.

Sometime after the release of the LNNB, a children's version of the battery, the LNNB-C (Golden, 1987), was developed and made available. The LNNB-C is used with patients from age 5 to age 12. The developmental appropriateness of this measure has been repeatedly called into question because the authors of the test developed the children's version by administering the LNNB to children and removing items that appeared to be too difficult (Berg, 1999). As a result, further development of the LNNB-C required data from multiple administrations of various versions of the test. Adaptations and additions to the test content have led to the current version. However, unlike many other tests, the purpose of the LNNB-C was not to provide an in-depth analysis of a single behavior. It was designed as a broader set of items to analyze major variations of skill areas while maintaining internal reliability (Karras et al., 1987).

The LNNB-C uses stimulus materials identical to those for Form I of the LNNB plus three additional cards and an audiotape. The LNNB-C has 149 items assigned to 11 heterogeneous scales and takes approximately 2½ hours to administer. This version can be hand or computer scored. Although the LNNB-C has far fewer items than the LNNB, the LNNB-C items have multiple components and tasks and therefore have many more items than specified. The following scale descriptions are adopted from Davis et al. (2005), Golden et al. (1985), Lezak et al. (2004), Reynolds and Fletcher-Janzen (in press); and Teeter and Semrud-Clikeman (2007).

Motor (C1)

The Motor Scale evaluates a range of motor skills, including drawing tasks and simple hand movements. The items also measure basic motor speech, imitation, construction skills, and coordination.

Rhythm (C2)

This scale requires the reproduction and analysis of tones and rhythms. The items measure the patient's ability to hear simple tones and repeat them, sing songs from memory, and repeat and count rhythmic patterns (Berg, 1999).

Tactile (C3)

The Tactile Scale involves touching the patient to evaluate the patient's sensations. The patient must determine the location and amount of pressure put on him or her without using vision. Abilities such as finger and arm localization, strength discrimination, movement detection, and stereognostic skills in the hands and arms are measured.

Visual (C4)

This scale requires organization and analysis of visual-spatial skills. The patient must identify and name common pictures and objects. Objects that have been visually distorted must also be identified and named. Patients may also be asked to identify overlapping figures and utilize visual memory skills (Berg, 1999).

Receptive Speech (C5)

The Receptive Speech Scale measures the client's ability to understand speech. Phonemic analysis and ability to understand complex sentences are assessed on this scale.

Expressive Speech (C6)

The client's ability to use speech is measured by the Expressive Speech Scale. Tasks range from repeating simple phonemes, words, and sentences to understanding and generating more complex sentences (Berg, 1999).

Writing (C7)

The Writing Scale measures the client's ability to analyze words phonetically and his or her ability to spell and write.

Reading (C8)

The Reading Scales assess a variety of abilities, beginning with simple reading tasks, such as naming letters and reading simple words, and expanding to more complex skills such as reading sentences and paragraphs (Berg, 1999).

Arithmetic (C9)

Number recognition and comparison and writing, as well as simple mathematical processes, are assessed on the Arithmetic Scale.

Memory (C10)

This scale measures verbal and short-term visual memory, verbal memory under interference conditions, and verbal-visual association memory (Berg, 1999).

Intellectual Processes (C11)

Some items on this scale are similar to several subtests from the Wechsler scales. The purpose of the tasks on the Intellectual Processes Scale is to discriminate between patients with brain damage and those with normal functioning. Tasks include visual analysis of pictures, simple arithmetic, story interpretation, and comparison of objects.

SCORING AND INTERPRETATION OF THE LURIA-NEBRASKA

Detailed administration and scoring criteria are provided in the manual (Golden et al., 1985). Items can be scored in one of three ways. A score of 0 indicates normal performance. Next, a score of 1 represents mild dysfunctional performance suggesting a possible brain disorder. Finally, a score of 2 indicates severely dysfunctional performance and probable brain dysfunction. Item cluster raw scores can be converted into scale scores for four general areas (clinical scales, summary scales, localization scales, and factors scales). Overall summaries of function and range from other scales are provided in the clinical scales. Lateralization and impairment indices are in the summary scale. The localization scales are measures that are specifically designed to provide information related to the localization of brain dysfunction. Finally, the factor scales consist of clusters of items that purport to measure discrete neuropsychological functions. Although detailed instructions for administration are provided in the manual, the ambiguity in altering instructions to meet the needs of the individual patient (Golden et al., 1980) raises concern about just how much alteration should exist in a standardized measure. The directions are the focus of concern of critics who contest that a model developed by Luria cannot be standardized (Adams, 1980b).

The LNNB can be administered by psychometricians or trained paraprofessionals (Golden et al., 1985). However, the responsibility for the test, as well as the interpretation, should lie solely with professionals with training and experience in clinical neuropsychology. Indeed, extreme caution should be used in interpretation, even by clinical neuropsychologists who do not have training in the measure. This is due to the problems with interpreting the T-scores without conducting concurrent item analysis or considering the interrelated nature of the skills assesses on the LNNB. Recommendations for diagnosing localized disorders and formulating hypotheses regarding etiology and rehabilitation may require 1–2 years of specialized postdoctoral training and supervision. However, those lacking training may still be effective in using the LNNB for screening and referral purposes, provided that the individual is well trained in administering and scoring the screening battery. Some practitioners do use only the first four subtests with patients with poor test-taking skills (e.g., those caused by extreme fatigue or attention problems) in hospital-based settings (e.g., patients who have experienced an acute stroke) or on an outpatient basis with patients with advanced dementia.

In the interpretation of the LNNB, less emphasis is placed on the individual scales since many items are not intended to measure only one ability. Instead, a pattern analysis is suggested as being far more appropriate (Golden et al., 1985). However, the literature has produced a variety of interpretive methods (Berg, 1999; Franzen, 1999; Golden & Freshwater, 2001; Golden, Freshwater, & Vayalakkara, 2000). The first level of interpretation should focus on the presence of a brain injury in the patient and use the LNNB as a screening measure to differentiate neuropsychological disorders from other possible disorders. This level of analysis is appropriate in cases where the patient may have experienced a brain injury but the details are vague. However, this level of analysis is not used when there has been a confirmed brain injury. Next, the LNNB can provide a description of what the patient is capable of doing and the areas in which he or she is experiencing difficulties. The third level of interpretation expands on the findings of the second level by speculating on the possible underlying causes leading to the patient's presenting behavior. Finally, in the fourth level of interpretation, all the findings are integrated into a conclusion of how the brain functions in the particular individual (Golden et al., 1985).

PSYCHOMETRIC CHARACTERISTICS OF THE BATTERY

The LNNB has undergone numerous reliability studies since its conception. However, many of these studies occurred in the 1980s soon after the test debuted. Most of these studies have been drawn from Form I of the LNNB (Franzen, 1999). Similarly, initial validation studies for the LNNB-C suggested its usefulness as a neuropsychological test for children (Golden et al., 1985). Coefficient alpha was used to establish the level of internal consistency of the LNNB in several studies. Values in the range of .78 to .89 were found for the clinical and summary scales (Moses, Johnson, & Lewis, 1983). Similar results were reported in later studies (Maruish, Sawicki, Franzen, & Golden, 1985; Moses, 1985).

Interrater reliability of the LNNB has been conducted by the test authors as well as other researchers, and these studies have shown generally good results. On the clinical scales, agreement between raters was high, with the overall agreement of 95% (Golden et al., 1978). As a follow-up, Bach, Harowski, Kirby, Peterson, and Schulein (1981) found coefficient kappa (Cohen, 1960) to be over .80. The original study by Golden and colleagues (1978) was later replicated by Moses and Schefft (1985), and similar results were found. However, results were not so favorable when the interrater agreement of ambiguous responses was contrasted with clearly scorable responses. One study found that interrater reliability for the clear responses was .90; however, for the ambiguous responses, the agreement fell to .75.

Golden, Berg, and Graber (1982) explored the test-retest reliability of the LNNB. The reported test-retest coefficient was .88. Others found an average of .89 for 30 patients over an 8-month interval (Plaisted & Golden, 1982). Later, another study claimed the coefficient was slightly higher at .92 (Campbell, 1983). Other studies found adequate split-half reliability for the LNNB (Campbell, 1983; Maruish et al., 1985), including one study with a sample size of 74 normal patients, 83 psychiatric patients, and 181 neurological patients (Golden, Fross, & Graber, 1981). In general, research has shown the reliability of the LNNB to be good. Despite characteristics such as high interrater agreement, test-retest stability, and split-half reliability, the LNNB appears to lack a consistent psychometric foundation and appears to pose validity difficulties with various populations.

CONCLUSIONS

More than two decades ago, the LNNB was hailed as "a powerful tool to use in assessing cognitive strengths and weaknesses" (Golden et al., 1985, p. 1). Some still argue that this is one of the most popular neuropsychological measures currently available (Davis et al., 2005). However, because of many of the difficulties discussed, the measure does not seem to have sustained a high level of national prominence. Accordingly, practitioners may see a need to combine the LNNB with more current measures of cognition, achievement, and/or memory. Nevertheless, studies indicate some correlation between the Memory Scale of the LNNB and other memory measures (McKay & Ramsey, 1983; Ryan & Prifitera, 1982). Similarly, studies have shown a link between the WAIS and the Intellectual Processes Scale (McKay, Golden, Moses, Fishburne, Wisniewski, 1981; Picker & Schlottmann, 1982; Prifitera & Ryan, 1981). Unfortunately, these studies have been criticized for their sampling (Koffler & Zehler, 1986). Although the LNNB has long been used as a stand-alone instrument, it now seems more useful as part of a larger battery of neuropsychological measures.

Another caveat must be made regarding the current utility of the LNNB. Given that the standardization sample is now over 20 years old, the comparison groups may not be relevant to currently practicing clinicians. The lack of recent norms has limited the usefulness of the LNNB as newer measures have begun to take center stage in neuropsychological assessment. Many clinicians are electing to use the NEPSY-II for assessing younger children, and the Dean-Woodcock Neuropsychological Assessment System for assessing adult populations. For the LNNB to retain its place as a relevant measure, it will need to be restandardized and republished.

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7

Understanding and Using the NEPSY-II With Young Children, Children, and Adolescents

JONATHAN E. TITLEY AND RIK CARL D'AMATO

The NEPSY-II is a comprehensive neuropsychological assessment battery for children and adolescents based on the work of the Russian neuropsychologist Luria (1966) and recent neuropsychological cognitive research. This newly revised test battery serves as an excellent tool to evaluate a child or adolescent's needs and strengths related to neuropsychological functioning. This measure provides in-depth assessment in six functional domains in order to facilitate effective intervention (Korkman, Kirk, & Kemp, 2007). The NEPSY-II is a unique instrument in that it was designed to assess the neuropsychological development of young and school-age children and adolescents up to age 16. The purpose of this chapter is to provide the reader with an understanding of the development, psychometrics, and practical applications of the NEPSY-II in neuropsychological assessment for intervention, as well as the theoretical constructs measured by the NEPSY-II.

DEVELOPMENT AND THEORETICAL FOUNDATION OF THE NEPSY-II

This theoretically based battery assists the neuropsychologist or trained psychologist in offering treatment recommendations based on a neuropsychological framework. Luria (1973) viewed cognitive abilities as representing the coordination of different cerebral areas of the brain. Luria conceptualized the brain as organized in three primary functional units. According to Luria, when one of these units is not operating at an optimal level, neuropsychological functioning can be impaired. Luria's original examination was extremely comprehensive. The examination involved testing a series of hypotheses to determine which units or sub-areas of units were functioning at a less-than-optimal level. In chapter 6, Table 6.1 provides a comparison of Luria's perspective on assessment with that of a quantitative neuropsychological approach. There are elements of both types of neuropsychological items (quantitative and qualitative) in the NEPSY-II. For example, the visuomotor precision subtest, in addition to providing an overall scaled score, provides a box to check qualitative observations of the child's pencil grip. This mix of quantitative and qualitative information is a unique feature of this measure that sets it apart from other neuropsychological tests.

The authors of the NEPSY-II sought to design a test that would measure each area of cognitive functioning that was described by Luria. The neuropsychological model of conducting a series of hypothesis tests based on a pass-fail method, which is thought to work well with adults, can become problematic when applied to developing children and youths. Thus, Korkman (1999) indicated that the identification of strengths and weaknesses is more useful and practical for children (D'Amato, Crepeau-Hobson, Huang, & Geil, 2005). Hence, some elements of Luria's theories were adapted for use in the NEPSY-II, with the goal of helping to explain a comprehensive pattern of neuropsychological processes. For example, Luria (1973) believed that functions such as language, learning, movement, and memory were the result of an interaction of simple and complex brain systems, and this viewpoint is reflected in the construction of the NEPSY-II. Some of the subtests assess basic subcomponents of neuropsychological domains; other subtests tap into neuropsychological functions that require contributions and interactions between the functional domain areas (D'Amato, 1990; Korkman et al., 2007; Rhodes, D'Amato, & Rothlisberg, in press). Many of the subtests on the NEPSY-II were adopted from well-researched traditional neuropsychological tasks but have been adapted to be more child friendly and easier to administer (e.g., see Lezak, Howieson, Loring, Hannay, & Fischer, 2004).

Many learning difficulties are a manifestation of neuropsychological processing problems in one of the functional cognitive areas assessed by the NEPSY-II. For example, a reading problem may be the result of a deficit in phonological processing, poor attention and inhibition skills, insufficient memory processes, visual-spatial difficulties, or even poor oral motor skills. All these processing abilities are assessed under the functional domains in the NEPSY-II. A diagnosis of a specific learning disability often includes a deficit in a processing skill that is unclear on traditional measures of cognitive assessment; the NEPSY-II was designed to assist in the identification of neuropsychological-based processing disabilities (D'Amato, Gray, & Dean, 1988).

The NEPSY was originally published in Finnish in 1980 by Korkman for children ages 5 and 6 years old (Ahmad & Warriner, 2001). The first English version was published by Korkman, Kirk, and Kemp (1998) for children ages 3 through 12, followed by the second version, the NEPSY-II, in 2007. The first English version of the NEPSY consisted of five domains with a group of core subtests for each domain, depending on age. Additional supplemental subtests could be administered to gather more information if needed.

The NEPSY-II was released in the summer of 2007, and there have been many notable updates and improvements since the first English version. The NEPSY-II reflects better psychometrics, an improved standardization sample, and an age range extended into the adolescent years from 12 to 16. The total number of subtests on the NEPSY-II has increased from 27 to 36 (including the 4 delayed memory subtests). Korkman et al. (2007) indicate that 10 subtests were added in order to provide better domain coverage, and a new domain (i.e., social perception) was introduced to the NEPSY-II. Due to limited clinical validity compared to other subtests, 4 subtests were dropped from the NEPSY-II, including 3 from the attention and executive functioning domain (i.e., Knock and Tap, Tower, and Visual Attention), and one from the sensorimotor domain (i.e., Finger Discrimination). Korkman et al. (2007) now encourage a flexible battery approach and include suggestions on areas to evaluate for general referrals. The examiner is free to administer subtests in any order and to select the subtests that are most sensitive to assessing the needs of various referral questions. A list of recommended subtests is also provided in the NEPSY-II interpretative manual for various referral issues (e.g., learning differences–reading, attention/concentration, behavioral problems). The revision of the NEPSY was comprehensive and included a review of current research, a pilot phase, a tryout phase, and a national standardization and validation phase.

MATERIALS

The NEPSY-II supplies are contained in a professional-looking soft-sided briefcase with easily accessible pockets. The administrative manual and clinical and interpretative manual appear comprehensive, easy to read, and well organized; however, the quality of the materials themselves is disappointing. The manuals have poor-quality paper and flimsy covers. Tabs that can be attached to the pages in the administrative manual are included, but these also seem to lack durability. The NEPSY-II includes two stimulus books, which appear to be well made and durable, with sturdy dividers. The stimulus books are easy to use, with subtests tabbed in alphabetical order. They feature a foldout design that allows the examiner to view and read the instructions while the examinee views each item. The illustrations and pictures included in the items are colorful and engaging. The scoring templates appear easy to use but are disappointing in quality, as they are printed on a thin plastic sheet. Two pencils, a set of 12 red blocks, and cards are also included in the NEPSY-II.

The NEPSY-II has a record form for young children ages 3 and 4 and a separate record form for children and youths ages 5 to 16. The forms are easy to navigate, with subtests listed in alphabetical order, and the marking and scoring are straightforward. The cover page allows the examiner to record scores for all subtests under each domain. However, the cover page is difficult to follow, since all subtests are abbreviated, requiring the examiner to consult the manual in order to determine the abbreviation for each subtest. This cover page would be easier to follow if titles of subtests were spelled out. A response booklet is also included for ages 5 to 16, which allows the child or adolescent to record his or her answers directly in the booklet for subtests requiring writing or drawing.

ORGANIZATION AND ADMINISTRATION

An examiner may choose to use the NEPSY-II in a variety of ways depending on the intended purpose, for example, as a screener, as a flexible battery, or as a comprehensive wideband neuropsychological battery. Although the NEPSY-II no longer provides domain scores, the subtests remain placed in various neuropsychological domains. The 36 subtests are grouped into six domains of neuropsychological functioning: (1) attention and executive functioning, (2) language, (3) memory and learning,

(4) sensorimotor, (5) social perception, and (6) visuospatial processing domains. Table 7.1 presents the six domains with subtests listed under each domain. According to Korkman et al. (2007), the six domains on the NEPSY-II were theoretically derived. The attention and executive functioning domain is designed to assess for deficits along a continuum from simple attention to more complex self-monitoring tasks. The subtests in the language domain assess subcomponents of oral and written language that can relate to problems in reading, writing, spelling, and oral communication. The memory and learning domain provides a more comprehensive assessment of memory than most cognitive batteries. It is possible to isolate the deficits and strengths that exist in verbal and nonverbal processes related to learning and retrieval of information. The sensorimotor domain assesses coordination and fine motor ability. Sensory functioning is only indirectly assessed through smooth and precise motor functioning. The subtests (e.g., Fingertip Tapping) also allow the examiner to compare dominant and nondominant hand functioning. The social perception domain is designed to assess how accurately the child or adolescent is able to interpret the nonverbal social, contextual, and behavioral cues of other individuals. The visuospatial processing domain uses subtests with motor and nonmotor activities to measure the ability to discriminate, evaluate, and manipulate objects in space (Korkman et al., 2007). Table 7.1 includes all of the subtests from the NEPSY-II organized by the six domains described previously.

Although the domains are helpful in organizing the subtests into categories, Korkman et al. (2007) are careful to indicate that not all cognitive functions within a particular domain are assessed by the NEPSY-II; they also suggest that examiners should not draw broad conclusions based on individual subtests that measure only one aspect of a domain (e.g., concluding from a child's poor performance on an auditory attention task that the child has poor overall attention abilities). In addition, there is overlap between domains with many subtests, representing several complex cognitive functions (e.g., many of the subtests from the language domain and the memory and learning domain have strong language components).

The domain layout is confusing since the NEPSY-II no longer uses domain scores. This significant change is problematic because domain scores are typically more psychometrically sound than scores for individual subtests. While past research suggested difficulties with the previous test version's factor structure (Stinnett, Oehler-Stinnett, Fuqua, & Palmer, 2002), abandoning the idea of domain or composite scores

Table 7.1

NEPSY-II SUBTESTS BY DOMAIN

ATTENTION AND EXECUTIVE FUNCTIONING	LANGUAGE	MEMORY AND LEARNING
Animal Sorting (AS)*	Body Part Naming (BPN) and Identification (BPI)**	List Memory (LM)**
Auditory Attention (AA) and Response Set (RS)**	Comprehension of Instructions (CI)**	List Memory Delayed (LMD)**
Clocks (CL)*	Oromotor Sequences (OS)	Memory for Designs (MD)*
Design Fluency (DF)	Phonological Processing (PH)**	Memory for Designs Delayed (MDD)*
Inhibition (IN)*	Repetition of Nonsense Words (RN)	Memory for Faces (MF)**
Statue (ST)**	Speeded Naming (SN)**	Memory for Faces Delayed (MFD)**
	Word Generation (WG)**	Memory for Names (MN)**
		Memory for Names Delayed (MND)**
		Narrative Memory (NM)**
		Sentence Repetition (SR)**
		Word List Interference (WI)*
SENSORIMOTOR	**SOCIAL PERCEPTION**	**VISUOSPATIAL PROCESSING**
Fingertip Tapping (FT)**	Affect Recognition (AR)*	Arrows (AW)**
Imitating Hand Positions (IH)	Theory of Mind (TM)*	Block Construction (BC)**
Manual Motor Series (MM)		Design Copying (DC)**
Visuomotor Precision (VP)**		Geometric Puzzles (GP)*
		Picture Puzzles (PP)*
		Route Finding (RF)

* The subtest is new to the NEPSY-II.
** One or more change has been made to subtest (i.e., administration modified, recording/scoring adjusted, new items added, and/or age range changed).

seems questionable. This new structure creates serious difficulties in the interpretation of subtest scores.

The interpretative manual provides alternate hypotheses for low performance on specific subtests to assist the examiner in determining the underlying neurocognitive deficits that may be affecting performance on the NEPSY-II (Korkman et al., 2007). It is important for the clinician who administers and interprets the NEPSY-II to be familiar with the cognitive and neuropsychological concepts underlying the domains and subtests. Table 7.2 provides a brief description of all subtests within each of the six domains, including cognitive functions measured and the age range each subtest is designed to assess.

THE PSYCHOMETRIC PROPERTIES OF THE NEPSY-II

Prior to the publication of the NEPSY in 1998, neuropsychologists in the United States were limited in their selection of comprehensive, well-standardized, and well-normed batteries for children; this often required clinicians to assemble subtests or tests from several different measures (e.g., Halstead-Reitan Neuropsychological Battery, Test of Memory and Learning; D'Amato, Fletcher-Janzen, & Reynolds, 2005; Reitan & Wolfson, 1993; Reynolds & Bigler, 1994). One of the greatest strengths of the NEPSY-II is the recent and comprehensive standardization of 1,200 children and adolescents, which closely approximates the demographics of the U.S. population based on 2003 census data. An additional 260 children and adolescents with clinical diagnoses were tested. Korkman et al. (2007) carefully reviewed theoretical and psychometric issues for subtests and decided not to renorm or modify 7 of the 27 subtests from the 1998 version of the NEPSY, including Design Fluency, Imitating Hand Positions, List Memory, Manual Motor Sequences, Oromotor Sequences, Repetition of Nonsense Words, and Route Finding. These subtests measured constructs that were less likely to be affected by the Flynn effect (Flynn, 1984; Korkman et al., 2007), which is the rise of intelligence test scores over time. Eleven of the subtests on the NEPSY-II have been expanded from the first version with additional items, creating improved floors and ceilings.

The clinical and interpretative manual for the NEPSY-II (Korkman et al., 2007) provides detailed information concerning subtest reliability estimates for all subtests at the various age levels. The authors have included evidence of internal consistency reliability using split-half

Table 7.2

NEPSY-II SUBTEST DESCRIPTIONS AND ABILITIES MEASURED[1]

	SUBTEST	AGES	COGNITIVE ABILITIES MEASURED	SUBTEST DESCRIPTION
Attention and Executive Functioning Domain	1.1 Animal Sorting*	7–16	Cognitive flexibility; initiation, self-monitoring, concept formation, categorizing, conceptual reasoning, semantic knowledge	The examinee sorts picture cards of various animals into two groups of four cards using self-initiated sorting criteria that may be related to the animals (e.g., animals with fur or no fur) or other background features of the cards (e.g., tree or no tree in the picture). No reading is involved in this task.
	1.2 Auditory Attention and Response Set	5–16	Sustained auditory attention, response inhibition, cognitive shift, working memory	The examinee listens to an audio recording that names colors and other words. The examinee is required to touch the appropriate color circle in the stimulus book when he or she hears the target word. The tape-recorded voice speaks at a rapid pace, and the examinee is required to maintain a high level of attention to ensure that the correct colored circles are selected while ignoring distracter words.
	1.3 Clocks*	7–16	Planning and organization, visuospatial skills, concept of time	The examinee must read the time on analog clocks with and without numbers and draw an analog clock or the hands on an analog clock based on the time displayed by a digital clock or the time as it is told to the examinee by the examiner.
	1.4 Design Fluency	5–12	Initiation, productivity, cognitive flexibility, psychomotor speed, visuo-perceptual skills, comprehension of directions, sustained attention, motor speed	The examinee has 60 seconds to connect five dots inside 35 squares. Each design pattern must be unique in order for the examinee to receive credit. This subtest was not renormed or modified from the 1998 version of the NEPSY.

	1.5 Inhibition*	5–16	Inhibitory control, cognitive flexibility, self-monitoring, self-regulation, working memory, naming speed, oromotor fluency	This subtest has naming, inhibition, and switching sections. In the naming section, the examinee names each shape (circle or square) or the direction of arrows (up or down). In the inhibition part of this subtest, the examinee is asked to say the opposite of what he or she sees (e.g., to say "circle" for "square," or "up" for "down"). In the switching section, the examinee's response depends on the color of the shape (e.g., the examinee is instructed to say "circle" for a black circle, but "square" for a white circle). Due to the complexity of this test, it is important to use error scores in addition to the primary score when this subtest is being interpreted.
	1.6 Statue	3–6	Inhibitory control, motor persistence, self-monitoring, comprehension of verbal instructions	The examinee must maintain a standing position for 75 seconds without responding to sound distracters.
Language Domain	2.1 Body Part Naming and Identification	3–4	Expressive language, receptive language, semantic knowledge and naming, working memory	The examinee is required to respond to the examiner's query to name parts of the body when they are pointed to in a stimulus booklet. Identification items have also been added that require the examinee to point to parts of the body as the examiner reads them aloud. To explore receptive and expressive language, a naming versus identification contrast scaled score can be calculated.

(*Continued*)

Table 7.2

NEPSY-II SUBTEST DESCRIPTIONS AND ABILITIES MEASURED[1] (*Continued*)

SUBTEST	AGES	COGNITIVE ABILITIES MEASURED	SUBTEST DESCRIPTION
2.2 Comprehension of Instructions	3–16	Receptive language, executing oral directions of increasing complexity, semantic knowledge, working memory, sequential processing	This subtest assesses an examinee's ability to follow spoken directions and point to different-colored geometric shapes or rabbits in a stimulus booklet based on increasingly complex directions read by the examiner. Comprehension of Instructions clearly relates to an individual's difficulty in following directions, especially multistep directions, from a teacher.
2.3 Oromotor Sequences	3–12	Oromotor coordination, verbal short-term memory, phonological decoding	In this subtest the examinee is asked to repeat articulatory sequences and tongue twisters provided by the examiner. This subtest was not renormed, and no modifications to the 1998 version of the NEPSY were made.
2.4 Phonological Processing	3–16	Phonological segmentation, phonological awareness, auditory discrimination, working memory	There are two parts to the Phonological Processing subtest. The first part asks the examinee to identify the correct word from three choices when part of the word is provided (e.g., "og" for "dog"). The second part is more complex; the examinee is given a word and asked to repeat the word with a phoneme changed or deleted (e.g., "Say 'flight.' Now say it again but instead of *fl*, say *br*").
2.5 Repetition of Nonsense Words	5–12	Phonological encoding and decoding, attention, short-term memory	The examinee is required to repeat nonsense words from an audio recording. This subtest was not renormed, and no modifications to the 1998 version of the NEPSY were made.

	2.6 Speeded Naming	3–16	Processing speed, lexical access, automaticity of verbal information, attention, basic expressive language	This task is administered from the stimulus booklet and requires the examinee to name the size (big or little), shape (square or circle), and color (yellow, black, red, etc.) of some objects in a rapid and alternating manner. There is also a letter/number naming part for this subtest.
	2.7 Word Generation	3–16	Vocabulary knowledge and retrieval, speed of processing, initiation, working memory, attention	The examinee is asked to name as many words as possible in a particular category (e.g., animals) or words that begin with a specific letter.
Memory and Learning Domain	3.1 List Memory and List Memory Delayed	7–12	Verbal memory, verbal retrieval, attention, planning, monitoring, delayed recall	The examinee is asked to learn a list of 15 words (e.g., "rabbit," "dog," "apple") over five trials. An interference list is administered and the examinee is then asked to recall the original word list again.
	3.2 Memory for Designs and Memory for Designs Delayed*	3–16	Visual memory, spatial memory, visual recognition, delayed visuospatial recall	A four-by-four grid with various designs in each grid (e.g., two sets of parallel lines) is shown and then removed from the examinee's view. The examinee must select the correct designs from a set of cards and place them on the grid in the correct location. In the delayed task, the examinee is asked to recall each design and location on the grid.

(*Continued*)

Table 7.2

NEPSY-II SUBTEST DESCRIPTIONS AND ABILITIES MEASURED[1] (*Continued*)

SUBTEST	AGES	COGNITIVE ABILITIES MEASURED	SUBTEST DESCRIPTION
3.3 Memory for Faces and Memory for Faces Delayed	5–16	Visual memory, visual perception, visual discrimination, delayed visual recall	Memory for Faces has two parts, an immediate recall phase and a delayed recognition phase, which occurs 15 to 25 minutes after the initial presentation of the stimulus. Participants are presented with pictures of children's faces from a stimulus book for 5 seconds. Immediately following the presentation, the examinee is asked to look at a page containing pictures of three faces, one of which was viewed during the stimulus presentation. Thirty minutes later, examinees repeat the delayed recognition part of the task. A contrast score is provided to compare performance on the immediate and delayed phases.
3.4 Memory for Names and Memory for Names Delayed	5–16	Verbal learning, verbal retrieval paired with visual stimuli, attention, planning, delayed recall	Participants are presented with a series of cards that have pictures of children's faces. The examiner tells the examinee a name to go with each face presented. The examiner then shuffles the cards and asks the examinee to identify the names that go with each face. This is repeated for three trials. After 25 to 35 minutes, the examinee is again presented with the cards and asked to identify the name of each child pictured.
3.5 Narrative Memory	3–16	Receptive language, expressive language, language encoding and retrieval, oral comprehension, attention, working memory	Examinees are read a story by the examiner and then are asked to retell the story. After examinees retell the story, they are prompted for content that they missed. An easier story and a harder story have been added to the NEPSY-II to better cover the age levels. The score on this subtest is based on the number of items recalled (under free recall and prompted conditions); items recalled under the free-recall task receive more points.

	3.6 Sentence Repetition	3–6	Verbal short-term memory, attention, expressive language	Examinees are asked to repeat verbatim sentences of increasing length. One of the advantages of this subtest over other memory span auditory tests is that the task contains a naturalistic component that is related to everyday functioning.
	3.7 Word List Interference*	7–16	Verbal working memory, receptive and expressive language	The examiner reads two group of words (two to five words in length) and the examinee repeats each list immediately after it is read and then is asked to recall both lists. Behavioral observations are made regarding the number of times the examinee asks for the words to be repeated.
Sensorimotor Functioning Domain	4.1 Fingertip Tapping	5–16	Fine motor coordination and control	Part 1 of this task has the examinee tap his or her index finger against the thumb, first with the preferred hand, and then with the nondominant hand. The second component of this task asks the examinee to tap the four fingers of the dominant hand against the thumb in a sequential pattern and then repeat with the nondominant hand. Qualitative observations include rate changes, incorrect positions, opposite-hand mirroring, and speech action during finger movement.
	4.2 Imitating Hand Positions	3–12	Fine motor coordination, tactile processing; kinesthetic praxis (ability to perform skilled movement)	The examiner models a variety of hand positions that the examinee must imitate, first with the preferred hand and then with the nonpreferred hand. Behavioral observations on this task include noting if the examinee uses one hand to help set the acting hand into position (which is not allowed) and observing if the other hand mirrors the task. This subtest was not renormed, and no modifications to the 1998 version of the NEPSY were made.

(*Continued*)

Table 7.2

NEPSY-II SUBTEST DESCRIPTIONS AND ABILITIES MEASURED[1] (*Continued*)

	SUBTEST	AGES	COGNITIVE ABILITIES MEASURED	SUBTEST DESCRIPTION
	4.3 Manual Motor Series	3–12	Sequential motor ability, attention	The examiner models a series of hand movements and the examinee imitates the motions. This subtest was not renormed, and no modifications to the 1998 version of the NEPSY were made.
	4.4 Visuomotor Precision	3–12	Graphomotor skills, fine motor ability, visual-spatial integration, self-regulation, visuo-motor coordination, planning	The examinee is required to use a pencil to quickly draw a line inside a track that resembles a racing track or train tracks. Behavioral observations are made regarding the examinee's pencil grip (i.e., mature, intermediate, immature, or variable).
Social Perception Domain	5.1 Affect Recognition*	3–16	Affect recognition, affect identification, interpretation of nonverbal cues, visual attention, visual discrimination	This subtest is made up of four tasks of increasing difficulty that ask the examinee to recognize affect from photographs of children's faces. In the first task, the examinee must view two children's faces and determine whether the children feel the same way. The next three tasks involve matching the faces of children who have the same affect. The tasks do not require a verbal response in order to allow nonverbal communication

	5.2 Theory of Mind*	3–16	Comprehension of others' perspectives, experiences, and beliefs; attention/ concentration	This subtest involves two tasks. In the first, the examinee is read scenarios and shown pictures by the examiner and then must take on another individual's perspective to answer a question correctly (e.g., the examinee is shown a picture of a boy standing with a briefcase dressed in a suit that is too big; the examinee must indicate what the boy is pretending to be, such as a business man or teacher). In the second task, the examinee must select from four faces the appropriate face for a pictured situation (e.g., the examinee is asked to identify the correct affect for a girl who just fell off her bike). Both tasks involve the ability to take on another person's perspective and recognize appropriate affect.
Visuospatial Domain	6.1 Arrows	5–16	Visuospatial skills, planning, judging direction, estimating distance, orientation	This visual-spatial task requires the examinee to look at a stimulus booklet, which contains a series of drawings with a target in the center of the page and numbered arrows that point in the direction of the target. However, only two arrows are pointing to the center of the target, and the examinee must choose the correct arrows. This is an interesting visual-spatial task because it does not require motor skills.
	6.2 Block Construction	3–16	Visuospatial skills, visuomotor skills, motor skills	This task involves manipulating a set of blocks to match a picture in the stimulus book. The examinee has 30 or 60 seconds to arrange the blocks exactly as they appear in the picture. An extra point is awarded on the last nine items when examinees finish in 20 seconds or less.

(*Continued*)

Table 7.2

NEPSY-II SUBTEST DESCRIPTIONS AND ABILITIES MEASURED[1] (*Continued*)

SUBTEST	AGES	COGNITIVE ABILITIES MEASURED	SUBTEST DESCRIPTION
6.3 Design Copying	3–16	Visuospatial skills, visuomotor skills, planning	The examinee is required to copy a series of two-dimensional drawings of increasing difficulty from a stimulus booklet. The scoring considers the overall gestalt of the figure, fine motor skills, and attention to detail.
6.4 Geometric Puzzles*	3–16	Mental rotation, visuospatial analysis, attention to detail	A large grid is presented with several black shapes inside it. Various shapes are also presented outside the grid. The examinee must match the shapes that are outside the grid with the shapes inside the grid.
6.5 Picture Puzzles*	7–16	Visual discrimination, spatial localization, visual scanning, simultaneous processing	A large picture is presented within a grid, and four smaller pictures are presented outside a grid. Each of the four smaller pictures can be found in the larger picture. The examinee must match where each of the smaller pictures fit into the larger picture.
6.6 Route Finding	5–12	Visuospatial relations and orientation	The examinee is shown a map with a house and then asked to find the same house on a larger, more detailed map. This subtest was not renormed, and no modifications to the 1998 version of the NEPSY were made.

[1] Subtest descriptions and abilities measured were adapted from Korkman et al. (2007).
* The subtest is new for the NEPSY-II.

methods (i.e., degree to which two halves of the subtest correlate) and alpha methods (i.e., degree to which individual items correlate with each other). A test-retest method (i.e., degree to which a subtest correlates with itself when administered to the same individual twice) was used to report some subtest reliabilities when it was not feasible to divide the subtest into equivalent halves. Approximately 80% of the reliability coefficients are above .70 for subtest scores in the normative sample. However, those subtest scores that have a reliability coefficient below .70 should be approached with caution. Reliabilities that fall at .60 or below are of particular concern. Subtest scores with very low reliability reported by Korkman et al. (2007) in Table 4.1 include Design Fluency total score for ages 5 to 12 (.59), Word Generation Semantic total score for ages 3 and 4 (.59), Memory for Designs Content score for ages 3 and 4 (.47), Design Copying Local score for ages 7 to 12 (.57). These three subtests do not appear to be reliable measures of functioning at the specified ages.

A consistency of classification criteria was used for subtests that had highly skewed and limited score ranges when a test-retest method was used. To obtain the consistency of classification, Korkman et al. (2007) provided the percentage of the standardization sample who scored at the 10th percentile or less on both administrations of the same subtest (see tables 4.4, 4.5, and 4.6 in Korkman et al., 2007). The consistency of classification for various subtest scores may be examined in tables 4.4, 4.5, and 4.6 of the NEPSY-II clinical and interpretative manual. The consistency of classification scores for Oromotor Sequences (.50 to .73), Manual Motor Series (.46 to .63), and Route Finding (.61 to .75) indicate that these subtests are not reliable for identifying neuropsychological deficits in certain age groups of children and adolescents. These subtests should not be used for making diagnostic decisions. The examiner should consult the reliability scores for various age groups when deciding which subtests to administer and also recognize the type of reliability procedure that was used (e.g., split-half, consistency of classification criteria). The lowest reliability coefficients often appear on the low or high end of the age ranges, which means that the examiner should be cautious when administering a subtest at either end of the age range continuum.

The NEPSY-II clinical and interpretive manual (Korkman et al., 2007) provides evidence of content, concurrent, and construct validity. To provide evidence of content validity, the authors indicated that the revision process included multiple revisions of test content based on a review of the research literature, the authors' clinical and research experience, expert analysis, pilot studies, and qualitative analysis of individual responses to test items. Evidence for construct validity seems questionable in some areas. Examination of the table of correlations among subtests raises more questions about the validity of domains used to organize subtests. Subtests that appear to fit better with a different domain include Animal Sorting (within-domain correlations for ages 7 to 12 range from .08 to .24), Narrative Memory (within-domain correlations for ages 7 to 12 range from .05 to .17), and Visuomotor Precision (within-domain correlations for ages 7 to 12 range from–.07 to–.02). All three of these subtests showed higher correlations with subtests from other domains, which suggests that they may fit better in a different domain. Korkman et al. (2007) account for the low correlations between subtests in the same domain by indicating that various subtests may measure very different neuropsychological functions within a single domain.

The relationship between NEPSY-II subtests and other measures of cognitive, neuropsychological, academic, adaptive, and behavioral functioning was considered in the examination of the concurrent validity. Correlations of the NEPSY-II with the 1998 version of the NEPSY ranged from .35 on the Auditory Attention task to .83 on Sentence Repetition. As would be expected, subtests with less revision of items had higher correlations.

More research concerning the reliability and validity of the NEPSY-II is needed. Although most subtests appear to have adequate initial reliability and validity, some of the subtests may not provide consistent and accurate scores. Design Fluency, Oromotor Sequences, Manual Motor Series, and Route Finding appear to have low reliability. The reliability should also be examined before the NEPSY-II subtests are administered to young children (i.e., some subtests show poor reliability for ages 3 to 5). Animal Sorting, Narrative Memory, and Visuomotor Precision should be interpreted with care since they do not appear to measure the same construct as other subtests in these domains. The fact that these subtests were included in the NEPSY-II despite these psychometric problems raises concern.

CLINICAL UTILITY OF THE NEPSY-II FOR DIAGNOSIS

Since the second edition of the NEPSY has only recently been released, there are currently no independent studies in the research literature specific to the NEPSY-II. However, special group studies were conducted by Korkman et al. (2007) in order to examine the clinical utility of the

NEPSY-II. The clinical studies included groups of individuals with attention-deficit/hyperactivity disorder (*n* = 55), specific learning disorders in reading (*n* = 36), specific learning disorders in mathematics (*n* = 20), language disorders (*n* = 29), intellectual disabilities (*n* = 20), autistic disorders (*n* = 23), Asperger's disorder (*n* = 19), and emotional disabilities (*n* = 30), as well as individuals who were deaf and hard of hearing (*n* = 18). Korkman et al. indicated that independent researchers conducted these studies with small samples of convenience. The comparison samples for each clinical group were matched to a group in the standardization sample according to age, sex, race/ethnicity, and parents' educational level. Some of the clinical group studies reported by Korkman et al. in the NEPSY-II manual will be reviewed along with studies from the 1998 version of the NEPSY that provide further information on the clinical utility of the NEPSY-II in assessing special populations.

The sample of individuals diagnosed with a specific learning disability in reading (*n* = 36) scored significantly lower on the NEPSY-II on all language domain subtests, which suggests that subtests for this domain are effective in the diagnosis of reading problems (Korkman et al., 2007). Consistent with research in reading, the Phonological Processing and Speeded Naming subtests showed the largest discrepancies (Wolf & Bowers, 1999). Research using the 1998 NEPSY suggests that the test may be useful in differentiating among children with reading disabilities (Crews & D'Amato, in press). In a research study, Crews and D'Amato were able to differentiate subtypes of reading disabilities by using the memory and learning domain and the language domain subtests of the NEPSY.

The clinical group of individuals with a learning disability in mathematics (*n* = 20) had significantly lower scores than controls on some subtests in the attention and executive functioning domain (i.e., Auditory Attention and Response Set, and Inhibition Naming), the memory and learning domain (i.e., Memory for Designs, Memory for Faces, Narrative Memory, and Word List Interference), and the visuospatial domain (i.e., Block Construction, Geometric Puzzles, and Picture Puzzles). Thus, the NEPSY-II appears to show differences in attention, executive functioning, and visuospatial processing for children and adolescents with a learning disability in math (Korkman et al., 2007).

In another study, Bjoraker (2001) found that children diagnosed with an emotional disability differed significantly from those in a control group, and that all NEPSY composite scores contributed to the difference. The largest difference between groups was found on the language domain. Korkman et al. (2007) also indicated deficits in all domains for the group diagnosed with an emotional disability (n = 30), compared to a control sample. Although scores were low for two language domain subtests (Comprehension of Instructions and Speeded Naming), the lowest score appeared on the Inhibition Switching score in the attention and executive functioning domain. More research is needed to determine what subtests are most useful in distinguishing children with an emotional disability from those in a normal control group.

In the clinical group study of children with autism (n = 23), Korkman et al. (2007) reported lower functioning on subtests across all domains of the NEPSY-II, with the most severe difficulties in executive functioning, language, and memory. The lowest scores for the group with autism were in the Animal Sorting, Comprehensions of Instructions, Narrative Memory, and Word List Interference subtests. The sample of individuals diagnosed with Asperger's disorder (n = 19), which is also an autism spectrum disorder, scored lower than the standardization sample on subtests that involved speed, visual memory, attention, fine motor skills, and visuoconstructive abilities. Children with Asperger's generally showed adequate language and verbal memory and better affect recognition than children diagnosed with autism. These results are consistent with previous studies that examined children with autism spectrum disorders. Several studies established that children diagnosed with autism scored significantly lower on the executive functioning domain of the NEPSY than a control group (Hooper, Poon, Marcus, & Fine, 2006; Joseph, McGrath, & Tager-Flusberg, 2005). It was found that the NEPSY was a useful assessment tool in gathering information on the neuropsychological functioning of children with autism and appeared to add unique information beyond what a traditional intelligence test would provide (Hooper et al., 2006).

Children in an ADHD clinical group reported in the NEPSY-II manual scored significantly lower than a control group sample on a number of subtests from different domains that had an attention component (e.g., Phonological Processing, Speeded Naming, Visuomotor Precision, Arrows, and Geometric Puzzles; Korkman et al., 2007). All subtests except for Animal Sorting were significant in the attention and executive functioning domain, and the Auditory Attention and Response Set subtest had the highest effect size (Korkman et al., 2001). Thus, the NEPSY-II appeared valid in distinguishing between individuals with and without ADHD. This is consistent with the findings of Ahmad and Warriner (2001), who suggested that the NEPSY may be particularly useful in diagnosing children with ADHD.

In addition to the relationship between deficits in the attention and executive functioning domain and ADHD, several other studies indicated preliminary support for the validity of this domain in assessments of groups of children with various disorders (O'Brien et al., 2004; Riddle, Morton, Sampson, Vachha, & Adams, 2005). O'Brien et al. (2004) found significant differences between the findings on the attention and executive functioning domain of the NEPSY for children diagnosed as sleep disordered and those for a control group matched for gender, ethnicity, age, maternal education level, and maternal smoking. Similarly, statistically significant moderate to strong correlations between the attention and executive functioning domain of the NEPSY and other executive functioning measures were indicated for 30 children diagnosed with spina bifida and hydrocephalus (Riddle et al., 2005). However, the relationships between the attention and executive functioning domain of the NEPSY and other measures were significantly mediated by intelligence scores, which limits the evidence for convergent validity of the attention and executive functioning domain on the NEPSY for this population. A review of available research may have led to the revision of the underlying structure of the domains for the new NEPSY-II (Davis & D'Amato, 2005; Stinnett et al., 2002).

These studies generally support the clinical usefulness of the NEPSY-II in distinguishing between various neuropsychological disorders and also support the use of selected subtests with various populations (Schmitt & Wodrich, 2004). The NEPSY-II appears to be especially effective in assessing children with ADHD, autism spectrum disorders, and learning disabilities. More research is needed to support and expand on the findings in the NEPSY-II manual and previous research using the NEPSY (e.g., Crews & D'Amato, in press; Hooper et al., 2006).

INTERPRETATION

As with any neuropsychological test or battery, caution should be exercised in drawing brain-related conclusions about evaluation results unless the examiner is trained in neuropsychological assessment, interpretation, and intervention development. The NEPSY-II should only be interpreted by an examiner who is familiar with theories and research related to typical and atypical neuropsychological development. Although the NEPSY-II may be useful in helping to determine whether a child or adolescent meets *DSM-IV-TR* criteria, it was not designed to focus on diagnostic considerations alone (Korkman et al., 2007). The majority of the NEPSY-II is easy to administer and score, and any psychologist with sufficient training in neuropsychology is able to administer these tasks. The NEPSY-II is also easy to interpret, and psychologists can draw a tremendous amount of behavioral information for neuropsychological intervention. Evaluation results should be interpreted in light of everyday observations by the child's parents, teachers, and other professionals, and other available psychological data, since even a normally developing child or adolescent may display below average performance on some of the NEPSY-II subtests (D'Amato et al., 2005; Korkman et al., 2007).

One of the strengths of the NEPSY-II is the different types of scores for interpreting performance in different neuropsychological functions. The NEPSY-II features primary scores, contrast scores, and behavioral observation scores. The primary scores represent the overall performance on a subtest, which is usually given as a scaled score on the NEPSY-II. Contrast scores allow the psychologist to compare two primary scores to determine whether the processing deficit is related to higher- or lower-level cognitive functioning. Finally, some behavioral observations may be represented as quantitative scores on the NEPSY-II. These scores provide the examiner with tools to thoroughly assess neuropsychological functioning.

Interpretation of the NEPSY-II should be a multifaceted process, the depth of which depends on the user's familiarity with neuropsychology and the underlying paradigm that flows from the theoretical construct on which the NEPSY-II was based (Korkman et al., 2007). Intra-individual analysis is especially useful on this measure since psychologists can use neuropsychological strengths uncovered on this instrument to compensate for neuropsychological weaknesses when planning interventions. The NEPSY-II clinical and interpretative manual by Korkman et al. (2007) provides a wealth of information about interpreting and analyzing scaled scores and percentile ranks, and interested readers are directed to that source.

CONCLUSION

The NEPSY-II may be used to assess neuropsychological skills or domains across the areas of attention and executive functioning, language, memory and learning, sensorimotor skills, social perception, and visuospatial processing. Few contemporary neuropsychological batteries have been designed to meet the needs of children and adolescents. The NEPSY-II is child friendly, flexible, and more educationally focused than traditional neuropsychological tests. This measure has many strengths, including a broad and representative standardization sample, excellent clinical utility, and a variety of different scores that can be obtained to help interpret performance. The instrument's integration of qualitative and quantitative evidence from a Lurian perspective allows for an in-depth consideration of a child or adolescent's ability to process information. The NEPSY-II appears to hold great promise and is an excellent instrument that provides reliable and useful information regarding the neuropsychological functioning of children and adolescents.

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8

Understanding and Using the Dean-Woodcock Neuropsychological Battery With Children, Youth, Adults, and in Geriatrics

ANDREW S. DAVIS

The assessment of neurocognitive and sensorimotor functioning is a customary aspect of neurological and neuropsychological examinations. Whether done formally or informally, the assessment of these areas is integral to the determination of functional capacity and is also necessary for gauging performance on other neuropsychological assessment domains. For example, poor performance on a block construction task cannot be accurately attributed to a higher-order processing deficit unless lower-order processes such as motor coordination and tactile perception are examined. Despite the critical importance of accurately quantifying sensory and motor deficits, many neurologists and neuropsychologists rely upon qualitative estimations or patient reports. This is particularly problematic, considering that even one error on a sensory or motor task may be pathognomic of dysfunction and/or provide important information regarding lateralization of cerebral impairment. The sensitivity of sensorimotor measures can be contrasted to a crystallized knowledge (e.g., a vocabulary) test on which the patient may miss several items and still be considered to have intact functioning. The assessment of sensory and motor functioning is particularly critical for treatment planning and interventions because patients who struggle with sensory and motor skills have significant levels of difficulty effectively interacting with their environments. The use of a standardized and norm-referenced approach to the measurement of sensorimotor functioning increases in importance for the intervention or rehabilitation process because longitudinal measurements are often used to mark or measure progress. Repeated quantitative, as opposed to qualitative, assessments of sensorimotor functioning are more likely to accurately reflect change during the rehabilitation process.

The Dean-Woodcock Sensory-Motor Battery is part of the Dean-Woodcock Neuropsychological Battery (DWNB; Dean & Woodcock, 2003), although it can also be used as an independent measure. In addition to the Dean-Woodcock Sensory-Motor Battery, the Dean-Woodcock Neuropsychological Battery includes the Emotional Status Examination, the Structured Neuropsychological Interview, the Woodcock-Johnson III Tests of Cognitive Abilities, and the Woodcock-Johnson III Tests of Achievement. This chapter will primarily focus on the Dean-Woodcock Sensory-Motor Battery because it represents the newest and most innovative of the components of the DWNB; however, a review of the other elements of the battery will also be offered.

THE DEAN-WOODCOCK SENSORY-MOTOR BATTERY (DWSMB)

The DWSMB arose from the need for a comprehensive, standardized measure of sensorimotor functioning that could overcome some of the psychometric shortcomings of other measures. Indeed, many sensory and motor tests do not offer their users information regarding validity and reliability (Woodward, Ridenour, Dean, & Woodcock, 2002). Many of the measures of the DWSMB are drawn from traditional neuropsychological and neurological tasks. For example, several of the tasks of the DWSMB are similar to those from the widely used and respected Halstead-Reitan Neuropsychological Test Battery (Reitan & Wolfson, 1993). However, the DWSMB offers several advantages compared to several other measures of sensory and motor functioning. These advantages include a large, recently collected normative sample; easy portability; and derived W-scores, which allow for a wider quantification of ability than cutoff scores. The use of derived standard scores, as opposed to cutoff scores (i.e., scores that indicate only if an examinee can or cannot perform a task), is especially useful in rehabilitative settings to measure improvements or declines within a skill set, given that there is an expanded floor and ceiling as opposed to scores of 0 or 1.

The DWSMB can be administered by examiners fully trained in psychological assessment, although the examiner should use caution when interpreting the battery unless he or she has extensive training in neuropsychology. The administration time of the DWSMB is approximately 45 minutes, and it is relatively easy to administer with sufficient practice. The DWSMB has 18 subtests, 8 of which are designed to measure sensory functions (e.g., auditory, tactile, and visual perception), and 10 that measure cortical and subcortical motor functions. Some of the subtests have multiple scales, such as dominant hand versus nondominant hand or left versus right functioning. The subtests from the DWSMB are displayed in Table 8.1 along with an easy reference indicating what each subtest measures.

One of the primary strengths of the DWSMB is the large, recently collected normative sample of 1,000 individuals ranging in age from 4 to 90. The manual, which comes with the test kit, contains the directions for standardized administration in both English and Spanish. The following section of this chapter briefly describes each subtest from the DWSMB and provides some implications for treatment planning.

DWSMB SUBTESTS

Lateral Preference Scale

This subtest was adapted from a scale published by Dean (1988) and is designed to determine a patient's handedness. Although this seems like one could accomplish this by simply asking the patient, it is important to quantitatively determine the patient's dominant hand since many tests of the DWSMB require a differentiation between the patient's dominant and nondominant hands. A five-point Likert scale is used to score this subtest, which gauges which hand or leg the examinee uses to conduct 17 different motor movements. The correct establishment of hand dominance is critical in gauging lateralization of cerebral functions.

Near-Point Visual Acuity

The formal assessment of visual acuity is one of the most overlooked aspects of typical neuropsychological assessments. Although it is common to ask whether patients wear glasses or contacts or can see the test materials, quantitative analysis of corrected vision is not typical. This

Table 8.1

SUBTESTS OF THE DWSMB

DWSMB SUBTEST	ABILITY OR SYMPTOM ASSESSED
Sensory Subtests	
Lateral Preference Scale	Laterality and handedness
Near-Point Visual Acuity	Corrected visual acuity, visual perception
Visual Confrontation	Peripheral visual fields
Naming Pictures of Objects	Dysnomia, anomia, visual dysgnosia, visual agnosia, confrontation naming, expressive language
Auditory Acuity	Auditory acuity
Palm Writing	Graphesthesia, tactile discrimination
Object Identification	Astereognosis
Finger Identification	Asomatognosia, finger agnosia
Simultaneous Localization (Hands only, hand and cheek)	Asomatognosia, broad sensory and tactile reception, left-right confusion
Motor Tests	
Gait and Station	Ataxia, coordination, lower extremity gross motor functioning, presence of subcortical lesions, spasticity
Romberg	Cerebellar dysfunction, vestibular dysfunction
Construction	Construction dyspraxia, visual motor integration, visuospatial awareness and memory
Coordination (Finger-to-nose, hand-to-thigh)	Coordinated motor movement at the cerebral and cerebellar levels, myoclonic jerks, upper extremity motor functioning
Mime Movements	Ideomotor dyspraxia, receptive language, verbal agnosia
Left-Right Movements	Left-right confusion, perseveration
Finger Tapping	Fine motor speed, manual dexterity, overall functioning of the motor strip and precentral gyrus
Expressive Speech	Dysarthria, dysnomia, peripheral speech mechanisms

(*Continued*)

Table 8.1

DWSMB SUBTEST	ABILITY OR SYMPTOM ASSESSED
Grip Strength	Deficits in the contralateral motor strip, overall integrity of the cerebral hemispheres, upper extremity motor strength

Source: Adapted from Davis and D'Amato (2005).

is a significant oversight, given that difficulty seeing neuropsychological test materials could mask a difficulty in fluid reasoning, visual-spatial processing, visual attention, or other higher-order deficits. The Near-Point Visual Acuity subtest uses Snellen notations (e.g., 20/20 vision) and a cardboard eye occluder to measure visual acuity from a distance of about 14 inches for the left and right eyes. It is important to note that this subtest measures corrected visual acuity; patients complete this subtest while wearing their glasses or contacts. Thus, this subtest does not directly measure visual impairment but is best used as an indicator of a patient's ability to see the rest of the neuropsychological test materials. Clinically, this subtest could be useful for inspecting visual changes if the patient's prescription for glasses or contacts has recently been updated. It is also important to track visual acuity for assessment and intervention purposes, as patients may not alert the examiner or therapist if they are having trouble seeing the materials.

Visual Confrontation

Visual confrontation tests are a common aspect of neurological examinations, as they can be sensitive to sudden-onset neurological conditions, such as cerebral vascular accidents. The purpose of this subtest is to assess the integrity of the peripheral visual fields. Patients are required to keep their eyes forward and note any movements they see in the examiner's fingers as the examiner assesses the left, right, upper, and lower visual fields. Dean and Woodcock (2003) note that this subtest is useful for identifying contralateral deficits in the prechiasmal, chiasmal, and postchiasmal areas. The assessment of visual fields can also be important in making determinations about a patient's ability to safely operate a motor vehicle or perform certain vocational tasks.

Naming Pictures of Objects

This subtest requires the patient to name 21 simple objects in a stimulus booklet. This type of task is fairly typical of neurological and neuropsychological examinations, and failure or difficulty on this task is indicative of visual agnosia or a possible language disturbance, such as anomia or aphasia. Indeed, caution should be used in assuming that difficulty with this task is representative of a sensory problem, given that confrontational naming deficits are often indicative of a broader language problem (Dean & Woodcock, 2003). Naming difficulty is present in several neurological conditions, such as semantic dementia and traumatic brain injury, and can also be part of the normal aging process (Tsang & Lee, 2003).

Auditory Acuity

This subtest is similar to the Visual Acuity subtest in that a simple ability that is highly critical for valid neuropsychological test results and many types of therapy is assessed. Difficulty hearing any component of a neuropsychological test can erroneously present as agnosia, anomia, aphasia, or a receptive or expressive language deficit. Deficits in auditory acuity can have a profound impact on the ability to interact with the environment, including the ability to drive a car, hold a conversation, enjoy television or the radio, and complete vocational tasks, all of which render auditory acuity an important aspect for treatment planning. Additionally, deficits in auditory acuity have also been associated with cognitive and memory decline (Valentijn, van Boxtel, van Hooren, Bosma, Beckers, Ponds, & Jolles, 2005). In order to administer this task, the examiner stands behind the patient and rubs his or her thumb and index finger together near the patient's ears, and the patient is required to notify the examiner in which ear (or both) they hear the sound. Testing is conducted for the left ear, the right ear, and bilaterally.

Tactile Examination–Palm Writing

This subtest is a derivation of a classic measure of graphesthesia, or the ability to recognize simple stimuli (usually numbers or letters) written or traced on the palm. This subtest requires the patient to determine if an X or an O is written on his or her palm. A second task has the patient identify numbers written on his or her palm. Both the left and right hands are investigated. Tactile perception and discrimination are generally considered to be indicative of contralateral parietal involvement and thus can aid in lateralization. For example, measures of graphesthesia have been shown to be sensitive to somatosensory dysfunction in patients with strokes (Julkunen, Tenovuo, Jääskeläinen, & Hämäläinen, 2005), which can suggest lateralization. Agraphesthesia has also been seen in psychiatric conditions, such as obsessive compulsive disorder (Guz & Aygun, 2004) and schizophrenia (Chang & Lenzenweger, 2004).

Tactile Identification–Object Identification

Asking patients to identify simple objects by touch in the absence of visual stimuli (stereognosis) is a sensitive measure of tactile perception and is a typical component of many neurological and neuropsychological examinations. Both hands are tested in this subtest, which allows for input into cerebral lateralization decisions. Difficulty recognizing objects by touch suggests a deficit in tactile perception, which may lead to problems with dexterity and/or the ability to manipulate small objects. This could have a potential impact on activities of daily living and may influence some vocational tasks.

Tactile Identification–Finger Identification

The assessment for finger agnosia (the inability to recognize tactile stimuli in the fingers) is an important component of a neuropsychological examination. This is especially true in children with academic problems, as finger agnosia is a key symptom of Gerstmann's syndrome. On this subtest the patient is asked to identify which finger is being stimulated; this is conducted for both hands. Children may struggle with finger gnosis tasks up until early adolescence (Miller & Hynd, 2004), which increases the importance of using a standardized measure, such as the DWSMB, on this type of task. Finger agnosia has also been associated with other conditions. A recent study found that 37% of a sample of 38 patients with Alzheimer's disease exhibited finger agnosia, whereas none of the 10 matched controls did (Shenal, Jackson, Crucian, & Heilman, 2006). The association of finger agnosia with disorders as diverse as Gerstmann's syndrome and Alzheimer's disease increases the connection between difficulty on these types of tasks and neuropathology. Additionally, deficits in tasks used to test for finger agnosia are associated with contralateral parietal lobe involvement (Reitan & Wolfson, 1993).

Tactile Examination–Simultaneous Localization

This is perhaps the most simple of the tactile sensory tasks. Simple tactile tests can be among the most powerful predictors of impairment because the vast majority of healthy individuals will complete the entire test without errors. Unilateral single and bilateral double sensory stimulation is combined since double sensory stimulation has long been known to be more sensitive to deficits in tactile perception (e.g., Kahn, Goldfarb, Pollack, & Peck, 1960). On this subtest the examiner lightly touches the patient's hands and cheeks in a standardized series, and the patient is asked to identify the source of the stimuli.

Gait and Station

Although the assessment of gait and station is a common aspect of a neurological examination, standardized assessments of these functions are not found on commonly used neuropsychological batteries that assess sensorimotor functioning, such as the Halstead-Reitan Neuropsychological Test Battery (HRNB; Reitan & Wolfson, 1993) and the Luria-Nebraska Neuropsychological Test Battery (LNNB; Golden, Purisch, & Hammeke, 1985). Indeed, the sensory and motor components of both the LNNB and the HRNB focus solely on upper-extremity motor functioning. Lower-extremity motor skills are often assessed qualitatively by neuropsychologists, although quantitative assessment offers obvious advantages, such as the ability to numerically track progress or decline for ongoing treatment planning and rehabilitation. There are four components to this subtest. The first, Gait–Free Walking, measures normal walking gait. The second, Gait–Heel-to-Toe, requires the patient to walk by directly placing one foot in front of the other, with the front foot's heel touching the back foot's toe. The third task, Gait-Hopping, requires the patient to hop on one foot and then the other. The final task, Station, examines the patient's ability to stand steady with feet together and eyes open. Dean and Woodcock (2003) note that this subtest is thought to be sensitive to the presence of subcortical lesions.

Romberg

The Romberg test is a classic test typically used in neurological examinations. It was derived from the work of Moritz Heinrich Romberg (1795–1873) and reported in Dr. Edward Sieveking's *Manual of the Nervous Diseases in Man* in 1853 (Rogers, 1980). The Romberg sign is generally observed when there is a deterioration in standing balance (including increased swaying and possible falling) when the patient's eyes are closed. Loss of balance is an important indicator in several neurological conditions and is frequently reported in the brain injury literature. Campbell and Parry (2005) describe the impact that dysfunctional balance can have and the importance of assessing balance in the process of treatment planning:

> Disordered balance has the potential to limit many aspects of personal and social participation. Efficient performance of functional movement is dependent on good balance or postural control to provide a background of stability and to orientate the body with regard to gravity during movement (Shumway-Cook & Woollacott, 2001). In addition, the balance system is directly involved in holding the object of gaze steady with regard to the fovea, the primary area of focus on the retina of the eye, and in processing and synthesizing sensory information upon which overall orientation and safety within the wider environment are judged. (Qtd. in Nolte, 1999, p. 1095)

The DWSMB improves upon the classic measure by using increasingly complex tasks that allow for more sensitivity to balance problems.

Construction

The ability to construct designs based upon visual representations using drawing or manipulatives (such as matchsticks) is a common neuropsychological and psychological technique. The popularity of construction tasks likely arises from the wide range of constructs they can measure. The DWSMB uses two traditional construction tasks, one in which the patient copies a cross from a stimulus booklet, and the second in which he or she draws a clock with the hands indicating a specific time. Cross-copying tasks are indicative of sensorimotor integration and visual-spatial ability and are sensitive to construction deficits. Clock-drawing tasks have an additional cognitive component and are thus commonly used screening tools due to their sensitivity to neurological impairment. For example, performance on the clock-drawing task from the DWSMB has been shown to be sensitive to multiple sclerosis (Davis, Whited, Williams, Pass, Gupta, & Hudson, 2006). Clock-drawing tests have also been used to track reaction to intervention in Alzheimer's disease (e.g., Paskavitz, Gunstad, & Samuel, 2006). The ease of administration and short administration time can make construction tasks useful screening devices for patients in rehabilitation settings.

Coordination

The testing of coordinated smooth motor movements is an important aspect of assessing cerebellar and basal ganglia integrity; these movements can be affected by several neurological conditions, including strokes, multiple sclerosis, Parkinson's disorder, and brain injury (Swaine, Lortie, & Gravel, 2005). Disruptions in coordination can result in several complications in activities of daily living and this is thus an important component of an assessment, especially for individuals with sudden-onset neurological conditions. The coordination subtest on the DWSMB has two tasks. First, the patient is required to touch his or her nose and then the examiner's finger as the examiner moves his or her finger across the patient's field of vision. This measures the constructs of the traditional finger-to-nose task but adds a level of complexity by asking the patient to follow the examiner's fingers and then initiate and complete a movement to a moving target (i.e., the examiner's finger). The second task requires the patient to tap his or her thigh with an alternating movement of the front and back of the hand. Both tasks assess the left and right hands, which aids in lateralization of impairment.

Mime Movements

The Mime Movements subtest asks patients to mimic a series of movements performed by the examiner with the hands, head, and mouth and assesses ideomotor apraxia. Ideomotor apraxia is difficulty with the spatial or temporal components of executing well-learned, or simple, motor movements upon command in the absence of basic sensory or motor deficits (Ambrosoni, Della Sala, Motto, Oddo, & Spinnler, 2006). Deficits are generally thought to be in the motor program, or in the translation of a visualization of a mental movement into a physical movement (Ambrosoni et al., 2006). Furthermore, patients with dyspraxia are generally able to spontaneously perform the motor movement; dyspraxia is evident when the patient attempts to volitionally initiate the motor movement upon command (Kaya, Unsal-Delialioglu, Kurt, Altinok, & Ozel, 2006). There are several ways to assess dyspraxia (or apraxia), although the two primary methods revolve around verbal commands or requests for the patient to mimic motor movements. The advantage of using a mimicking approach is that there is no interference from a potential receptive language problem. The ability to follow directions for motor tasks may be a key component in patient compliance in physical or occupational rehabilitation following the sudden onset of a neurological condition, which can dramatically affect functional outcome (Kaya et al., 2006).

Left-Right Movements

On this subtest, examinees are required to follow a series of directions using their left and right hands as well as identify the left and right sides of their body. Difficulty with knowing the left versus the right side of the body generally does not occur past the age of 9; therefore, difficulty with this task after this age may be indicative of neurological impairment (Dean & Woodcock, 2003). There is a developmental component in the acquisition of the ability to differentiate between the left and right sides of the body, as evidenced by the inclusion of left-right differential questions on the 1916 version of the Stanford-Binet intelligence test (Jordan, Wustenberg, Jaspers-Feyer, Fellbrich, & Peters, 2006). Indicators of left-right confusion are a sign (along with finger agnosia) of Gerstmann's syndrome and may be predictive of academic problems. For example, Stein (2001) indicates that left-right confusion may be a helpful factor in diagnosing dyslexia.

Finger Tapping

Measures of finger tapping, or finger oscillation, are common in neuropsychological test batteries such as the HRNB, the LNNB, and the NEPSY (Korkman, Kirk, & Kemp, 1998). Finger-tapping measures are commonly used to assess lateralization since unilateral impairment tends to affect the motor speed of the contralateral hand. This renders finger-tapping tests particularly useful in conditions such as unilateral stroke for tracking progress of recovery. Interestingly, recent research has revealed that ipsalateral finger tapping in patients with unilateral strokes may also be negatively affected, and this ability may even be predictive of recovery (de Groot-Driessen, van de Sande, & van Heugten, 2006). One of the advantages of the DWSMB Finger Tapping subtest is that an inexpensive calculator can be used to record the examinee's responses, which can greatly reduce the cost of purchasing or replacing equipment.

Expressive Speech

The assessment of expressive and receptive language should be part of a comprehensive neuropsychological examination. The purpose of the Expressive Speech subtest from the DWSMB is not to assess expressive language, but to examine dysarthria (i.e., weakness or incoordination of the muscles necessary for speech production). Dysarthria may affect the timing, strength, rate, and accuracy of speech and typically arises from the incoordination and hypotonia associated with cerebellar lesions (Paquier & Marien, 2005). The Expressive Speech subtest requires the patient to repeat simple words and phrases. Difficulty on this subtest may reflect a language problem, but the results should not be used to diagnose a language problem without corroborating evidence.

Grip Strength

The assessment of a patient's grip strength is a typical part of the neurological examination and is also common in neuropsychological assessment (e.g., the HRNB). Although neurologists typically assess grip strength, it is usually done through qualitative techniques such as asking the patient to squeeze his or her fingers. Although this can help with lateralization and a qualitative rating (e.g., 4/5), the DWSMB uses a hand dynometer, which allows for a more accurate quantification of deficits. As with other tests in this battery, the quantification of deficits allows for more accurate tracking of progress for ongoing treatment planning. Grip strength is particularly useful since it is a traditional measure of contralateral cortical integrity, particularly the contralateral motor strip (Dean & Woodcock, 2003).

VALIDATION OF THE DWSMB

As with any new test, it is necessary to examine the psychometric properties of the DWSMB before gauging its reliability and validity. This is somewhat of a unique proposition for the DWSMB, considering it is largely based upon extremely well-validated measures that have been used for decades in both neurology and clinical neuropsychology. However, the addition of a large normative sample and derived W-scores mandate that statistical analysis be conducted to determine the usefulness of the normative sample and standardized instructions. To date, a review of the literature reveals that many of the publications involving the DWSMB have been conducted by the test authors and the author of this chapter. However, an objective review of the published and presented data so far has yielded promising results. There has been only one published study involving the reliability of the DWSMB. An unpublished version of the battery was determined by Woodward et al. (2002)

to demonstrate sufficient inter-rater reliability. This is important, given that, even though the test is standardized, several subtests still require the examiner to make subjective ratings. It is important to note that the standardization and quantification of sensory and motor tasks alone represent an important improvement in reliability over the traditional qualitative orientation of many of these measures. For example, simply using a hand dynometer instead of asking the patient to squeeze the examiner's fingers improves the reliability of measures of grip strength.

The validity of the DWSMB has been investigated through the use of factor analysis. Davis, Finch, Dean, and Woodcock (2006) investigated the construct validity of the DWSMB with a combined sample consisting of 1,651 individuals, 701 of whom had psychiatric and/or neurological impairment and 950 healthy individuals. Exploratory factor analysis was used with principle axis factoring. The analysis revealed that a three-factor solution accounted for 58.2% of the variance. The results of the factor analysis from this study are displayed in Table 8.2.

Although some may have expected a two-factor solution (sensory and motor), this was not hypothesized as a result of several more complex delineations among the constructs, namely simple versus complex and cortical versus subcortical abilities. The first factor, simple sensory skills, was comprised of tasks that require the individual to perceive and discriminate tactile stimuli. The increased evidence of cross-loadings as the tactile identification task increased in complexity provides evidence for the simple versus complex hypothesis aspect of sensory skills. The second factor, cortical motor and complex sensory skills, consisted of more complex sensory tasks, Palm Writing and Object Identification (i.e., measures of graphesthesia and stereognosis, respectively), and motor tasks, which are primarily associated with the contralateral motor strip. The third factor, subcortical motor tasks and auditory/visual acuity skills, consisted of subcortical motor tasks (e.g., Coordination, Romberg, Gait and Station) and visual and auditory acuity subtests. The factor loadings in Table 8.2 demonstrate good construct validity in regards to the construction of the DWSMB and should serve to aid in ipsative analysis.

Another validity study that also demonstrated the clinical utility of the DWSMB in identifying pathognomic signs of dysfunction was conducted by Davis, Finch, Trinkle, Dean, and Woodcock (2007). They used classification and regression tree analysis to develop a hierarchical decision tree for the subtests of the DWSMB with a neurologically impaired and a nonclinical group. Cross validation of the hierarchical decision tree

Table 8.2

PROMAX FACTOR LOADING MATRIX FROM DAVIS, FINCH, DEAN, & WOODCOCK (2006)

DWSMB SUBTEST	FACTOR 1	FACTOR 2	FACTOR 3
Simultaneous Localization Hand (left)	**.973**	−1.60	−0.52
Simultaneous Localization Hand (right)	**.968**	−1.58	−0.56
Simultaneous Localization Hand (both)	**.935**	−1.60	−0.20
Simultaneous Localization Hands and Cheeks (left)	**.802**	.066	.020
Simultaneous Localization Hands and Cheeks (right)	**.798**	.076	.009
Simultaneous Localization Hand and Cheek (simultaneous)	**.756**	.095	.033
Visual Confrontation Total (right)	**.688**	.027	.048
Visual Confrontation Total (both)	**.664**	.000	.130
Visual Confrontation Total (left)	**.657**	.052	.093
Finger Identification (right)	**.462**	.375	−.036
Finger Identification (left)	**.450**	.403	−.042
Grip Strength (dominant)	−.043	**.884**	−.137
Grip Strength (nondominant)	−.049	**.859**	−.113
Finger Tapping (nondominant)	−.129	**.815**	.025
Finger Tapping (dominant)	−.098	**.742**	.050
Coordination Hand-to-Thigh (right)	–.252	**.721**	.235
Coordination Hand-to-Thigh (left)	−.253	**.719**	.231
Construction Part B	.161	**.688**	−.082
Object Identification (right)	.270	**.549**	−.088
Construction Part A	.144	**.548**	.145
Palm Writing Total (nondominant)	.380	**.538**	−.104
Object Identification (left)	.196	**.537**	−.009
Palm Writing Total (dominant)	.395	**.509**	−.095
Left-Right Movements Total	.332	**.422**	−.141
Expressive Speech	.158	**.402**	.042

(*Continued*)

Table 8.2

DWSMB SUBTEST	FACTOR 1	2	3
Mime Movements	.252	**.370**	.103
Auditory Acuity (both)	.078	−.099	**.836**
Auditory Acuity (left)	.108	−.109	**.800**
Auditory Acuity (right)	.150	−.111	**.768**
Gait and Station	.103	.168	**.622**
Romberg	.077	.131	**.583**
Near-Point Visual Acuity (right eye)	−.180	.020	**.611**
Near-Point Visual Acuity (left eye)	−.197	.018	**.588**
Coordination Finger-to-Nose (right)	−.146	.171	**.384**
Coordination Finger-to-Nose (left)	.163	.175	**.351**

Note: Numbers in bold indicate the variable loaded on that factor.

revealed that the model correctly predicted 84.5% of the nonclinical group and 71.4% of the neurologically impaired group. These high prediction variables are particularly impressive when one considers that *only* sensory and motor tasks were used; there were no measures of higher-order cortical functioning, such as intelligence, memory, or language, used to differentiate the two groups. Classification and regression tree analysis shows great promise for differential diagnosis; however, more research is needed for specific diagnoses. The results of the hierarchical decision tree from the Davis, Finch, Trinkle, et al. (2007) study are displayed in Figure 8.1. The scores represent derived W-scores.

In summary, it can be generally judged that the DWSMB seems to exhibit sound psychometric properties. As mentioned, many of the measures employed in the DWSMB are adapted from traditional measures with extensive histories of validation. However, as with any new test, some caution must be used since, as of this writing, the published DWSMB is only 4 years old and relatively few validation studies have appeared in the literature.

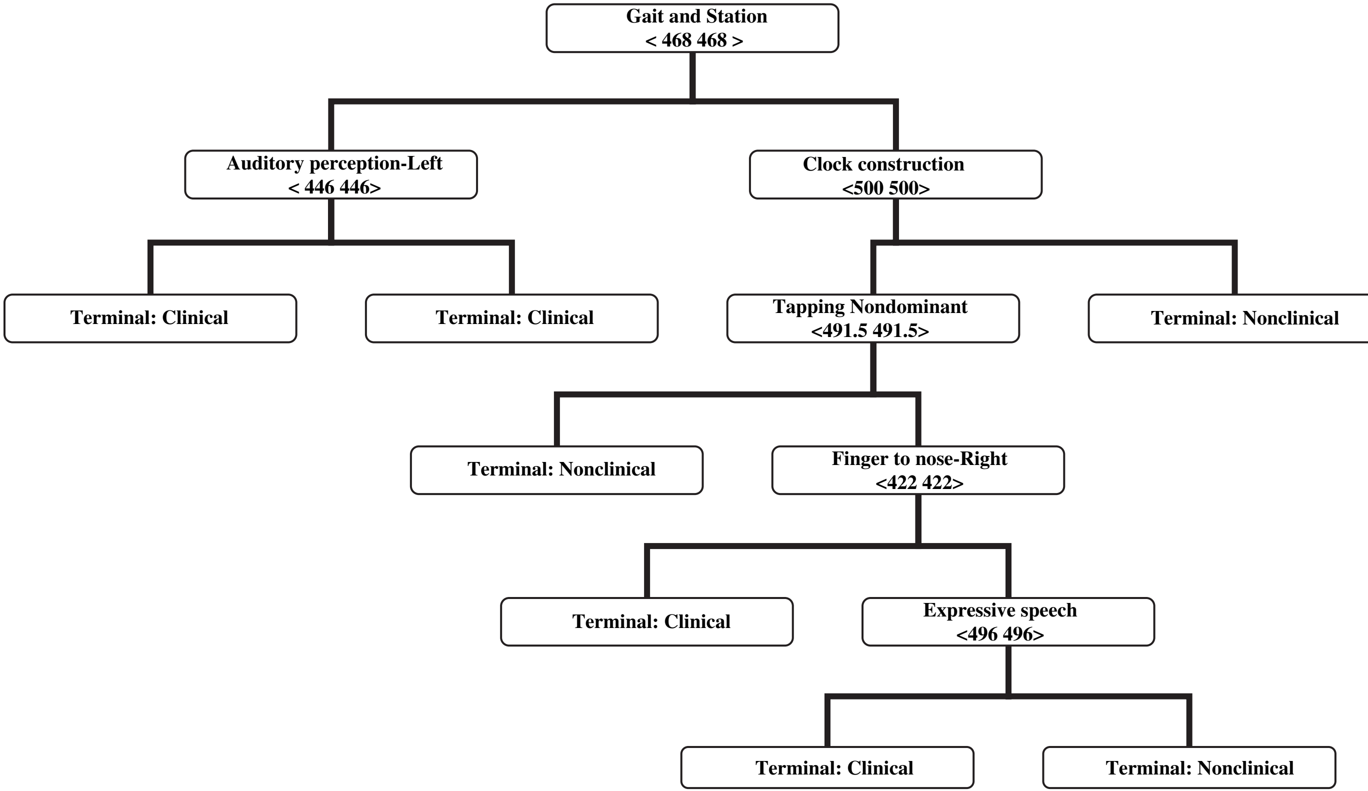

Figure 8.1 Classification and regression tree analysis results from the Davis, Finch, Trinkle, et al. (2007) study for the DWSMB. Numbers in boxes represent W-scores from the DWSMB.

CLINICAL RECOMMENDATIONS FOR PROFESSIONAL PRACTICE FOR THE DWSMB

The ease of administration, short administration time, standardized instructions, large normative sample, and wide variety of sensorimotor skills of the DWSMB make a case for its use in assessments of patients with known or suspected neurological conditions. Although a case could be made that not all patients with neurological impairment demonstrate sensorimotor deficits, some recent research is suggesting a more salient role for sensorimotor skill deficits. For example, an unpublished study conducted by Davis, Finch, Dean, and Woodcock (2007) investigated the relationship between sensorimotor skills and higher-order processing, such as cognitive processing and academic achievement. The authors used canonical correlation to investigate 265 children with neurological and psychiatric impairment. After age was partialed out, which was necessary due to the use of W-scores, there was a 90% overlap in variance between sensorimotor skills and academic achievement and 92% overlap in variance between sensorimotor skills and cognitive processing. Some degree of overlap in variance was expected, but certainly not to the extent demonstrated in this analysis. The shared variance suggests that many neurological and psychiatric disorders in children have a sensory and motor component, which further recommends the assessment of these skills in a multitude of clinical conditions.

The Dean-Woodcock Emotional Status Examination (DW-ESE)

The Dean-Woodcock Emotional Status Examination (Dean & Woodcock, 2003) offers an ideal methodology, especially for new or inexperienced neuropsychologists, for gathering social and emotional information regarding a patient's functioning on various factors that could be affecting the presentation and tracking recovery from injury. Most clinicians acknowledge the influence of psychiatric functioning on neurological status, although the reliance on lengthy measures of personality often precludes quantitative measurement. The DW-ESE offers a comprehensive measure of psychiatric functioning that is much briefer, although it is obviously lacking in history of psychometric validity compared to traditional measures (e.g., the Minnesota Multiphasic Personality Inventory). The DW-ESE can be used to collect information from either the patient or an informant who is familiar with the patient.

There are three sections to the DW-ESE. The patient's identifying demographic information is entered in the first section. The second section uses a structured psychiatric interview to obtain information about the patient's emotional functioning. The questions are posed in such a fashion that an admit-deny format, which can aid new clinicians in helping to structure diagnostic questions, can be used. The structured format also ensures that longitudinal assessment consistently assesses all relevant areas of functioning. There are 50 questions that examine domains such as mood, anxiety, somatic symptoms, executive functioning, and attention. The third section allows the examiner to note behavioral observations that are indicative of signs of psychiatric and neurological functioning. This includes orientation, physical appearance, behavioral observations, emotional status, and cognitive status. This will be particularly helpful for patients in rehabilitation settings because of the fluctuating nature of some of these conditions as a result of the sequelae of some neurological and psychiatric problems. Regular assessment of these domains will allow practitioners to note longitudinal changes as they relate to the patient's recovery.

The Dean-Woodcock Structured Neuropsychological Interview (DW-SNI)

The Dean-Woodcock Structured Neuropsychological Interview (Dean & Woodcock, 2003) is a structured diagnostic interview that allows a patient's relevant history to be collected. Similar to the DW-ESE, the DW-SNI provides a structured format that is ideal for new clinicians to ensure that all relevant information is obtained. Another advantage of the DW-SNI is that the patient, or a knowledgeable informant, is able to independently complete the interview. The DW-SNI collects a patient's history and evidence of current functioning from the following seven broad areas: identifying information/biographic information, referral information/chief complaint, medical history, history of psychiatric/psychological evaluation and/or treatment, personal and social history, psychiatric and neurologic family history, and birth and development. The DW-SNI takes about 30 minutes to complete, and the information collected from this part of the DWNB makes it easy for clinicians to write the background information/chief complaint section of a neuropsychological report.

Woodcock-Johnson III

The Woodcock-Johnson III Tests of Cognitive Abilities (WJ-COG-III; Woodcock, McGrew, & Mather, 2001b), and the Woodcock-Johnson III Tests of Achievement (WJ-ACH-III; Woodcock, McGrew, & Mather, 2001a) are the cognitive and achievement components of the DWNB. The WJ-COG-III and WJ-ACH-III are some of the most widely used psychoeducational and psychological tests in school psychology and other settings, and much has been written about these tests and their previous versions. The third versions of the cognitive and achievement tests represent well-researched and well-validated measures that have been improved with each iteration. The WJ-COG-III and WJ-ACH-III were "co-normed," which greatly facilitates comparisons between the two measures. McGrew and Woodcock (2001) wrote,

> Comparisons among and between a subject's general intellectual ability (g), specific cognitive abilities, oral language, and achievement scores can be made with greater accuracy and validity than would be possible by comparing scores from separately normed instruments. Unlike other approaches, the actual discrepancy norm procedure in the WJ III is not biased by the phenomenon of regression to the mean that must be estimated and corrected for when determining an ability/achievement discrepancy. (p. 4)

Additionally, the WJ-COG-III and WJ-ACH-III offer a significant advantage compared to many other measures of cognitive processing because of their strong theoretical basis. The WJ-COG-III and WJ-ACH-III were designed based upon the Cattell-Horn-Carroll (CHC) theory of cognitive abilities. Much has been written about the CHC theory, and it is currently one of the most commonly researched and discussed theories of cognitive processing. A comprehensive review of the CHC theoretical background and development and validation of the WJ is beyond the scope of this chapter, and thus only the tests of the WJ-COG-III and the standard battery tests of the WJ-ACH-III will be reviewed. Readers interested in more information about the history and validation may wish to start with the technical manuals of the WJ-COG-III and WJ-ACH-III, which provide excellent overviews of the CHC theory and background and development of these tests. Additional readings are also suggested at the end of this chapter.

Woodcock-Johnson III Tests of Cognitive Ability

The Woodcock-Johnson III Tests of Cognitive Ability (Woodcock et al., 2001b) is composed of 20 tests, 10 of which are the standard battery, and 10 additional tests from the extended battery. The CHC factors can be derived from administration of tests 1 through 7 and tests 11 through 17. Additional composites of clinical clusters, cognitive categories, and three different measures of intellectual ability can also be determined (Schrank, Flanagan, Woodcock, & Mascolo, 2002). The tests from the WJ-COG-III will be briefly reviewed, with some comments regarding interpretation and use for rehabilitation.

Test 1: Verbal Comprehension

Verbal Comprehension is divided into four different subtests: Picture Vocabulary, Synonyms, Antonyms, and Verbal Analogies. Although one of the longer tests to administer, Verbal Comprehension is a good measure of the CHC factor comprehension knowledge (*Gc*) because it assesses several aspects of acquired verbal knowledge and the ability to apply and use that knowledge. As with most measures of verbal ability, clinicians should exercise caution in interpreting the results if any dysarthria, dysnomia, dysphasia, dyspraxia, or dysgnosia is present. Additionally, patients whose primary language is not English or who have had inadequate exposure to academic opportunities should not be given this test, or it should be interpreted with extreme caution. Both the WJ-COG-III and WJ-ACH-III are available in a Spanish-language version.

Test 2: Visual-Auditory Learning

This test is a measure of the CHC factor long-term retrieval (*Glr*) and requires the examinee to learn and recall rebuses, which are pictorial representations of simple words (Schrank et al., 2002). The examinee is taught a series of rebuses and then must "read" the rebuses to form sentences. Immediate corrections are made by the examiner when the examinee makes an error. Although memory is an important component of this test, there is a heavier learning element here than in most "pure" tests of memory. Thus, this may be a particularly valuable test in rehabilitative settings for the determination of vocational or academic aptitude because it can demonstrate how well patients learn new information and then apply that information in a relatively quick fashion.

Test 3: Spatial Relations

Test 3 is the first test in the CHC factor of visual-spatial thinking (*Gv*). Examinees are asked to identify pieces that form a unified whole. Examinees are required to mentally analyze, rotate, and determine the location in space of two-dimensional objects to form a visual gestalt. Because no motor manipulation is required, this test provides neuropsychologists a measure with which to compare motor tests to investigate the visual and motor components of visual-motor abilities, essential tasks for academic and, in some instances, vocational success.

Test 4: Sound Blending

Sound Blending is part of the CHC factor auditory processing (*Ga*). Examinees listen to an audio recording that presents words segmented into phonemes, and they are subsequently required to reproduce the word. This is a classic measure of phonological awareness that also appears on other neuropsychological tests. This test may help identify receptive and expressive language deficits in patients, although the examination of other measures may be necessary to determine if the deficit originates in difficulty comprehending the segmented phonemes or producing expressive language.

Test 5: Concept Formation

Concept Formation, the first test in the CHC factor fluid reasoning (*Gf*), measures inductive reasoning and executive functioning, including cognitive flexibility (Schrank et al., 2002). Patients are required to determine a "rule" from a set of stimuli on a printed page and then apply that rule to solve problems. As in many other measures of executive functioning, patients with high levels of attentional impairment will likely struggle on this task.

Test 6: Visual Matching

Visual Matching is part of the CHC factor processing speed (*Gs*) and also measures graphomotor speed for older children. Patients are required to either point to (Visual Matching 1) or circle with a pencil (Visual Matching 2) matching items presented along with visual distracters. Although it is mostly considered a processing speed or cognitive efficiency test, patients with activation or vigilance problems and/or fatigue issues may struggle on this type of task. Furthermore, in examining processing speed, clinicians should take into account which type of medications their patients are taking. Many medications designed to treat psychiatric and neurological conditions may have an effect on cognitive efficiency. For example, Oken, Flegal, Zajdel, Kishiyama, Lovera, Blagert, and Bourdette (2006) reported that a group of patients with multiple sclerosis taking central nervous system–activation medication had higher levels of impairment on processing speed and sustained attention tasks.

Test 7: Numbers Reversed

This is the last test of the standard battery that contributes to the calculation of the CHC clusters. One of the strengths of the WJ-COG-III is that only seven tests are required to obtain an estimate of the CHC factors. Test 7 is part of the CHC factor short-term memory (*Gsm*). In addition to measuring short-term memory, numbers reversed also assesses working memory (Schrank et al., 2002). The patient is required to listen to a series of numbers administered via a recording and then repeat them in reverse order to the examiner. This is a classic task with which most neuropsychologists are familiar, as it appears on many other cognitive measures and is a common part of a mental status examination and neurobehavioral examination. Despite the ease of administration, it is a powerful test of higher-order attention skills, which contribute to working and short-term memory abilities. Practitioners in rehabilitative settings may regularly use this type of task, but the extensive normative sample of the WJ-COG-III and standardized administration offers a valuable alternative.

Test 8: Incomplete Words

Test 8 is also administered via an audio recording. Patients are required to listen to words with missing phonemes and identify the words. This test is a measure of "auditory analysis and auditory closure, aspects of phonemic awareness, and phonetic coding" (Schrank et al., 2002, p. 43) and contributes to *Ga.* Along with Sound Blending, this test should allow examiners to obtain a good estimate of phonological awareness, an important consideration in work with patients with dominant hemisphere compromise. Patients with deficits in phonological awareness will likely need significant accommodations and interventions, including reliance upon visual processing, if intact.

Test 9: Auditory Working Memory

As the name implies, this test is a measure of working memory and higher-order attention skills and contributes to *Gsm.* Patients listen to a recorded list of words and numbers and are asked to reorder the auditory stimuli into words first and then numbers, listing both in the order in which they were presented. Working memory is one of the most critical processes to be assessed when interventions are being designed because deficits in this area can affect reasoning, calculation, comprehension, and the ability learn and use both written and spoken language (Vallat, Azouvi, Hardisson, Meffert, Tessier, & Pradat-Diehl, 2005).

Test 10: Visual-Auditory Learning–Delayed

This test is administered at least 30 minutes following Visual-Auditory Learning and uses the same rebuses that were presented earlier. Since participants are not warned that they need to remember the rebuses for later use, this test is a good measure of associative long-term memory under natural conditions. This makes it a good test for both children and adults who are planning to return to either school or work following an injury, because associative learning and recall without deliberate effort are required in these settings. Visual-Auditory Learning–Delayed contributes to the *Glr* CHC factor.

Test 11: General Information

This is the first test in the extended battery. General information is one of the comprehension-knowledge (*Gc*) CHC factors and is a measure of general knowledge. Patients are asked to answer a series of "Where" and "What" questions. Children who struggle on this type of task may be found to have language problems or global cognitive problems, which interfere with the acquisition and expression of verbal knowledge.

Test 12: Retrieval Fluency

Retrieval Fluency is a measure of the CHC factor long-term retrieval (*Glr*). Patients are required to rapidly name words within a 1-minute time limit. This type of task is found on many neuropsychological tests and is a variation of a type of classic measure of verbal fluency. Verbal fluency tasks are sensitive to executive dysfunction, including problems in flexibility, the ability to strategize, and inhibition, as well as to expressive language deficits (Ross, Calhoun, Cox, Wenner, Kono, & Pleasant, 2007). Functionally, patients with verbal fluency problems may have trouble generating novel or creative speech and may struggle with basic conversation.

Test 13: Picture Recognition

Test 13 is part of the visual-spatial thinking (*Gv*) CHC factor. This test requires the examinee to recall a series of visually presented stimuli and discriminate the target response from distracting stimuli. This test provides an example of how practitioners who are unfamiliar with the CHC factors should not interpret the WJ-COG-III without sufficient training and experience. This is because some neuropsychologists would consider this test to be a variation of a visual memory test, which may not be encompassed by some under the term "visual-spatial thinking."

Test 14: Auditory Attention

This test falls under the CHC factor of auditory processing (*Ga*). Patients are required to listen to a recording of a word and point to the picture of the word in a stimulus booklet. What makes this test a measure of auditory attention, as opposed to language ability, is that the simple words become increasingly obscured by background noise (the author's students have described it as "cafeteria noise"). First-time administrators of this test will likely note that this test has high face validity; for example, it appears to directly and saliently measure auditory attention.

Test 15: Analysis-Synthesis

Analysis-Synthesis is a fluid reasoning (*Gf*) test on the WJ-COG-III. Similar to the other *Gf* test, Concept Formation, Analysis-Synthesis is a measure of reasoning ability, although it measures deductive reasoning (Schrank et al., 2002). Patients are required to use deductive reasoning to solve problems presented in a stimulus booklet. The WJ-COG-III contains several tests that are related to and involved with executive functions, but some examiners who want other measures of verbal and visual executive functioning may wish to include other tests, such as the Delis-Kaplan Executive Function System (Delis, Kaplan, & Kramer, 2001), along with the DWNB.

Test 16: Decision Speed

Decision Speed is a measure of the CHC factor of processing speed (*Gs*). This test asks examinees to choose two conceptually similar objects among distracters (Schrank et al., 2001). This is a measure of processing speed, as there is a 3-minute time limit and the scoring is based on the number correct within that time limit. As with any test that involves the use of a pencil to measure processing speed, patients with graphomotor difficulty may struggle on this task. Likewise, higher-order attention deficits can have a dramatic impact on the measurement of processing speed as well.

Test 17: Memory for Words

This is the last test on the extended battery that contributes to the calculation of the CHC factors, in this case, short-term memory (*Gsm*). Memory for words requires patients to repeat lists of unrelated words that they hear on an audio recording. This task assesses verbal memory span and can be affected by problems in higher-order attention and short-term memory. Performance on this test can also be influenced by language problems, including deficits in expressive, receptive, or conductive aphasia. Thus, like any memory test that uses verbal stimuli or responses, language deficits should first be ruled out as potential contributors to poor performance.

Test 18: Rapid Picture Naming

Rapid Picture Naming is a variation of a classic measure of rapid automatized naming in which the patient is required to quickly name a series of familiar stimuli. A review of the literature reveals that rapid automatized naming is a significant predictor of current and future reading ability even after factors such as phonological awareness, IQ, past reading ability, and socioeconomic status are controlled for (Georgiou, Parrila, & Kirby, 2006). Rapid Picture Naming contributes to *Gs*.

Test 19: Planning

On this test, patients are asked to trace patterns written on paper without retracing or lifting their pencil. This test contributes to *Gv* and "is a test of executive processing that measures the mental control process involved in determining, selecting, and applying solutions to problems using forethought." (Schrank et al., 2001, p. 53). As in other paper-and-pencil tests of executive function, care should be given to rule out graphomotor and higher-order attention impairment before deficits are attributed to planning ability. For example, if a patient presents with poor scores on test 19 but intact scores on tests 7, 9, and 14, attention deficits may be ruled out, and scores from the motor subtests of the DWSMB may help rule out graphomotor problems. This profile could lead to a conclusion that the patient needs interventions to help with higher-order planning problems (please note that this is a simple example and does not account for possible multiple environmental, psychiatric, and neurocognitive factors, among others, that can contribute to a patient's profile of test scores).

Test 20: Pair Cancellation

This is the last test on the extended battery and contributes to the *Gs* factor. Pair Cancellation is a paper-and-pencil task that requires the examinee to circle certain pairs of objects within a 3-minute time limit. Pair Cancellation is a variation of classic measures of processing speed, cognitive efficiencies, attention, and concentration. Graphomotor speed is a potential complicating factor.

Woodcock-Johnson III Tests of Achievement

The Woodcock-Johnson III Tests of Achievement (Woodcock et al., 2001a) is the academic achievement part of the DWNB. Academic achievement in such areas as reading, writing, and mathematics is obviously an important component of academic and vocational success. Although many patients with sudden-onset neurological conditions may retain previously overlearned information such as basic reading ability, other patients lose or suffer declines in these skills (e.g., alexia without agraphia). Some patients struggle with more complex academic concepts, such as reading comprehension or mathematical reasoning, while maintaining intact basic abilities. Regardless of the level of decline, measures of academic skills are almost always critical in a comprehensive neuropsychological battery, especially in the assessment of children and adults who are still working. Additionally, children and adults who present with neurological and psychiatric conditions may have comorbid developmental learning disorders that dramatically interfere with functioning. The WJ-ACH-III assesses reading, mathematics, written language, academic knowledge, and oral language. The standard battery is composed of 11 tests, and the extended battery consists of 11 additional tests. Similar to the WJ-COG-III, the WJ-ACH-III is based upon the CHC theory. The following section will review the 11 tests of the standard battery of the WJ-ACH-III; readers interested in the extended battery are referred to the technical manual of the test and to Mather, Wendling, and Woodcock (2001).

Test 1: Letter-Word Identification

The first test of the WJ-ACH-III is part of the CHC factor reading-writing (*Grw*) and requires patients to read aloud a list of letter and/or words. Test 1 is part of the reading tests. Patients may use a phonemic decoding approach or identify the words by sight. Although a good measure of word reading ability, this test alone does not quantitatively allow examiners to determine if difficulties arise from dysphonetic or other types of dyslexia. However, qualitative observation may assist in this process and by examining other tests and subtests from the DWNB (including tests from the WJ-ACH-III Extended Battery), examiners can make conclusions regarding the etiology of the word identification deficit.

Test 2: Reading Fluency

Reading Fluency is a measure of *Grw* and also a reading test. Patients are required to read sentences and answer basic comprehension questions by circling "yes" or "no" during a 3-minute time limit. According to Mather et al. (2001), difficulty on this test may indicate "limited basic reading skills, slow perceptual speed, comprehension difficulties, or an inability to sustain concentration" (p. 116). Intact basic reading skills may be insufficient to cope with academic and vocational demands if reading is not quick and automatic. Thus, screening reading tests that do not use a timed measure of reading fluency may not accurately predict a child or adult's functional reading ability.

Test 3: Story Recall

Story Recall is part of the comprehension-knowledge (*Gc*) CHC factor and is an oral language test. This test is administered via an audio recording that tells a short story to the patient, and the patient subsequently recalls the important parts of the story. Although this test may appear to be a memory test and indeed contains elements of immediate memory, Story Recall is more a measure of receptive and expressive language and listening comprehension (Mather et al., 2001). As is true of many achievement tests, higher-order attention deficits will contribute to poor results on this task. Thus, it is also important to assess receptive and expressive language by using tasks that have less of an attentional demand, such as test 1 on the WJ-COG. Indeed, comparing the performance of different tests that fall within the same CHC factors allows clinicians to draw conclusions about the etiology of deficits, which allows for the design of interventions that either target the ipsative weakness or utilize the relative strength.

Test 4: Understanding Directions

This is also a test of *Gc* and an oral language test and requires the patient to listen to a recording and follow a series of sequential directions and point to different stimuli. As a measure of *Gc*, this test assesses language ability, specifically receptive language and the ability to follow multistep directions. Again, although higher-order attentional deficits can interfere with completion of this test, it is still a valuable test in regards to practical functioning. For example, children who present with oppositionality or attention problems may actually have difficulty following multistep directions, which can lead to boredom and frustration. An obvious intervention for both children and adults with this type of deficit is for their teachers and/or caregivers to ask the patient to repeat directions back in his or her own words to ensure understanding and to help differentiate between a language, attention, or compliance problem.

Test 5: Calculation

Calculation is the first test in the CHC factor of mathematics (*Gq*) and is part of the mathematics tests. Patients are required to solve a series of increasingly complex mathematical calculation problems. Substantive impairment on this test is generally predictive of difficulty using basic math calculation skills to perform functional mathematical tasks required by activities of daily living and/or problems in academic tasks using calculation. Patients may have either developmental math learning disabilities or acquired dyscalculia, both of which can contribute to calculation impairments.

Test 6: Math Fluency

Math Fluency is the second *Gq* and mathematics test. In general, "fluency" refers to both the speed and automaticity with which a patient can complete a task (see test 2). Patients are required to quickly solve mathematical problems in a 3-minute limit. This test, like the other fluency tests on the WJ-ACH-III, is a good indicator of how well a patient can perform a task under pressure, which may be a better indicator of real-life performance for adults on simple vocational tasks or children completing timed academic tasks. For example, an adult with intact basic calculation skills but impaired math fluency skills would likely struggle with performing rapid cash transactions. Likewise, children may obtain failing grades on timed math tests despite knowing how to perform the math calculations.

Test 7: Spelling

Spelling falls under the reading-writing (*Grw*) CHC factor and is the first of the written language tests. Patients are required to write letters and/or spell words in response to pronounced words from the examiner. This may help examiners gauge the patient's phoneme-to-grapheme transfer abilities and can aid in the determination of a patient's writing abilities. It is important to note that poor handwriting is not penalized, so motor difficulties (other than the inherent relationship between developmental motor problems and written language) are minimized.

Test 8: Writing Fluency

Writing Fluency is also a part of the CHC factor of *Gc* and is one of the written language tests. On this test, patients are given 7 minutes to write simple sentences that follow the rules of the written English language. Although the scoring criteria are well specified, there is still a small degree of subjectivity. As with the other fluency tests, failure to produce automatic writing could have a significant functional impairment despite intact basic writing abilities.

Test 9: Passage Comprehension

This test is part of the *Grw* CHC factor and is one of the reading tests. Patients are required to read a passage and fill in a missing word from a sentence that determines if the patient understood the passage. Performance on the other *Grw* tests and tests from other CHC factors, such as *Gc,* may help identify the source of the patient's reading comprehension problem.

Test 10: Applied Problems

Applied Problems is part of the mathematics (*Gq*) CHC factor and one of the mathematics tests. Patients are required to use mathematical abilities to solve real-world types of math problems. Mather et al. (2001) point out that no reading is required for this test so there is not a confound with reading comprehension abilities.

Test 11: Writing Samples

Writing Samples is one of the reading-writing (*Grw*) CHC factor tests and is part of the written language tests. Patients are required to produce sentences based upon a series of prompts. Neuropsychologists who are not used to scoring writing achievement tests may be struck by the seemingly subjective nature of the scoring. However, experienced users of these types of tests will likely report that the scoring is less subjective than it first appears. There are special scoring procedures listed in the examiner's manual, and it is strongly recommended that first-time administrators carefully examine these guidelines when scoring the results.

CONCLUSION

One of the strengths of the DWNB is its ability to provide a structured, standardized, and well-normed approach to neuropsychological assessment. Although many experienced clinicians have developed their own diagnostic interviews and neurobehavioral examinations, less experienced clinicians will welcome the structured format of the DW-ESE and DW-SNI. The WJ-COG-III and WJ-ACH-III provide extremely well-validated measures of higher-order neurocognitive processing. There is no doubt that the most unique aspect of the DWNB is the DWSMB, which also represents the newest aspect of the battery in regards to the normative components of the DWNB. Although the DWSMB can be useful in clinical practice, it shows particular promise in rehabilitative settings. Many sudden-onset neurological conditions, such as cerebral vascular accidents and traumatic brain injuries, present with sensorimotor deficits that may remit over time. A standardized assessment of sensorimotor skills helps track longitudinal recovery. The connection between sensorimotor skills and functional abilities, such as driving, writing, typing, manipulation of objects, balance, and motor coordination, highlights the importance of assessing and quantifying these skills during a patient's recovery. The combination of assessing more basic (i.e., sensorimotor) and higher-order (i.e., cognitive processing and achievement) neurocognitive processes makes the DWNB a good choice for identifying functional strengths and weaknesses in the design of interventions. In sum, the DWNB shows great potential to become a widely used comprehensive neuropsychological battery. However, as for any new test, extensive outside validation and reports of its utility will be necessary.

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9

A Descriptive Summary of Essential Neuropsychological Tests

CYNTHIA A. RICCIO

The major premise of neuropsychological assessment is that evaluation of various behavioral domains will provide information on the integrity of corresponding functional systems within the brain (Luria, 1980). From this premise, the neuropsychological assessment process involves making inferences from various domains of behavior, including cognition, achievement, and behavior/personality, as well as perceptual, motor, language, sensory, attention, executive function, and learning/memory domains (Riccio & Reynolds, 1998). Thus, neuropsychological assessment tends to be time intensive, requiring approximately 5 or more hours per client (Sweet, Peck, Abramowitz, & Etzweiler, 2002). To assess all domains, clinicians often combine various measures or use a published battery in conjunction with other measures. Various batteries, as well as individual measures for different domains, will be discussed in this chapter. These are examples only, as this chapter is not intended to be exhaustive; the Halstead-Reitan, Luria-Nebraska, NEPSY-II, and Dean-Woodcock neuropsychological batteries were discussed in chapters 5 to 8 of this volume.

COMPREHENSIVE NEUROPSYCHOLOGICAL TEST BATTERIES

There is a long-standing tradition of using a fixed/standardized battery in neuropsychological assessment, often referred to as a nomethetic approach. The best known of the published batteries are the Halstead-Reitan Neuropsychological Battery (HRNB; Reitan & Davison, 1974; Reitan & Wolfson, 1985) and the Luria-Nebraska Neuropsychological Battery (Golden, Freshwater, & Vayalakkara, 2000). An alternative to the Halstead-Reitan and Luria-Nebraska is the Kaplan Baycrest Neurocognitive Assessment (Leach, Kaplan, Rewilak, Richards, & Proulx, 2000). For children, the downward extension of the Halstead-Reitan is the Reitan-Indiana Neuropsychological Battery (Reitan, 1969). An additional child battery is the Neuropsychological Investigation for Children, or NEPSY (Korkman, Kirk, & Kemp, 1997). At least one comprehensive battery, the Cambridge Neuropsychological Test Automated Batteries (CANTAB), is available as well (Morris, Evenden, Sahakian, & Robbins, 1986). Although the CANTAB indicates an age range of 4 to 90 years, the majority of research has been with adults (Strauss, Sherman, & Spreen, 2006).

As an alternative to published batteries, some clinicians use a predetermined battery of select tests that tend to be more actuarial in nature and are vested in the use of standardized procedures, objective methods, and psychometrics (Lezak, 1995). An example of a clinician-generated or site-based battery is the compilation of measures used at the Benton Laboratory of Neuropsychology (Benton, Sivan, Hamsher, Varney, & Spreen, 1994). A variety of published measures have been combined to create alternative batteries. The National Institute of Mental Health Core Neuropsychological Battery and the World Health Organization Neurobehavioral Core Test Battery are examples of this type of battery (Lezak, Howieson, & Loring, 2004). The comprehensive battery (site based, clinician determined, or published) is generally supplemented with a traditional measure of cognitive ability and at least a screening of academic achievement. This chapter will address specific tests from published batteries, as well as tests that may be incorporated into a site-based or clinician-determined battery, by domain of interest (see Table 9.1). How components of cognitive ability testing may be conceptualized within these domains is presented as well.

Table 9.1

SUMMARY OF DOMAINS AND POSSIBLE MEASURES BY BATTERY

	LANGUAGE/ AUDITORY SKILLS	NONVERBAL REASONING	VISUAL/SPATIAL CONSTRUCTION	MOTOR SKILLS	MEMORY AND LEARNING	ATTENTION/ CONCENTRATION AND CONCEPT TRACKING
HRNB	Aphasia Screening Test, Speech Sounds Perception Test	Category Test	Tactual Performance Test	Grip Strength, Finger Oscillation or Tapping	Tactual Performance Test Recall	Trail Making A and B
Benton Laboratory of Neuropsychology	Multilingual Aphasia Examination–3 (Token Test, COWAT)		Benton Visual Form Discrimination Test		Digit Serial Learning, Benton Visual Retention	
Wechsler Intelligence or Memory Scales	Comprehension, Vocabulary, Similarities	Matrix Reasoning, Picture Concepts	Block Design, Picture Arrangement, Picture Completion, Object Assembly		Digit Span, Letter-Number Sequencing, Spatial Span	Arithmetic, Digit Symbol/Coding, Cancellation

(*Continued*)

Table 9.1

SUMMARY OF DOMAINS AND POSSIBLE MEASURES BY BATTERY (*Continued*)

	LANGUAGE/ AUDITORY SKILLS	NONVERBAL REASONING	VISUAL/SPATIAL CONSTRUCTION	MOTOR SKILLS	MEMORY AND LEARNING	ATTENTION/ CONCENTRATION AND CONCEPT TRACKING
CANTAB	Big Little Circle	Stockings of Cambridge, Intra/Extra-dimensional Shift	Matching to Sample Visual Search	Motor Screening	Spatial Span, Spatial Working Memory, Paired Associate Learning, Spatial Recognition Memory	Rapid Visual Information Processing
Other (Non-Battery Measures)	Dichotic Listening Tasks	Wisconsin Card Sorting Test, Tower of Hanoi, Tower of London	Rey-Osterrieth Complex Figure Test, Clock Drawing Test	Grooved Pegboard	Rey Auditory Verbal Learning Test, Rey-Osterrieth Recall	Continuous Performance Tests, Paced Auditory Serial Addition Test, Comprehensive Trail Making Test, Colored Trails Test

TESTS OF LANGUAGE ABILITY

Language is an important aspect of functioning; disruption of language functioning (i.e., aphasia of one type or another) is one of the most common outcomes of stroke, head injury, and developmental disorder. As a result, it is not surprising that there are multiple measures to screen or assess language functioning (Salter, Jutai, Foley, Hellings, & Teasell, 2006). In the assessment of aphasia, the basic components should include assessment of spontaneous speech; repetition of words, phrases, and sentences; comprehension of speech; object-naming ability; reading ability; and writing ability (Lezak et al., 2004). Reading and written expression are addressed in part through achievement testing. Additional measures might assess auditory perceptual abilities.

Aphasia Screening Test

The original version of the Aphasia Screening Test (Reitan & Wolfson, 1985) consisted of 51 items. It has been revised, and the most current version of the Aphasia Screening Examination (ASE) consists of 32 items. It is usually administered in conjunction with the HRNB but can be administered by itself. The ASE is said to provide a brief assessment of basic language in areas of comprehension and expression (Reitan & Wolfson, 1992). It includes assessment of spoken language (articulation), repetition, naming, and basic reading, writing, spelling, and arithmetic skills. Copying tasks are included but are interpreted relative to the examinee's ability to follow verbal directions (Reitan & Wolfson, 1985). In general, the ASE is purported to be both valid and reliable. Internal consistency (coefficent alphas) was adequate across age ranges studied (Livingston, Gray, & Haak, 1999). The major limitations of the ASE are the limited normative sample; the potential for education, ethnicity, and gender to moderate results; and the test's generation of only a global score (Salter et al., 2006).

Speech Sounds Perception Test

The Speech Sounds Perception Test is used for assessment of auditory perceptual ability as part of the HRNB (Reitan & Wolfson, 1985). Administered with a tape recorder, the long form consists of six sets of 10 nonsense words each. For each item, the individual must select which of three written words matches the spoken word. The first 30 items are used for the short form. Internal consistency is adequate for both the long and short forms, and some concerns have been noted for the short form at some ages (Livingston et al., 1999). The task is believed to measure verbal ability, as well as attention and concentration (Reitan & Wolfson, 1985).

Multilingual Aphasia Examination–Third Edition (MAE-3)

The MAE-3 (Benton, Hamsher, Rey, & Sivan, 1994) is a comprehensive aphasia battery intended to complement other tests of neuropsychological function developed at the Benton Laboratory. The MAE-3 assesses language ability with a variety of tasks. Three tests assess different aspects of oral expression; three tests assess oral-verbal understanding; one test assesses reading comprehension; and three tests assess oral, written, and block spelling. Speech articulation and the fluency-nonfluency dimension of expressive speech are assessed via rating scales, but not systematically sampled. Writing is evaluated from performance on the test of written spelling. The manual includes normative standards for elderly individuals, data on the discriminative value of each test, and recent clinical research results. A Spanish version (MAE-S) was developed and is intended for use with Cuban, Mexican, and Puerto Rican populations (G. J. Rey & Benton, 1991). The MAE-S is not a direct translation of the MAE-3, but an adaptation that takes into consideration terms and items relevant to Spanish-speaking individuals. Two subtests of the MAE-3, the Token Test and Controlled Oral Word Association Test, are frequently used, with or without the rest of the scale. Concerns with the MAEs include the absence of a specific model of language function, the absence of reliability data, limited normative data, and limited validity data (Strauss et al., 2006).

Token Test

The Token Test is used to assess the individual's comprehension of verbal commands (for example, "Put the red circle on the green square"). Two versions of the Token Test are included in the MAE-3 for repeat assessment; each version consists of 22 items and is an abbreviated version of the original Token Test (De Renzi & Vignolo, 1962). The advantages of the Token Test are its long history, minimal administration time, and reasonable reliability and validity. Disadvantages include the dated nature of the normative sample. Variations of the Token Test are found on the NEPSY and other language measures; there are also computer-generated versions available (Strauss et al., 2006).

Controlled Oral Word Association Test (COWAT)

The COWAT is one version of a verbal fluency task; the MAE-3 includes two sets of letters to allow for repeat assessment. For the COWAT, the examinee is required to generate as many words that begin with specified letters as possible in a limited time span; the letters for the English and Spanish versions are not the same but reflect the same level of frequency in the respective languages (Strauss et al., 2006). The COWAT has been found to be sensitive to age difference, particularly after the age of 40; by 60 years of age, gender appears to be a factor in performance as well (Rodríguez-Aranda & Martinussen, 2006). In addition to phonemic fluency tasks such as the COWAT, other fluency tasks may include semantic or category items (e.g., animals, foods). Research suggests that normative data differ for some letter combinations and categories; it is important, therefore, to ensure normative data for the letters or categories being used. In addition to being part of the MAE-3, fluency tasks similar to the COWAT are included on the NEPSY, the Kaplan Baycrest Neurocognitive Assessment, and the Delis-Kaplan Executive Function System (Delis, Kaplan, & Kramer, 2001). In general, phonemic and other verbal fluency tasks evidence adequate reliability for use across multiple time points (e.g., test-retest for monitoring purposes), with minimal practice effects evident on phonemic and semantic versions, particularly for versions using intervals longer than 30 seconds (Lemay, Bédard, Rouleau, & Tremblay, 2004).

Wechsler Scales and Language Ability

The Wechsler scales are the most frequently used measure of cognitive ability; depending on the age of the client being evaluated, different versions are used. Regardless of whether it is the third edition of the Wechsler Adult Intelligence Scale–(WAIS-III), the fourth edition of the Wechsler Intelligence Scale for Children (WISC-IV), or other versions of the scale, within the verbal portion of the test, the three subtests that evidence the highest loadings on verbal ability are Comprehension, Similarities, and Vocabulary (Wechsler, 1997a, 2003). Taken together, these subtests yield a representation of Bannatyne's verbal conceptualization ability; they provide some measure of expressive language abilities, awareness of social norms, and prior learning (Kaufman & Lichtenberger, 1999).

Comprehension Subtest

The Comprehension subtest requires the examinee to respond to verbally presented questions regarding socially normative behaviors or reasoning (Wechsler, 1997a). The unique abilities measured by this subtest include demonstration of practical information and knowledge and awareness of social norms, as well as the ability to verbalize accepted standards of behavior. Because responses reflect social norms, results may be influenced by culture and past experience (Kaufman & Lichtenberger, 1999).

Similarities Subtest

The Similarities subtest requires the examinee to identify the category to which two objects or concepts belong (Wechsler, 1997a). The unique abilities measured by this subtest include logical abstraction and categorical thinking. Although the score obtained on Similarities is less affected by school learning than by vocabulary, it is influenced by the individual's extent of leisure reading as well as verbal expressive abilities (Kaufman & Lichtenberger, 1999).

Vocabulary Subtest

This subtest requires the examinee to provide a definition of a word that is presented in print as well as orally (Wechsler, 1997a). The unique abilities assessed by this subtest include language development and word knowledge. Because the items are open ended, expressive language ability and verbal fluency are also tapped. Results are likely influenced by school learning, leisure reading, availability of enrichment activities, and culture (Kaufman & Lichtenberger, 1999).

TESTS OF NONVERBAL REASONING ABILITY

Reasoning and Problem Solving

Category Test

The Category Test in its original form is part of the HRNB (Reitan & Davison, 1974). There are seven sets of items, each organized based on a different principle or rule for correct responding (e.g., number of objects). The individual uses feedback from one response to make subsequent choices based on his or her ability to abstract the principle or rule being used. The task is believed to assess general abstraction ability and concept formation; it also is used as a general indicator of overall neuropsychological functioning (Riccio & Reynolds, 1998). In addition to the original version, additional versions (e.g., booklet, computer versions) have been developed with alternative modes of test delivery to facilitate administration. Shorter versions of the Category Test also have been developed (Boll, 1993; Wetzel & Boll, 1987). While standard versions may take up to 2 hours for an impaired individual (Strauss et al., 2006), the shorter versions are estimated to take about 20 minutes. The Children's Category Test (Boll, 1993) was developed as an alternate version for use with children. Computer versions are also available but vary with regard to normative data and validity and reliability studies (Choca & Morris, 1992).

Reliability and validity studies are available for the standard version and generally yield slightly higher reliability than the shorter booklet versions (see Strauss et al., 2006, for a complete review). High correlations with measures of nonverbal ability raise the question of the extent to which the Category Test is solely a measure of nonverbal ability or what the difference is between nonverbal ability measures and the problem solving involved in the Category Test. At the same time, factor analytic studies suggest that Category subtests load on factors other than global intelligence (Johnstone, Holland, & Hewett, 1997). Interpretation with the original version is limited to the use of cut scores; however, limited normative data and conversion of standard scores are available (Heaton, Grant, & Mathews, 1991). Sensitivity to various disorders has been evidenced (Choca, Laatsch, Wetzel, & Agresti, 1997), but research suggests there is limited specificity to frontal lobe damage (Anderson, Bigler, & Blatter, 1995; Hom & Reitan, 1990).

Wisconsin Card Sort Test (WCST)

The WCST was introduced as a test of problem solving and decision making (Berg, 1948; Grant & Berg, 1948) and is still used for this global purpose. WCST performance involves component behaviors, including the use of external cues to guide behavior, self-monitoring, the tendency to perseverate, hypothesis generation, and ability to shift response sets. Although the WCST was originally designed for use with adults, the measure is sensitive to developmental and maturational changes. Initially it was believed that adult-level performance was achieved by 10 years of age (Chelune & Baer, 1986); more recent findings have suggested a more protracted development continuing well into adolescence (Heaton, Chelune, Talley, Kay, & Curtiss, 1993).

The WCST requires the individual to discern the sort criterion for a set of cards based upon "correct" and "incorrect" feedback given by the examiner. After the examinee matches a card according to a stimulus feature (color, form, or number) for 10 consecutive trials, the feature used for sorting changes. This occurs six times or until all 128 cards are administered, whichever comes first. The problem-solving component has the examinee consider a variety of hypotheses and reject them if they prove incorrect based on the feedback received; this also requires the individual to use both positive and negative feedback to alter or maintain response sets (Heaton et al., 1993).

The original administration procedures, with the exception of an alteration in the discontinuation criteria, have been used to evaluate two alternative short forms (Robinson, Kester, Saykin, Kaplan, & Gur, 1991). For one of these versions, the WCST-64, the task is discontinued after the examinee sorts one deck of 64 cards rather than two decks. A second alternative, the WCST-3, uses three categories successfully obtained by the examinee as the discontinuation rule. The WCST-64 yields moderate correlations with the WCST (Pearson correlations ranging from .70 to .91); correlations between the WCST and WCST-3 were somewhat lower at .36 to .82. Overall, individuals were classified more accurately by the WCST-64 than the WCST-3 (Robinson et al., 1991). There is, however, limited normative data for the short forms (Smith-Seemiller, Arffa, & Franzen, 2001). There is also a computerized version of the WCST (Heaton, 1999). Computerized administration can be less time consuming to administer and score; computerized administration provides greater accuracy in data collection, as well as greater control over a wide range of extraneous variables (Ozonoff, 1995). Overall, research has demonstrated general equivalence between computerized administration and card administration of the WCST (Hellman, Green, Kern, & Christenson, 1992).

In conjunction with the emphasis on reasoning and problem solving, one limitation of the WCST is the extent to which results may be confounded by the effects of intelligence (Chelune & Thompson, 1987; Riccio, Hall, Morgan, Hynd, Gonzalez, & Marshall, 1994). Although poor performance on the WCST may be to the result of one or more of a number of different deficits in cognitive abilities, including those in cognitive flexibility, selective attention to relevant dimensions of stimuli, working memory to hold the sorting principle online, attention to and encoding of the examiner's feedback, use of this feedback to inhibit prepotent responding, and the ability to shift set, the available scoring procedures do not allow a differential analysis of component skills (Ozonoff, 1995). This makes it difficult to determine which cognitive processes are deficient in an individual who has performed poorly on the WCST, and it has been suggested that the WCST's specificity of the WCST may be less robust than its sensitivity. For children, this has been supported by meta-analysis of extant research (Romine, Lee, Wolfe, Homack, George, & Riccio, 2004).

Tower Tasks

Another set of tasks used to assess problem solving, planning, and abstraction that is nonverbal is the tower task (Anzai & Simon, 1979; Levin et al., 1991; Welsh, Satterlee-Cartmell, & Stine, 1999). Based on the Tower of Hanoi (Simon, 1975) or the Tower of London (Shallice, 1982), the tower task has been revised numerous times by independent researchers and practitioners; the Stockings of Cambridge from the CANTAB is a similar type of task (Strauss et al., 2006). Each version has its own norms and unique administration and scoring procedures with some similarities to the original Tower of Hanoi or the later-developed Tower of London. Regardless of the version, tower tasks are popular as a neuropsychological measure that is presumed to tap planning and problem solving; it is assumed that solving the task is best accomplished through strategy use and the planning of a sequence of moves (Morris, Miotto, Feigenbaum, Bullock, & Polkey, 1997).

All tower tasks involve a problem-solving and transfer task wherein examinees must rearrange balls, beads, or disks in a minimum number of moves to match a model. It is believed that in order to obtain the correct solution, the individual must visualize the solution several moves in advance, which places demands on the prefrontal cortex. Research has emphasized the role of planning and fluid ability, as well as other abilities in tower performance (Luciana & Nelson, 1999; Welsh et al., 1999). The tower tasks have traditionally been viewed as planning tasks because individuals make fewer total moves if they plan their course of action before starting to move the disks, beads, or balls. Tower tasks differ in terms of the rules, the structure of the tasks, and the means of performance evaluation (Welsh, Pennington, & Groisser, 1991). Further, differences relate to the number of trials allowed, the number of disks or beads involved in the task, rules governing the placement of disks or beads, and the level of difficulty. For example, the number of items on which a disk must be moved away from its intended final location (referred to as counterintuitive behavior) in order for the task to be solved varies from version to version (Phillips, Wynn, Gilhooly, Della Sala, & Logie, 1999). Concerns related to the low reliability of movement scores, particularly over repeated administrations, have been raised (Lemay et al., 2004).

Wechsler Scales

Although not well represented in earlier editions of the Wechsler scales, subtests representing nonverbal reasoning have been added to most recent editions (Flanagan & Kaufman, 2004). Two of these subtests will be discussed here briefly.

Matrix Reasoning

With the most recent edition of the WAIS-III, one of the new subtests added was that of Matrix Reasoning. This subtest is intended to provide a nonverbal measure of abstract reasoning skills, fluid reasoning, and simultaneous processing (Kaufman & Lichtenberger, 1999). Unique abilities are purported to be nonverbal problem solving and analogic reasoning; of the perceptual organization subtests, it is the only one that is not timed. It consists of 26 items; for each item the examinee completes a pattern by choosing from an array of five possible choices. Administration and content are similar to many other matrix tests.

Picture Concepts

A new subtest to the WISC-IV, Picture Concepts requires the individual to choose two items (one from each of two groups of pictures) that share a concept or common characteristic; it is a nonverbal counterpart to the abstraction required with other verbal tasks. Within the Catell-Horn-Carroll classifications, it is purported to load on fluid ability (Flanagan & Kaufman, 2004). Although nonverbal, the task is influenced by language, educational experiences and opportunities, and alertness to the environment. As such, the cultural loading and linguistic demands of the task are still considered to be moderate (Flanagan & Kaufman, 2004).

VISUAL-SPATIAL AND CONSTRUCTIONAL PERFORMANCE

Tactual Performance Test

A subtest of the HRNB, the Tactual Performance Test requires the blindfolded examinee to place blocks into a form board based on their shape (Reitan & Wolfson, 1985). There are three trials—preferred hand, nonpreferred hand, and both hands. It is considered a valid measure of tactual recognition and sensitivity (Riccio & Reynolds, 1998). Discriminant validity was evidenced for all but three of the indexes computed based on blocks-per-minute scores (Charter, Lopez, Oh, & Lazar, 2001). Based on the blocks-per-minute score and time reliabilities, use of the preferred-hand score is of limited clinical usefulness (Charter et al., 2001). Additional concerns have been noted with regard to the use of the HRNB cut scores with older adults, as well as the potential discomfort of the examinee with the blindfold process (Strauss et al., 2006). Two additional components to the Tactual Performance Test are discussed in the learning and memory domain.

Benton Visual Form Discrimination Test

The Visual Form Discrimination Test from the Benton Laboratory is a variation of a match-to-sample task that measures the individual's ability to discriminate between complex visual stimuli (Benton, Sivan, et al., 1994). It consists of two demonstration items and 14 test items with a target stimulus and four choices for each item. The target stimulus includes major components as well as a peripheral component; distortions or rotations in the incorrect responses may be to the major or peripheral component. Each correct response is awarded two points; each response that contains only a peripheral error is awarded one point; all other incorrect responses are scored zero points. A total score is then obtained across the 14 items and cutoff scores are used to determine if performance is borderline/mildly defective, moderately defective, or severely defective (Benton, Sivan, et al., 1994). The Visual Form Discrimination Test has been found to be sensitive to effects of brain disease, and particularly useful for detecting early dementia (Benton, Sivan, et al., 1994).

Rey-Osterrieth Complex Figure Test–Copy

The use of complex figure drawing has been used to assess visual-spatial skills for more than 60 years (Hubley & Jassal, 2005). One of the figures used is the Rey-Osterrieth Complex Figure Test (Osterrieth, 1944). The Rey has been established as a measure of visual-motor integration; it has been asserted that the Rey assesses not only constructional ability, but also spatial organization, sequencing, and memory (Waber & Holmes, 1985, 1986). Because of the simple nature of the separate components of the figure, the task is believed not to be as affected by drawing skills as by organizational strategy (A. Rey, 1941).

The Rey is a two-dimensional line drawing comprised of 18 specific components; the initial task requires the examinee to copy the line drawing. There are several scoring systems available for scoring the Rey figure (Berry, Allen, & Schmitt, 1991; Hamby, Wilkins, & Barry, 1993; Lezak, 1995; Meyers & Meyers, 1995). Most often, each of the 18 components is scored zero, one, or two points depending on the accuracy of production and placement of that component. Others have suggested a complex scoring system in an attempt to dissociate the constructional components from the planning and organizational components (Stern et al., 1999). Alternate qualitative procedures also can be used to examine the approach to the task and the process (Hamby et al., 1993; Waber & Holmes, 1985), as well as the types of errors made (Loring, Lee, & Meador, 1988). There is evidence of Rey sensitivity to right hemisphere and frontal dysfunction, as well as ADHD and learning disabilities. The range of disorders that may have an effect on Rey function indicate that the task may require the integration of multiple component processes related to executive function. Alternative complex figures, including a Modified Taylor Complex Figure (Hubley, 1996), are available as well (see Strauss et al., 2006).

Wechsler Scales

Consistent with the long-standing tradition of separating verbal and nonverbal abilities, even the more recent editions of the Wechsler scales include a subgroup of tasks to assess visual-spatial and constructional abilities. For the WAIS-III, this domain is best represented by the Perceptual Organization Index score, which is comprised of the Matrix Reasoning, Block Design, and Picture Completion subtests; this is termed Perceptual Reasoning on the WISC-IV and includes a subtest of Picture Concepts with Picture Completion as an optional subtest.

Block Design

For the Block Design subtest, the task is to replicate a model or picture of blocks that are red, white, or red and white (Wechsler, 1997a). A critical component of the subtest is the ability to deal with both two- and three-dimensional representations of a figure when the task consistently involves three-dimensional construction (Kaufman & Lichtenberger, 1999). The unique abilities believed to be assessed by this subtest include the use of analytic strategies and nonverbal concept formation, which is believed to rely on simultaneous processing. This subtest is sensitive to virtually all types of brain damage, but most notably damage in the right hemisphere (Kaufman & Lichtenberger, 1999).

Picture Completion

For this subtest, the examinee is presented with a picture in the stimulus book and asked to answer the question "What important part is missing in this picture?" within 20 seconds (Wechsler, 1997a). The only unique ability suggested is that of visual recognition, but the task also taps holistic processing and visual organization. Traditionally, the ability to distinguish essential from nonessential detail has been emphasized as well (Kaufman & Lichtenberger, 1999). Although it is timed, there are no time bonuses; the task does not appear to be as sensitive to brain damage as other tasks (Kaufman & Lichtenberger, 1999).

Object Assembly

Now an optional subtest for the WAIS-III and no longer part of the WISC-IV, object assembly tasks on all Wechsler scales require the examinee to construct an object from non-interlocking pieces; the individual is not told what the object will be (Wechsler, 1997a). It is believed to tap holistic processing, as well as the individual's ability to determine relationships between parts and wholes (Kaufman & Lichtenberger, 1999). Of interest in this task is the way in which the individual approaches the task and whether or not he or she recognizes the object that will result.

Picture Arrangement

Picture Arrangement requires the examinee to reorder a series of pictures to tell a complete story. Unique abilities tapped by this subtest include temporal sequencing and anticipation of consequences (Kaufman & Lichtenberger, 1999). Others have suggested that social adjustment or pathology, as well as cultural differences, may influence the score on this subtest. Historically, factor analyses have demonstrated almost equal verbal and visual-perceptual loadings for this subtest, possibly as a result of the individual's ability to use language to complete the task. On the WAIS-III, this is an optional subtest, and it is not included in the perceptual organization score; this subtest has been eliminated from the WISC-IV.

MOTOR SKILLS TESTS

Grooved Pegboard Test

The Grooved Pegboard Test (Klove, 1963) is used to provide a measure of the individual's visual-motor manipulation ability and control. The task requires the individual to move 25 pegs from a container to a pegboard. The pegs are shaped such that they will only fit in the hole when placed in a particular orientation, which makes the task more difficult to complete quickly. The individual is asked to complete two trials with each hand. The individual first completes the task with his or her dominant hand, and then with the nondominant hand. Alternate administration instructions may include asking the individual to remove the pegs from the holes and place them back into the container, beginning at the bottom of the board and working from the side opposite the hand being used (Brown, Roy, Rohr, & Bryden, 2006; Bryden & Roy, 1999). For both the standard and alternate versions, the variable of interest is the time required to complete the task. In most cases, the times obtained from the two trials with the same hand are averaged, and the average times are used to compute the laterality quotient (Brown et al., 2006). Normative data compiled across studies are available to supplement the original normative information (Mitrushina, Boone, Razani, & D'Elia, 2005).

The Grooved Pegboard Test is included as part of several perceptual-motor and neuropsychological batteries (Lezak et al., 2004). Because of the complexity of the task, it is purported to be sensitive to general decline or slowing due to various neurological disorders, or in conjunction with teratogenic effects. At the very least, the task assists in identifying laterality of impairment when the effects are not diffuse (Lezak et al., 2004).

Finger Tapping Test

The Finger Oscillation or Tapping Test is used to provide a measure of motor speed and dexterity, as well as lateral dominance (Reitan & Wolfson, 1985). For the task, the individual places his or her hand palm down on a table or other flat surface with the index finger extended to rest on a key. The other fingers are extended and resting on the table. Instructions are to tap the key as many times as possible in a 10-second period. Five trials are completed with each hand, with the dominant hand first. Number of taps in the 10-second trials is averaged for each hand. A manual or electric tapper can be used for administration (Reitan & Wolfson, 1985).

Grip Strength

For the grip strength task, the individual stands with his or her arm straight down at his or her side and uses a dynamometer to measure hand strength, as well as lateral dominance (Reitan & Wolfson, 1985). Three trials are conducted with each hand, alternating between dominant and nondominant hands; the average across trials is used for normative comparison or for determination of laterality. Males generally out-perform females, and there are some indications that males exhibit greater laterality differences; age effects are also evident. Some cut scores for differences are used as indicative of brain damage. Concern for high rates of false positives has been noted (Koffler & Zehler, 1985).

TESTS OF MEMORY AND LEARNING ABILITY

Tactual Performance Test–Memory and Location

In conjunction with the HRNB, two additional components of the Tactual Performance Test are incidental learning as measured by memory and location scores. Following successful placement of blocks into the foam board, the board is removed from sight, and the blindfold taken off, and the individual is then asked to draw a diagram of the board with the location of the blocks noted. Results are then scored in terms of memory and location. This is considered a measure of incidental spatial memory (Reitan & Wolfson, 1985).

Benton Visual Retention Test

The Benton Visual Retention Test (BVRT-5) is used predominantly to assess visual memory, visual perception, and constructional praxis (Strauss et al., 2006). The BVRT-5 (Sivan, 1992) is used with other tasks at the Benton Laboratory. There are multiple forms of approximately equivalent difficulty. Each form consists of 10 figures—two items are single geometric forms, eight items consist of two central figures and a peripheral form (similar to the Benton Visual Discrimination Test stimuli). In the standard administration, the examinee is shown each item for 10 seconds, the stimulus is removed, and the examinee is asked to reproduce the drawing. Alternative formats include only allowing 5 seconds, having the examinee copy the forms, or adding a 15-second delay after the presentation and before the drawing. For those for whom the constructional/motor component may be a confound, there is also a multiple-choice format, but this is only available in German (Strauss et al., 2006).

The BVRT-5 has a long history, requires a limited administration time, and has precise scoring criteria with good interrater reliability. The multiple formats and alternative versions can be of assistance in dissociating motor deficits, visual-perceptual deficits, and memory deficits. While clinical studies have indicated adequate discriminant validity, there are concerns with the outdated normative data provided in the manual. Concerns with potential ceiling effects for specific groups are also noted (Strauss et al., 2006). Additional normative data are available through other sources, including cross-cultural data, but sample sizes vary (Mitrushina et al., 2005).

Wechsler Memory Scales

Memory functioning is considered to be an essential component of neuropsychological evaluation (Lichtenberger, Kaufman, & Lai, 2002) and has a long history in the assessment and clinical literature. The third edition of the Wechsler Memory Scales, the WMS-III (Wechsler, 1997b), takes advantage of this history, as well as the research available on the previous editions of the WMS. From the seven original subtests of the 1945 version of the WMS to the current combination of core and optional subtests, aspects of both visual and auditory short-term and delayed memory as well as recognition are assessed. Many of these tasks, or comparable tasks, are also included on the Children's Memory Scale (Cohen, 1997), the Test of Memory and Learning (Reynolds & Bigler, 1994), and the second edition of the Wide Range Assessment of Learning and Memory (Sheslow & Adams, 2004). Specific subtests on the WMS-III, as well as other scales, are described in further detail.

Digit Span

The clinical assessment of intelligence has included tasks of memory since the beginning of formal intelligence testing (Ramsey & Reynolds, 1995). Forward and backward recall of digits has long been included as two of these tasks and is generally associated with short-term memory span, working memory, and immediate rote recall. The Digit Span subtest of the Wechsler intelligence scales as well as the WMS-III is comprised of Digits Forward and Digits Backward components that yield separate raw scores. Some argue that the current practice of combining Digits Forward and Digits Backward, as is done on the Wechsler scales, results in a loss of important information (Banken, 1985; Ramsey & Reynolds, 1995; Reynolds, 1997a). Specifically, it has been suggested that Digits Forward is a task of short-term auditory memory, sequencing, and simple verbal expression (Hale, Hoeppner, & Fiorello, 2002), while Digits Backward is more sensitive to deficits in working memory (Reynolds, 1997a). Because different neuropsychological processes are involved in Digits Forward and Digits Backward, Digit Span may not be an adequate predictor of attention problems or short-term memory.

Letter-Number-Sequencing (LNS)

The LNS task is similar to Digit Span but involves a greater reliance on working memory. LNS is believed to provide a measure of short-term memory, working memory, and facility with overlearned sequences (Kaufman & Lichtenberger, 1999; Lichtenberger et al., 2002). The array to be recalled is a combination of letters and numbers, which the individual must reorder such that the numbers come first, in order from lowest to highest, followed by the letters in alphabetical order. There are five practice items, followed by items of increasing difficulty. Testing is discontinued when the individual misses all three trials within an item (Wechsler, 1997b). Performance on LNS is believed to be affected not only by memory ability, but also by attention, anxiety, motivation, and verbal processing. Many behaviors are indicated as being of importance, including the use of any strategies and reversal of the number-letter sequence (Lichtenberger et al., 2002). Research suggests that the LNS can be used in documenting progression of decline or medication effects based on results of test-retest (Lemay et al., 2004).

Spatial Span

The initial spatial span task was developed as a nonverbal alternative to the digit task in which block-tapping sequences are the stimuli to be remembered (Berch, Krikorian, & Huha, 1998). The blocks in the Corsi block-tapping task were wooden, whereas the spatial span task in the WMS-III uses a three-dimensional plastic blue block board. For the WMS-III, the blocks are numbered on one side; it is important that the numbers be visible to the examiner and not the examinee. The examiner touches a sequence of blocks at a uniform pace according to the number sequence for that trial while the examinee watches. The examinee is then asked to repeat the sequence in the same order. The examiner records the number for the blocks in the order tapped by the examinee (Wechsler, 1997b). Testing is discontinued following a failure on both trials for an item for each subset. As with Digit Span, the initial subset of items is in forward sequence, while the second subset of items is to be repeated in backward order. Level of difficulty is believed to increase with the number of blocks in the sequence (Orsini, Pasquadibisceglie, & Picone, 2001) but is also associated with the path formed by the tapping sequence (Smirni, Villardita, & Zappala, 1983).

Serial Digit Learning

Similar to the Digit Span subtest on the Wechsler scales, Serial Digit Learning, or digit supraspan testing, is used as a measure of short-term learning and memory at the Benton Laboratory. Unlike the Digit Span subtest, the Serial Digit Learning uses either the eight- or nine-digit stimulus, presented at one digit per second. For the Serial Digit Learning, however, the span is repeated until the examinee gets two consecutive correct repetitions up to 12 trials. Although basic scoring is correct-incorrect for each trial, modified scoring can be implemented such that a perfect response is scored two points, and a "near correct" response is scored one point (Benton, Sivan, et al., 1994).

Rey Auditory Verbal Learning Test

For assessing verbal memory, the format of word list learning is preferred to prose or similar formats that may be confounded by semantic associations (Lezak et al., 2004). The Rey Auditory Verbal Learning Test (RAVLT; A. Rey, 1964) is comprised of five-trial presentations of a 15-word list, followed by an interference list trial, and two recall trials, which are intended to gain information on learning and retention. Words on both lists are read at a rate of one per second. After each trial, the examinee is asked to recall as many words as he or she can, and they are recorded in the order they are recalled by the examinee. The same list is read to the examinee five times, with a recall trial after each reading.

Normative data indicate that the average adult between the ages of 20 and 39 years old recalls 6–7 of the 15 words after the first trial. This increases to 12–13 by the fifth trial, followed by a minimal decrease after the interference trial (Mitrushina et al., 2005; Strauss et al., 2006). The change in number of words recalled can be used to determine the rate of learning. Age effects and gender effects have been found on the RAVLT. RAVLT results have been found to discriminate between groups with neuropathology and controls better than other memory tasks, including the Stroop and specific subtests of the Wechsler Memory Scales (J. B. Powell, Cripe, & Dodrill, 1991). Some concerns with test-retest reliability have been noted, but it was concluded that the RAVLT is reliable and useful in repeated assessments (e.g., for monitoring decline) as long as alternate forms are used (Lemay et al., 2004).

Multiple variants of the RAVLT have been constructed. These include shortened (10-word) lists to decrease the frustration of examinees who are not capable of completing the 15-word list, as well as two revised 15-word lists intended to minimize cultural bias (Maj et al., 1993); in addition, versions are available in multiple languages. Comparison study with the word list subtest of the WMS-III suggests that the RAVLT provides a more accurate picture (Wen & Boone, 2006). Some researchers have suggested using the serial position effect as an indicator of malingering (M. R. Powell, Gfeller, Oliveri, Stanton, & Hendricks, 2004). Unlike the RAVLT, the second edition of the California Verbal Learning Test (Delis, Kramer, Kaplan, & Ober, 2000) allows for evaluation of the use of semantic associations between the words (objects) on the lists as a strategy for learning and recall, as opposed to assessing memory and learning in a nonconfounded format. Other auditory-verbal learning tasks may incorporate selective reminding (i.e., only repeating the words omitted) as opposed to repeating all words on each trial.

Rey-Osterrieth Complex Figure Test–Recall

Immediately following the Rey copy task is a recall task; however, the examinee is not told in advance that he or she will be asked to recall the figure. Immediate recall is usually done about 1–3 minutes after the individual completes the copy task; approximately 20 minutes later, there is a delayed recall task. Studies that have manipulated the time for immediate recall have not yielded any differences between immediate and 3-minute performance (Meyers & Meyers, 1995). There also has been little difference found for variation in time for delayed recall up to 1 hour (Berry & Carpenter, 1992). It is presumed that the components recalled are a function of incidental learning rather than strategy use, as the examinee is not aware at the outset of the recall condition (Hubley & Tombaugh, 2003). The recall component of the Rey may be used as part of assessment before and after surgery, post-stroke and during rehabilitation, or as part of monitoring treatment for a disorder or progression of a disorder where memory is a component of concern (Hubley & Jassal, 2005).

TESTS OF ATTENTION, CONCENTRATION, AND CONCEPTUAL TRACKING

Trail Making Test Parts A and B

The Trail Making Test is one component of the HRNB; it was part of the Army Individual Test Battery (as cited in Lezak, 1995) and originally was developed as Partington's Pathways (Strauss et al., 2006). The Trail Making Test is a widely used neuropsychological measure that is believed to be sensitive to brain dysfunction (Lezak et al., 2004; Reitan & Wolfson, 1985; Strauss et al., 2006). It is frequently used as a measure of cognitive functioning or as a means for monitoring recovery of functioning (Butler, Retzlaff, & Vanderploeg, 1991). It is believed to involve processes of visual search, scanning, sequencing, switching, and processing speed (Strauss et al., 2006).

The Trail Making Test, in its traditional format, is a timed pencil-and-paper task. It consists of two parts, generally designated as parts A and B. On Trail Making A, the individual is required to connect encircled numerals in order. For Trail Making B, the individual is required to connect encircled numerals and letters in order, alternating from numeral to letter. It is believed that both tasks measure attention; given the emphasis on time, processing speed also is believed to be a component to the tasks (Tapert & Brown, 1999). Cognitive impairment, as reflected by difficulty counting, as well as motor impairment, visual scanning deficits, memory problems, and inability to understand the tasks may result in impaired performance on both Trail Making A and B and may reflect dysfunction of the posterior portion of the dominant hemisphere (Golden, Espe-Pfeifer, & Wachsler-Felder, 2000). As such, the Trail Making Test is seen as a good screening measure for neurological dysfunction. Variations to the Trail Making Test include the Comprehensive Trail Making Test (Reynolds, 2002), the Color Trails Test (D'Elia, Satz, Uchiyama, & White, 1996) and the Children's Color Trails Test (Llorente, Williams, Satz, & D'Elia, 2003).

Seashore Rhythm Test

The Seashore Rhythm Test (Seashore, Lewis, & Saetvert, 1960) is another component of the HRNB. It consists of 30 pairs of tonal patterns; for each pair presented, the individual must discern if the two patterns are the same or different (Reitan & Wolfson, 1992). It is generally considered to be a nonverbal auditory task requiring auditory discrimination, auditory perception, attention, and concentration (Batchelor, Sowles, Dean, & Fischer, 1991). The Seashore Rhythm Test is believed to be sensitive to generalized cerebral dysfunction (Reitan & Wolfson, 1985) and correlates moderately with reading ability (Batchelor et al., 1991). Both the Speech Sounds Perception Test and the Seashore Rhythm Test have been used to detect malingering (Ross, Putnam, Millis, Adams, & Krukowski, 2006). Concerns have been noted, however, with regard to low internal consistency (Livingston et al., 1999).

Wechsler Scales

The third factor of the Wechsler scales has historically been associated with attention and concentration (Riccio, Cohen, Hall, & Ross, 1997). More recently, it has been conceptualized as representing working memory, but highly influenced by problems in attention and concentration (Flanagan & Kaufman, 2004). Subtests that comprise the working memory index score include Digit Span, Letter-Number-Sequencing, and Arithmetic. Similarly, attention, concentration, and tracking are believed to influence performance on Digit Symbol/Coding and Symbol Search, as well as the cancellation task on the WISC-IV.

Arithmetic

The Arithmetic subtest is comprised of word problems presented orally or orally with written text provided in the stimulus booklet (Wechsler, 1997a). The items tend to be related to money, measurement, time, and applied math skills, but also requires the mastery of basic facts and retrieval in a timely manner. The unique abilities assessed by this subtest include acquired knowledge (i.e., math skills), sequencing, and mental alertness; however, scores may be negatively affected by attention span, distractibility, and concentration (Kaufman & Lichtenberger, 1999).

Digit Symbol/Coding Subtest

The required portion of the Digit Symbol subtest is the coding task, which requires the examinee to copy symbols paired with numbers under time constraints (Wechsler, 1997a). The coding component provides information on psychomotor speed and sequential processing, as well as short-term memory (Kaufman & Lichtenberger, 1999). It is included in this section because it is influenced by persistence, motivation, attention, and concentration. Incidental learning and symbol-copying tasks on the WAIS-III are optional tasks that can be used to help determine the extent to which psychomotor speed or memory may have contributed to a lower score (Kaufman & Lichtenberger, 1999).

Symbol Search

Symbol search is a visual tracking (match-to-sample) task that involves determining under time constraints if target symbols are repeated in an array of target and nontarget symbols (Wechsler, 1997a). While this subtest assesses visual perception, learning ability, clerical speed and accuracy, and short-term memory to some extent, the unique ability measured by this subtest is the speed with which the visual search is completed (Kaufman & Lichtenberger, 1999). Results can be negatively affected by carelessness, inattention, and motivation, as well as fatigue.

Cancellation Task

Included on the WISC-IV are two cancellation tasks. For the first of these tasks, the examinee is required to scan a random arrangement and mark out target pictures within a specified time limit (Wechsler, 2003). The targets remain the same for the second task, but the arrangement is nonrandom (i.e., columns). The task is aligned with the other perceptual speed tasks, but performance on the tasks may be influenced by attention span, impulsivity, planning, and visual acuity (Flanagan & Kaufman, 2004). The number of correct and incorrect items marked is counted in order to determine standard scoring; process scoring can be used for additional information. For subtests of the WISC-IV, the cultural and linguistic loading for the cancellation task is described as low (Flanagan & Kaufman, 2004).

Continuous Performance Tests (CPT)

The CPT is a group of paradigms for the evaluation of attention as well as response inhibition; these tasks have been described as the "gold standard" for measuring sustained attention (Fleming, Goldberg, & Gold, 1994). The original CPT was developed as a research tool to study vigilance (Rosvold, Mirsky, Sarason, Bransome, & Beck, 1956). Since that time, there have been multiple variations in the components of the task; today, the majority of CPTs are computer administered. The CPT is an objective measure that is not subject to rater bias or observer drift; as such, the level of performance on CPTs may be helpful in ruling out or identifying attentional problems and in monitoring medication effectiveness (Riccio, Reynolds, & Lowe, 2001).

The basic CPT paradigm consists of rapid presentation of continuously changing stimuli. A stimulus or stimulus sequence is designated as the "target" such that the individual is to respond (or inhibit responding) based on the stimulus presented. Variations to the CPT include when to respond or inhibit, the characteristics of the target, variations in the interstimulus interval, presence or absence of distractors, modality of presentation, duration of the target presentation, and duration of task. The effects of some of these possible variations and modifications to the CPT on performance have been reviewed elsewhere (Riccio et al., 2001).

Taken together with direct observation, behavior rating scales, and other psychometric tests, the CPT may provide useful information.

OBJECTIVE PERSONALITY TESTING

Because neurological disorders can affect the modulation of emotion and interact with the temperament or personality of the individual to shape the manifestation, it is important to include some objective measure of everyday behavior, emotional status, or personality as needed. While some indications of possible issues (e.g., with attention, impulsivity, or social cognition) may be evident in test behaviors or response styles, none of the above measures have been validated for the purpose of describing social-emotional status or personality. Objective tests are usually considered those that are highly structured and are scored with a key so that all scorers agree on the scores; these are often paper-and-pencil questionnaires. They have an advantage over less objective and performance-based measures with regard to reliability of scoring, validity, and general psychometric properties that are evaluated. Some of these are administered to the person, and others are completed by significant others (e.g., caretaker, parent, or teacher). There are multiple broad-band or omnibus scales available that include a wider coverage of symptomatology. In addition, there are more narrow band scales that focus on specific types of problems, such as depression or post-traumatic stress. Two of the broad-band measures will be described briefly.

Minnesota Multiphasic Personality Inventory II (MMPI-II)

The initial MMPI was one of the first accepted self-report inventories used in the assessment of adults; it was one of the first tests to use an empirical approach to objective personality development. Since its inception, it has undergone significant revision but continues to be one of the most widely used measures among neuropsychologists (Rabin, Barr, & Burton, 2005). The MMPI-II is the most recent revision; the scale is lengthy with 567 true-false items. It can be done with pencil and paper or administered by computer; a taped version is also available for individuals whose reading level could interfere with accurate completion of the form. There are a variety of scales—both clinical scales and validity scales, as well as multiple supplementary scales that are incorporated into the interpretation of the MMPI-II. The extensive research base and variety of scales generated are probably the major advantages; the reliability of the content scales has been demonstrated, but the code-type interpretation is less so (Strauss et al., 2006). Some concerns have been raised with regard to the use of the MMPI with different cultural groups (Nagayama Hall, Bansal, & Lopez, 1999).

An alternate form for use with adolescents has been constructed based on the original MMPI. While the clinical and validity scales are retained, some of the content scales of the MMPI-A differ from those on the MMPI-II. Psychometric evidence for the MMPI-A is not as extensive as for the MMPI-II.

Behavior Assessment System for Children II

The Behavior Assessment System for Children II (Reynolds & Kamphaus, 2004) consists of multiple components for use in the assessment process. These include a detailed developmental history form, parent rating scales, teacher rating scales, self-report forms, a behavioral observation system, and a questionnaire specific to the relationship between the child and parents. The parent and teacher rating scales differ depending on the age of the child—preschooler, school-age child, adolescent—and the parent scale is available in Spanish. The self-report also differs by age range, with the school-age and adolescent forms. The rating scales and self-report cover both maladaptive as well as adaptive behaviors, including functional communication. Some items are worded to ensure validity, and the scales do yield a validity scale. Normative data are available for general, gender-specific, or clinical groups and are age based from a stratified random sample consistent with the U.S. population. The various scales have reasonable evidence of convergent validity. The computer scoring program as well as hand scoring include determination of 90% confidence intervals for each scale and subscale (Reynolds & Kamphaus, 2004).

TREATMENT PLANNING AND INTERVENTIONS

The goal of neuropsychological assessment is to inform treatment planning and develop recommendations regarding the extent to which the individual is in need of remediation or rehabilitation services, would benefit from compensatory strategies such as assistive technology, or would benefit from a combination of approaches (Gaddes & Edgell, 1994). For these reasons, it is important for the neuropsychological assessment not only to assess areas of presumed or suspected weakness, but also to identify individual strengths (Riccio & Reynolds, 1998). Strengths need to be maximized in the design of modifications and compensatory measures. Potential rehabilitation and instructional materials or methods that may be best suited to the individual should be indicated (Reynolds et al., 1997). Enough information should be provided to assist in the development of an appropriate rehabilitation plan to meet the needs of the individual and to give an indication of the appropriateness of specific types of interventions (e.g., neurocognitive therapy) or specific compensatory methods (e.g., assistive technologies). More importantly, the conclusions need to address the implications regarding the individual's ability to complete necessary activities (Spooner & Pachana, 2006).

CLINICAL RECOMMENDATIONS FOR PROFESSIONAL PRACTICE

For the majority of neuropsychologists, assessment in some form is the most prominent professional activity engaged in (Sweet et al., 2002). From an ethical as well as a legal perspective, it is imperative that the tasks used in a neuropsychological battery meet the designated standards for tests and measurement, yet the lack of current normative data is often cited as a concern (Reynolds, 1997b). Historically, the published batteries have been touted as the best choice in legal proceedings; however, the outdated nature of the normative data and the use of cut scores without corresponding evidence of appropriate sensitivity-specificity trade-off is a concern. Site-based or clinician-determined batteries of measures with adequate normative data and meeting suggested psychometric standards for best practice may be used as alternatives, but it is important to ensure that all necessary domains are assessed so that information about integrity of neurological function as well as strengths and weaknesses can be gathered (Riccio & Reynolds, 1998). Finally, in order for test results to be useful in intervention planning, the results need to be presented in such a way that individuals receiving the report can understand both the abilities and problems facing the individual in real-life situations. The notion of ecological validity or the potential for the information obtained to be used to predict functioning in real-life contexts has become increasingly important in the last 20 years, and it is important for neuropsychological assessments to demonstrate some connection to daily activities rather than relying solely on the inferences drawn from traditional measures (Spooner & Pachana, 2006). This will necessitate reevaluation of the various measures used in the neuropsychological battery, development and inclusion of more ecologically valid measures, and continued research to demonstrate the psychometric properties, including predictive power, of measures used in neuropsychological assessment.

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PART III

Treatment Planning and Intervening With Special Populations and Individuals With Disorders

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10 Brief and Comprehensive Neuropsychological Assessment of Children and Adults With Learning Difficulties and Disabilities

MARGARET SEMRUD-CLIKEMAN AND JODENE GOLDENRING FINE

The definition of the term "learning disability" is constantly evolving through empirical research. The initial definition focused on conditions such as minimal brain dysfunction, word blindness, and dyslexia. P.L. 94–142, which was passed in 1975, popularized the term "learning disabilities." The National Joint Committee for Learning Disabilities in 1981 suggested that "these disorders are intrinsic to the individual and presumed to be due to central nervous dysfunction." (qtd. in Hammill, Leigh, McNutt, & Larsen, 1981, p. 340). Included in this definition were difficulties with reading, mathematics, listening comprehension, written language, and expressive/receptive language. It was presumed that these difficulties were unexpected in the presence of adequate cognitive ability and instruction. The most common types of learning disabilities are reading problems. Empirical evidence suggests a reading disability is not one dimensional. Individual aspects may include difficulty with single-word reading, reading comprehension, and reading rate or fluency. Phonological processing appears to be at the heart of difficulties with word reading and reading fluency (rate) and may be an important marker in the diagnosis of learning disabilities independent of whatever model is used for diagnosis (Fletcher, Morris, & Lyon, 2003; S. E. Shaywitz, Escobar, Shaywitz, & Fletcher, 1992).

The empirical field shows an emphasis on reading. There is an abundance of articles about reading disabilities compared to those written on mathematics, written language, and social learning difficulties (Semrud-Clikeman, 2006). The purpose of this chapter is to briefly discuss reading- and written language-based learning disabilities, the possible etiologies involved, assessment issues, and representative intervention strategies. Given the space provided, it is not possible to discuss mathematical difficulties or language problems.

MODELS OF LD DETERMINATION

Methods used to determine whether a child shows a learning disability have changed as the understanding of what constitutes a learning disability has evolved. Currently there is a great deal of controversy regarding the identification of children and adults with learning problems. In the past, a child was determined to have a learning disability based on a discrepancy between scores obtained on an ability measure and on an achievement measure. This discrepancy was established either by a straightforward subtraction of the reading quotient from the full scale IQ obtained on standardized measures or a regression formula that controlled for inter-correlation between the ability and achievement measure (Semrud-Clikeman, Biederman, Sprich-Buckminster, Krifcher Lehman, Faraone, & Norman, 1992). The regression method yielded different estimates of incidence depending on the magnitude of the difference required. In some cases, the standard score difference was very liberal and set at 16 standard score points difference, while in others the difference was very conservative and set at 2½ standard deviations. Depending on how severity was defined, varying numbers of children were identified as learning disabled and provided special education services.

Some are questioning this method of identification based on a belief that the IQ discrepancy formula may not be the best way to identify these children (Fletcher et al., 2002). This area of theoretical and empirical controversy has generated somewhat opposing views. Some have suggested that the intra-individual difference is a reasonable method for identification (Kavale & Forness, 2003) while others suggest a problem-solving model that incorporates response to intervention (Fletcher, Morris, & Lyon, 2003). The intra-individual difference model stresses within-child reasons for learning problems (i.e., brain dysfunction), while problem-solving models link reading difficulties to teaching (Fletcher et al., 2003).

Kavale and Forness (2003) suggest that the definition of learning disabilities is complex and needs to be carefully evaluated because different definitions can support various viewpoints, depending on philosophical and theoretical differences. One type of definition, the within-child definition, is important for diagnosis and for understanding the underlying neurological substrates of learning disabilities. In that case, the ability to predict who has a learning disability and how to understand the learning problem is paramount. On the other hand, education-focused definitions emphasize advocacy for children, such as establishing appropriate programs and services as well as instituting policy. Advocates on both sides of this ongoing debate may lose sight of the commonalities shared by these views. The following section briefly discusses two currently utilized models for identification of a learning disability.

Intra-Individual Difference Model

As the discussion above indicates, this model evaluates the discrepancy between a child's ability and achievement. There is empirical evidence that this model was not strictly used to diagnosis children with learning disabilities. Studies have found a disproportionate rate of minority students classified as LD who did not show the level of discrepancy required by the state law. Such children were classified using clinically based criteria (Kavale & Forness, 2003; Kavale & Reese, 1992). Moreover, the use of this discrepancy as the sole determinant for whether a child shows a learning disability creates a difficulty in the fact that other information integral to making a diagnosis is ignored (Kavale & Forness, 2003).

Studies have also centered on distinguishing children with low ability from those with "true" learning disabilities. Some have suggested there is little difference between a child with low ability and commensurate achievement and those with a learning disability (Ysseldyke, Algozzine, Shinn, & McGue, 1982). Others have found that children with LD can be distinguished fairly consistently from those with low achievement, particularly when the degree of reading problems is severe (Gresham, MacMillan, & Bocian, 1996; Kavale, Fuchs, & Scruggs, 1994; S. E. Shaywitz, 2003). For example, Fuchs, Fuchs, Mathes, and Lipsey (2000) found that 72% of children who were low achieving in reading performed better than the LD group. These studies provide empirical evidence that the children who have been labeled LD are being adequately differentiated by the discrepancy model.

Additional criticisms of this model focus on the use of IQ for determining the presence of a learning disability (Stanovich, 1991). IQ has generally been used for diagnosis due to an assumption that children who show lower achievement due to lower ability do not have a true learning problem, while those with a discrepancy do have a learning disability (Kavale & Forness, 2003). Some argue that inclusion of IQ penalizes those children who have difficulty learning and who do not qualify for services due to lower IQ (generally in the 70–90 range) (Fletcher et al., 2003; Siegel, 1989). Others suggest that not utilizing IQ would open the classification of LD to children who are achieving commensurate with their ability and who do not have a true LD.

Gresham, MacMillan, and Bocian (1996, 1998) have found that when average ability measures were not used, the population of children identified as LD increased while the population of children with mental retardation decreased. In this situation, children with LD, low achievement, and mild mental handicaps would all be served in the same manner. Whether the children with LD and those with mental handicaps or low ability would profit in the same manner from this type of intervention is not clear from the empirical evidence. One factor that may be important is the fact that most children with low ability show delays across all academic areas, while children with a specific learning disability often show strengths and weaknesses. These issues continue to be unresolved at this time and dialogue on the subject continues.

Problem-Solving Model

This model stresses the treatment of LD rather than the diagnosis. A major tenet of this model is that diagnosis does not assist with interventions and thus is not helpful (Reschly & Tilly, 1999). Methods based on this model include curriculum-based assessment as well as progress monitoring to determine the success of the intervention. The progress of the child who is given good instruction tailored to his or her needs provides the information as to whether the child has a learning problem (Ysseldyke & Martson, 1999). If the child does not make the progress expected, the interventions are targeted to assist the child. Continued difficulty generally results in the child being identified as learning disabled (Reschly & Tilly, 1999).

The key to this model is the use of continued monitoring of the child's progress and changing the intervention as the child makes or does not make progress. Fletcher et al. (2003) rightly point out that the problem-solving model also utilizes the concept of discrepancy and the unexpected difficulty that arises when the child doesn't respond as most other children do to the intervention. In this model, standardized testing is utilized sparingly, while curriculum-based assessment and measurement are more commonly used.

For both of these models, intra-individual difference and problem solving, there are strengths and pitfalls. For the intra-individual discrepancy model, a great deal of testing, time, and effort is required before the child can receive services. This length of time is certainly shortened by the problem-solving model. In the problem-solving model, the child's progress is continually monitored and interventions are fairly rapidly provided. What hasn't been empirically validated by proponents of the problem-solving model is what is to be done in the classroom for a child who does not respond to interventions. In addition, many of the interventions have not been studied for children past the third grade, and it is not clear how ecologically valid or appropriate they may be for middle and high school students (Semrud-Clikeman, 2006). There is a wealth of literature suggesting that matching the intervention to the child's learning style or aptitude is not very effective (Reschly & Tilly, 1999). In the problem-solving model, although similar to an aptitude treatment method, the matching is between the specific reading difficulty and instruction. Empirical validation of this difference in process is not fully present at this time. Thus judgment as to the efficacy of the approach needs to be cautious and reserved.

A further difficulty for the problem-solving model is the possible presence of confounding issues that contribute to the child's learning problems. Depression, attention-deficit/hyperactivity disorder, and other mental health issues may contribute to or even cause learning problems. Further testing/interviewing for mental health problems is beyond the expertise of most classroom teachers. In some cases it would be reasonable to evaluate these areas when a child does not make adequate progress to rule out other possible causes of learning difficulty. The intra-individual differences model does not provide guidance for appropriate interventions. On the other hand, it does provide support in determining why a child is not making progress even when adequate and varied instruction is being provided.

It is reasonable to suggest that a combination of these two models would be the most ecologically valid and provide the child and his or her teacher with the most support. It is likely that a more comprehensive evaluation than one that uses IQ as the sole dimension for diagnosis of a learning problem can shed light on why a child is not progressing despite interventions that appear appropriate for his or her needs. Many studies have looked at IQ and its relationship to aspects of reading (phonological processing, rapid naming) without looking more fully at how these aspects contribute to problems in reading (Fletcher et al., 2002; Hoskyn & Swanson, 2000; Steubing, Fletcher, LeDoux, Lyon, Shaywitz, & Shaywitz, 2002). It appears to be important that research on learning disabilities more fully delineate appropriate interventions for when children do not learn, and that the role of neuropsychological testing be acknowledged when it is needed. Neuropsychological testing and response to intervention provide information that is invaluable for work with children but are neither necessary nor sufficient in the absence of a consideration of both.

The double-deficit theory of reading disability is an area of empirical investigation currently being explored in the neuropsychological literature. This theory suggests that deficits in phonological processing and in rapid naming are two causes of reading difficulties (Wolf & Bowers, 1999). According to this theory, a child with a more severe form of reading difficulty may show more severe problems in one of these areas when rapid naming and phonological processing deficits are present. Children with learning disabilities have been found to show impairment in these areas, and the most severely disabling reading problems co-occur with significant impairment in phonological processing and/or rapid naming (Vellutino et al., 1996). This model has been found to be helpful in identifying children and adults who have a learning disability in reading (Miller et al., 2006).

Semrud-Clikeman (2006) has suggested that a partial solution may be to develop appropriate screening instruments that can assist in identifying children most at risk for later difficulties along with tracking their progress carefully through the early school years. The problem-solving model can easily make use of this procedure, but agreement is needed as to what the most important aspects are that are evaluated and monitored early on. In addition, the use of measures to assess neuropsychological constructs such as attention or working memory could be incorporated into these screening processes to help rule out additional problem areas, comorbid conditions, and other disorders that better explain the problem.

Fletcher et al. (2003) provide convincing information about differences in performance between reading-disabled learners, math-disabled learners, learners with attention-deficit/hyperactivity disorder, combination groups, and normal learners on specific types of tasks. These findings are helpful in designing interventions but also for determining whether additional testing is appropriate (i.e., for a child scoring poorly on both attention and reading). Comorbidity of LD with another disorder has been repeatedly found to result in a more severe manifestation of the learning problems (Satz, Buka, Lipsitt, & Seidman, 1998).

COMORBIDITY

Learning disabilities are comorbid with other diagnoses including attention-deficit/hyperactivity disorder, anxiety, and depression (Martinez & Semrud-Clikeman, 2004; Semrud-Clikeman et al., 1992). Attention-deficit/hyperactivity disorder, or ADHD, has been found to co-occur with difficulties in mathematics (Semrud-Clikeman, 2003), written language (Hargrave, Corlett, & Semrud-Clikeman, 2002), and social-emotional learning disabilities (Semrud-Clikeman, 2003). When ADHD does co-occur with LD, the outcome is more problematic for these children and may well result in additional difficulties outside the academic arena (Fletcher et al., 2003; Satz et al., 1998).

When an internalizing disorder co-occurs with a learning problem, the child's ability to profit from tailored interventions is likely to be compromised. Martinez and Semrud-Clikeman (2004) found that a group of children who had learning problems in both reading and mathematics showed greater maladjustment on measures of atypicality, depression, sense of inadequacy, clinical maladjustment, personal adjustment, and emotional symptoms indexes relative to peers in the normally achieving group. Moreover, children with academic difficulty in more than one subject showed significantly more impairment than children with a learning disability in only one subject. These findings indicate that children with multiple problems have more difficulty learning and are more vulnerable to developing emotional difficulties that may further interfere with learning.

As our understanding of the scope of learning disabilities increases, it becomes apparent to many that the neurological underpinnings for these disorders need to be more clearly understood. Emerging evidence shows differences in structure, activation, and function in children and adults with learning problems compared to typical individuals. The following section provides a brief overview of the evidence for the overarching neurological differences that have been identified.

Brain Imaging and Learning Disabilities

Over the years, both autopsy and imaging research have contributed to our understanding of learning disabilities. Early autopsy studies found symmetrical plana temporale as well as cellular and cortical layer anomalies in adults with a history of reading problems (Galaburda & Kemper, 1979; Galaburda, Sherman, Rosen, Aboitiz, & Geschwind, 1985). Early imaging research concentrated on structural data gained from magnetic resonance imaging and computed tomography scans. Using MRI, Hynd, Semrud-Clikeman, Lorys, Novey, and Eliopulos (1990) found smaller left plana and symmetry of the planum in a group of children with dyslexia. These findings were significantly correlated with poorer performance on measures of reading achievement, word attack, and rapid naming ability (Semrud-Clikeman, Hynd, Novey, & Eliopulos, 1991). The corpus callosum has also been found to differ in children with dyslexia in regions connecting areas involved in language and reading (Fine, Semrud-Clikeman, Keith, Stapleton, & Hynd, 2006; Hynd, Semrud-Clikeman, Lorys, Novey, Eliopulos, & Lyytinen, 1991). These differences have been suggested to be to the result of decreased rates of pruning during the fifth and seventh months of gestation (Galaburda et al., 1985; Hynd & Semrud-Clikeman, 1989).

Emerging research using the advanced technology of functional magnetic resonance imaging suggests that children with learning disabilities process information differently from those without learning problems. From a developmental perspective, it appears that fluent adult readers demonstrate more activation of the frontal brain regions than do children who are beginning to read (Schlaggar, 2003). Similarly, more fluent child readers activate the frontal area more than children with difficulties (Schlaggar, Brown, Lugar, Visscher, Miezin, & Petersen, 2002). Overall, more diffuse activation throughout the brain is seen in children who are just beginning to read. As reading improves, the activation becomes more specialized and efficient.

In addition to having more diffuse activity, children with learning disabilities activate areas of the brain not usually associated with normal reading. Children with learning problems activate the parietal and occipital areas and show more activity in the right hemisphere than the left. In contrast, children without learning problems activate the frontal regions and the left hemisphere, with less activation in the right hemisphere. Similarly, when asked to read single words, normal readers show left hemispheric activation, while those with dyslexia show more right hemispheric activation (Breier, Simos, Fletcher, Castillo, Zhang, & Papanicolaou, 2003; Papanicolaou, 2003). Early readers use visual-perceptual processes generally situated in the posterior portion of the brain. As the reading process becomes more automatized, the frontal systems become more activated. Thus, the progression from simple letter and word calling to reading comprehension requires a maturation of neural pathways linking the back of the brain to the front (S. E. Shaywitz, 2003). Changes from right hemispheric processing to left hemispheric processing have been found to occur with improvement in reading skills. These changes are also found when improvement in language functioning occurs. Such changes are not found for children with dyslexia, as the reading process does not become automatic and effortless.

Brain regions that are in the left temporal region have been found to be more activated in good readers than in those who compensated for their dyslexia (Gabrieli, 2003). In addition, Gabrieli (2003) found that improvements were found in activation following remediation of auditory processing ability. It is not clear, presently, whether these changes continue over time. Further study is needed to understand possible brain response to remediation. This finding is important because activation of the left hemisphere, a region specialized for language functions, plays an important function in reading, while the right hemisphere has generally been implicated in processing of novel stimuli. Since children with learning disabilities activate the right hemisphere, it may be that they find reading to be more a novel task than a learned task, as would be expected with left hemispheric activation.

READING DISORDER

Estimates of the incidence of children with reading disorders (RD) vary from 5%–10% (S. E. Shaywitz, 1998) to as high as 15.7% of the general population (Breier et al., 2003). It is the most prevalent school-based learning problem, accounting for 80% of the children identified as learning disabled. Reports regarding the male-to-female ratio of RD range from 3.2:1 (Lewis, Hitch, & Waker, 1994) to 1.2:2 (S. E. Shaywitz, Shaywitz, Fletcher, & Escobar, 1990). This discrepancy in gender ratio may be attributed to the referring environment, severity of the disorder, or identification method. School-based referrals for reading difficulties have included more males, resulting in prevalence estimates two to four times higher for boys (Miles, Haslum, & Wheeler, 1999). In contrast, research-based diagnosis of RD indicates that boys and girls are equally likely to have a reading disorder when a liberal definition of what constitutes a reading disability is utilized (S. E. Shaywitz et al., 1990). When a more severe standard is utilized to determine the presence of a learning disability, the incidence increases for males from 3:1 to 4:1, with the incidence decreasing for females (Feldman, Levin, Fleischmann, & Jallad, 1995). Thus, when males are identified, they may likely show more difficulty than females and require more intensive interventions that begin at a younger age.

Diagnosis varies from state to state and even within states. Some states allow for a diagnosis of a specific disability in reading with 16 standard score point difference between a standardized measure of ability and reading achievement. Others require 20 to 28 points or use a regression model to determine the discrepancy based on how far above or below the average of most children the ability score is. Still others eschew the discrepancy model and use response to intervention, which requires the student to fail to profit from instruction after a specific period of time. For these reasons, differences are found in prevalence across states and may result in varying estimates of the incidence, severity, and gender distribution of RD.

Reading disorder is thought to be neurobiologically based and genetically heritable, which makes family history an important part of assessing a disability in reading (Semrud-Clikeman, Fine, & Harder, 2005). Early intervention is also indicated, because it is well established that a growing brain can respond to behavioral intervention (Teeter & Semrud-Clikeman, 1997). The cognitive area most often targeted is phonological processing, as this is thought to be an important neural substrate that underlies the acquisition of reading in youngsters.

Phonological Processing: The Primary Model for RD

Phonological processing refers to the automatic perception of the phonemic units of speech, though it is observed at a higher conscious level when words are sounded out (Brady, 2003). Phonological sensitivity develops in early states of pre-literacy and refers to the awareness that words have phonological units, known as phonemes, such as beginning sounds and syllables. For example, the word "dog" has three phonemes—*d, aw,* and *g*—that blend to make a single meaningful word sound, which eventually becomes associated with the letter symbols:

d-o-g. Full phonemic awareness develops reciprocally along with reading mastery as readers become able to recognize, segment, and manipulate phonemes and their symbolic representations (Habib, 2000). It is generally thought that reading disorders are related to a failure to perceive and extract phonemes from oral language, which prevents maturation of the ability to map sound units to letter symbols.

Other Models of Reading Disorder

Although readers rely on conscious phonological decoding when they are learning to read, as readers mature, they build up a store of visual word forms that can be quickly recognized without phonological decoding. Reading by word recognition is referred to as the orthographic reading route and is thought to be the foundation of reading fluency and comprehension. Researchers debate whether the orthographic route and the phonological route of reading are neurologically distinct (Berninger, Abbott, Abbott, Graham, & Richards, 2002; Compton, 2002; Pugh et al., 2001; Wolf, Goldberg O'Rourke, Gidney, Lovett, Cirino, & Morris, 2002; Zeffiro & Eden, 2000).

Although phonological processing deficits are widely accepted as playing a primary role in RD, other broader views of causal influences have also been suggested. Slower rapid automatic naming (RAN) has been implicated. Some suggest that a distinct orthographic deficit contributes to poor RAN (Wolf et al., 2002). Other researchers believe that RAN is, in part, a phonological process but go further to suggest that neurologically based timing deficits of a more general nature may be at work (Semrud-Clikeman, Guy, Griffin, & Hynd, 2000; Wolf, Bowers, & Biddle, 2000). Catts, Gillispie, Leonard, Kail, and Miller (2002) found that poor readers performed more slowly on both linguistic and nonlinguistic reaction timed tasks than did fluent readers, and that the RAN slowing matched the slowing seen on nonlinguistic tasks.

It may be that a more global timing issue underlies the slow RAN seen in children with RD. Tallal and colleagues have suggested that children with linguistic deficits, including RD, have difficulty processing not only auditory stimuli, but any brief, rapid, and successive sensory, perceptual, or motor stimuli (Tallal & Benasich, 2002; Tallal, Stark, & Mellits, 1985). The best infancy predictor of language-based disabilities in 3-year-old children was their ability as infants to detect nonlinguistic rapid auditory frequency changes (Benasich & Tallal, 2002; Tallal, 2003).

In other words, infants who needed longer times to detect changes in sounds appeared to have language-based problems later.

Timing deficits in the visual system have also been suggested to explain RD. The magnocellular neural pathways guide the eyes during reading, providing the reader with stable fixation of the eyes between the rapid successive eye movements (called saccades). Researchers have suggested that there is a delay in the neural response of people with RD in this system (Jenner, Rosen, & Galaburda, 1999). Whether this delay is specific to the magnocellular system or part of a more broad-based timing deficit is still undetermined.

As discussed earlier in this chapter, functional magnetic resonance imaging has contributed much to our conceptualization of RD in children. As children begin to read, they use many more neural systems than do fluent readers. Children with RD seem not to develop the tightly bound and organized pathways that signal efficiency in reading. Thus, it is the integration of systems in this complex cognitive process that appears to be an important factor in successful literacy. Asynchrony, slow timing, and neurological anomalies in phonological, rapid naming, and/or visual systems may all influence the development of reading competence.

Assessment of Children

Before any person, child or adult, can be assessed for reading problems, it is important to rule out primary sensory deficits. Complete hearing and vision examinations should precede any formal assessment. Similarly, it is important to evaluate adequate education in reading prior to assessing for learning disability. A complete family and developmental history needs to be obtained. Because of the heritability of reading disorder, it is also important to ask whether anyone in the extended family has or had difficulty learning to read. Birth and birth history are important because long-term effects of brain insult can include mild to profound learning disabilities with or without broader developmental delays (Ingalls & Goldstein, 1999).

A higher percentage of birth complications have been found among children with learning disabilities compared to their typically developing peers (Ingalls & Goldstein, 1999). Prenatal exposure to alcohol and drugs such as cocaine has been linked to learning and attention problems, but not specifically to reading (Ingalls & Goldstein, 1999). Likewise, fetal and post-birth exposure to neurotoxicants such as lead, mercury, and PCBs does not seem to produce specific disabilities in reading, but deficits of a more global nature that may include slow development of reading skills (Deitrich, 2000).

Although persistent ear infections have been thought to contribute to later reading problems (Kindig & Richards, 2000), not all studies have demonstrated a clear association (Peters, Grievink, van Bon, van den Bercken, & Schilder, 1997). However, ear infection in combination with other risk factors, such as preterm birth and low birth weight, does appear to have an effect on later reading and spelling (Peters et al., 1997). Low birth weight (less than 2,500 grams) and very low birth weight (less than 1,000 grams) have been associated with nonverbal, attentional, and verbal deficits. Even among those with normally developed IQs, significant differences have been found on tests of syntax and phonological processing (Picard, Del Dotto, & Breslau, 2000).

Poor reading has been associated with neurofibromatosis 1 (NF1), along with more global academic and cognitive changes (Hyman & Shores, 2005; Moore & Denckla, 2000). Although no specific cognitive profiles have been associated with NF1, rates of learning disability among such children have been estimated to be as high as 40%–50% (Moore & Denckla, 2000). In some studies, children with NF1 tended to have more nonverbal than verbal-related learning disabilities (Eliason, 1988; Moore, Ater, Needle, Slopis, & Copeland, 1994), while others found reading disabilities may be part of a more global learning problem (Brewer, Moore, & Hiscock, 1997).

Deficits in reading, but not math, have been found in some children with sickle cell disease (Ris & Grueneich, 2000). The reasons for this differential finding are unclear but may be related to the timing of neurological changes in children with sickle cell. Although it seems reasonable to associate poor reading with high absentee rates from school, the data suggest that there is no relationship between number of days absent and academic achievement in these children (Ris & Grueneich, 2000).

Developmentally, many children with early language problems do not go on to develop a verbal learning disorder. However, it is also true that many with early articulation problems and speech delays at 5 years of age exhibit a reading disorder at 8, and a writing disorder by the age of 14 (Lerner, 1997). Finally, comorbid conditions such as ADHD, depression, and anxiety can affect assessment performance. It is possible to obtain a considerable underestimation of skills and abilities when children have problems focusing, managing failure and feedback, or coping with anxiety. It is important to take note of motivation, attention, response to failure and encouragement, and energy level. These aspects of testing can influence the outcome, and although they shouldn't invalidate the results, such issues should be noted when they appear to affect assessment outcomes.

Assessment Instruments

Phonological Processing

Because phonemic awareness has been proved to be a robust predictor of disorders in reading (S. E. Shaywitz et al., 1998) and spelling (Sawyer, Wade, & Kim, 1999), this is a very important aspect of RD assessment. Testing for phonemic awareness can also precede reading instruction because it is based on parsing the individual sound units of words rather than alphabetic translation to sound. There are several phonemic awareness tests. One of the oldest and most utilized is the Auditory Analysis Test (Rosner & Simon, 1971). This test requires the child to say a word and then say it again without a portion that is identified by the administrator (e.g., "Say 'flee.' Now say it again without the *l*"). Norms for the test go from kindergarten to sixth grade, with the standardization sample based on White suburban elementary schools in Pennsylvania.

The Comprehensive Test of Phonological Processing (CTOPP; Wagner, Torgesen, & Rashotte, 1999) includes a phonemic awareness task called Elision. This task has fewer items than does the Auditory Analysis Test, but the norms are more widely distributed across ethnicity and socioeconomic status. There is, additionally, an elision task on the NEPSY (Korkman, Kirk, & Kemp, 1998), which has norms for individuals through 12 years of age.

There are other types of phonological processing tasks that are thought to contribute to reading acquisition. Synthesis of sounds is also thought to be related to phonemic awareness. There are several sound-blending tasks, including Blending Words in the CTOPP, and Sound Blending in the Tests of Cognitive Abilities of the Woodcock-Johnson III (WJ-III; Mather & Woodcock, 2001). For these tasks, the child synthesizes drawn-out phonemes to identify a word.

Rapid Naming

Tests of rapid automatic naming have been found to be diagnostic of reading disability (Waber, Wolff, Forbes, & Weiler, 2000), although these tests are thought to combine aspects of language and executive functions

(Baron, 2004). Performance on RAN tests have also been found to differentiate between normally developing children and those with ADHD (Semrud-Clikeman et al., 2000). On the RAN tests, the child is asked to "read" a card of color patches, objects, letters, and numbers as fast as possible. These four RAN tests are included in the CTOPP along with normative data. The NEPSY also includes a RAN subtest, though it is more complex in that it requires the child to name shape, color, and size simultaneously.

Word Reading

For young children, single real word reading is an appropriate method of assessing reading skill. Very bright children can build strong sight-word vocabularies, however, which may mask underlying deficits that become apparent when reading demands increase. To discover such children, use a non-word measure that presents made-up pseudo-words that must be phonetically decoded (e.g., "gloop," "rike"). There are many large achievement batteries that include real word decoding tests, including the WJ-III, the second edition of the Wechsler Individual Achievement Test (WIAT-II; Psychological Corporation, 2001), the fourth edition of the Wide Range Achievement Test (WRAT-4; Wilkinson & Robertson, 2005), and the Differential Ability Scales (Psychological Corporation, 1990). Single pseudo-word decoding can be found in the WJ-III and WIAT-II.

Fluency

As disabled readers mature, they may easily manage single-word measures that do not account for speed of reading. That is, readers with RD who have partially compensated for their disability will read, but with unusual effort and poor fluency, which in turn affects comprehension. Measures that test speeded single-word reading and paragraph reading are useful for determining reading skill based on both accuracy and fluency.

A timed single real and pseudo-word measure is the Test of Word Reading Efficiency (Torgesen, Wagner, & Rashotte, 1997), which includes normative data for individuals from ages 6 through 24. The fourth edition of the Gray Oral Reading Test (Wiederholt & Bryant, 1992) is an oral paragraph-reading test that includes normative data for accuracy, fluency, and comprehension of increasingly complex paragraphs. The

WIAT-II has timed sentence reading, along with some comprehension items, but the subtest yields a total score that is not separated into speed, accuracy, and comprehension as is for the Gray Oral Reading Test–4.

For the older student, the Nelson-Denny Reading Test (J. I. Brown, Fishco, & Hanna, 1993) is appropriate because it is a silent paragraph-reading test that is similar to a standardized testing environment. The student reads a set of paragraphs on a theme and then answers multiple-choice questions. The Nelson-Denny has normative data from individuals in ninth grade to the adult level and includes an extended time condition that allows one to see how much a student can improve when given more time to complete items.

Reading Comprehension

As mentioned above, comprehension becomes critical as readers mature. In early grades, children read to learn how to read. In later grades, readers are expected to read to learn new material. When RD readers encounter unfamiliar words in a new context, they are at a double disadvantage. They have difficulty sounding out the words and are prone to substitute a similar word when decoding words with which they are more familiar.

The Gray Oral Reading Test–4 includes a multiple-choice comprehension condition, but because missed words are supplied to the reader, some children perform very well on comprehension even though they cannot independently read the paragraphs. The WJ-III includes a passage comprehension test, which uses a “cloze” method for which the reader supplies a missing word. The WRAT-4 also uses the cloze method for a sentence comprehension task. The WIAT-II reading comprehension subtest includes sentence and short paragraph reading requiring free-form rather than cloze responses, but there is no time limit, and the material stays before the child. Examiners should watch for the bright child who goes back through the text to search for the answer. Also note that readers with RD are likely to do poorly on both short (cloze) and more lengthy measures, while readers with ADHD may perform well on short measures, but poorly on long passages (Joshi, 2003).

Listening Comprehension

Researchers have suggested using the discrepancy between listening and reading comprehension as a way of distinguishing phonologically based reading problems from problems in reading due to other factors (Joshi, 2003; Stanovich, 1993). Children with RD can be expected to have better listening skills than reading skills, while those with ADHD can be expected to have better reading than listening skills (Aaron, 2003). The listening comprehension subtest of the WJ-III is a short (cloze) passage task, while the WIAT-II listening comprehension test tests expressive vocabulary, receptive vocabulary, and short sentence comprehension. The Token Test provides a measure of comprehension for increasingly complex directives involving small tokens (e.g., "Put the green circle on the white square"); the normative data for the child version covers children ages 3 to 12.5. There is a similar test on the NEPSY and also on the Differential Ability Scales Preschool assessment (DAS-II; Elliot, 2007). The Oral and Written Language Scales: Listening Comprehension Scale (Carrow-Woolfolk, 1995) is a multiple-choice pointing response test with norms for individuals from ages 5 to 21.

Memory and Learning

The ability to internally hold a set of phonemes long enough to blend the sounds and then to make meaning of them is another area of basic functioning required for reading development. This is called working memory. Thus, testing for auditory working memory is an important part of any RD assessment. Most cognitive functioning (IQ) tests include measures for working memory. A common subtest is memory for digits forward and backwards, a task that can be found in the WISC-IV (Digit Span) and also the CTOPP (forward only). On the WISC-IV, a measure of letter-number sequencing for which the examinee must unscramble and sequence letters and numbers in working memory is also a useful subtest. Together, the Digit Span and Letter-Number Sequencing subtests yield a working memory index. Memory for spoken sentences has also been shown to be more difficult for RD readers than for typically developing readers, though it is thought that their problem with sentence memory stems from poor phonemic memory rather than semantic impairment (Mann, 2003). Sentence memory tasks can be found on the second edition of the Wide Range Memory for Learning (Sheslow & Adams, 2005) and the fourth edition of the Clinical Evaluation of Language Fundamentals (Psychological Corporation, 2004).

Verbal learning is also an important part of an RD assessment. Some bright older children with RD demonstrate excellent verbal list learning because they have developed close listening and memory skills as a method of compensating for poor reading in the classroom. On the other hand, children with poor verbal learning strategies in addition to an RD are at double disadvantage in the classroom if both their reading and listening skills are impaired.

Verbal learning tasks usually involve learning a list of words, or learning a list of paired words. The children's version of the California Verbal Learning Test (Delis, Kramer, Kaplan, & Ober, 1994) has normative data for children from ages 5 through 16–11. The Children's Memory Scales (Cohen, 1997) includes verbal working memory tasks, as do the NEPSY, the second edition of the Wide Range Memory for Learning, the CTOPP, and the Test of Memory and Learning (Reynolds & Bigler, 1994). Most of these tests require the child to recall word lists, word pairs, sentences, or stories.

Executive Functioning

Because of the high rate of comorbidity between RD and ADHD, an assessment of executive functioning is important to rule out possible ADHD symptoms and to assess whether deficits in attention are adding to reading problems. Moreover, there is evidence to suggest that children with RD have problems with planning and organization that are not necessarily associated with a clinical diagnosis of ADHD, though study findings are generally inconsistent (Reiter, Tucha, & Lange, 2005). Studies have found verbal and figural fluency problems (naming words and drawing designs quickly and flexibly) (Reiter et al., 2005) as well as problems with sequencing of events and ability to inhibit response to distracting stimuli (Brosnan, Demetre, Hamill, Robson, Shepherd, & Cody, 2002), though it should be mentioned that RD participants with ADHD were not necessarily removed from these studies.

A measure of verbal fluency is especially important to assess the presence of language-based executive issues as well. Children with RD have performed more poorly than their able-reading peers on measures of verbal fluency (Reiter et al., 2005). Verbal fluency tasks require the child to name as many words as possible during a short time period. Usually, words are required to begin with a specific letter sound (e.g., *s*) or belong to a specific category (e.g., animals). There is a question as to whether poor performance on verbal fluency measures is related to broad language processing issues, or more generalized slow response time. Reiter et al. (2005) found that dyslexic children produced fewer words than typically developing children on both phonological and semantic fluency naming tasks, concluding that reduced production rather than processing was the cause. The Delis-Kaplan Executive Functioning System (D-KEFS; Delis, Kaplan, & Kramer, 2001) and the NEPSY require the child to name categories of words or words with selected beginning letters as quickly as possible to measure both phonemic and categorical fluency. The FAS Test, part of the Neurosensory Centre Comprehensive Examination for Aphasia (Spreen & Benton, 1997) and the Controlled Oral Word Test from the Multilingual Aphasia Examination (Benton & Hamsher, 1976) both offer phonemic verbal fluency tests similar to the phonemic condition of the D-KEFS.

Other standard measures of fluency, flexibility, and planning such as the various tower tests, the Trail Making Test, and Stroop can be found both as individual tests with various norms (see, for example, Baron, 2004; Lezak, Howieson, & Loring, 2004; Strauss, Sherman, & Spreen, 2006) and within the D-KEFS, which is an omnibus executive functioning battery containing many subtests. The Tower Test is a measure of planning for which the examinee is asked to move disks between three posts to create a stack of disks on one post. Speed and rule following are typically measured. Small disks can never be under larger disks, which forces the examinee to use detailed strategy and planning to accomplish the task. The Trail Making Test is a test of mental flexibility during which the examinee connects alternating letters and numbers in dot-to-dot fashion. The Stroop is a measure of the ability to inhibit the automatic process of reading. Examinees are asked to name the color of ink in which a word that is an incongruent color word is printed (e.g., the word "red" printed in blue ink). Because reading is presumed to be less than fully automatic for RD readers, the Stroop may not necessarily be a good predictor of mental flexibility for individuals with RD.

Broad Language

Reading disorder can be part of a broader language problem. In this case, lower verbal IQ scores might be seen on tasks that demand rich expressive language, on a measure of verbal fluency, or on tasks that ask examinees to name words from pictures. If a broader language disorder is suspected, a language screening is recommended to reveal deficits in expressive and receptive language. For older children, a subtle language deficit may not be observed in single-word "naming" situations, such as on the Expressive One Word Picture Vocabulary Test (Brownell, 2000). Rather, eliciting responses that demonstrate proficiency in language syntax, semantics (meaning), and fluency may help uncover the child for whom language processing is not adequately developed. For children ages 5–21, the fourth edition of the Clinical Evaluation of Language Fundamentals (Psychological Corporation, 2004) is a broad language assessment tool covering expressive and receptive language (one word and sentences), verbal working memory, and language pragmatics (understanding social communication). The fourth edition of the Clinical Evaluation of Language Fundamentals includes a Spanish language edition and normative data for a variety of cultural/ethnic groups. For younger children up to 6 years of age, the fourth edition of the Preschool Language Scale (I. L. Zimmerman, Steiner, & Pond, 2002) offers assessment of expressive and receptive language in English and Spanish.

Conclusion

Once one has tested all the areas described above, it is important to determine whether the deficits observed are specific to reading and other related language functions. One question to ask is whether deficits are seen in other areas of functioning to the same extent, because poor reading may be part of a more global processing issue, such as mental retardation. It is also important to test for relative strengths of each individual. For example, a person with specific RD is not likely to have similar difficulties in math calculation or listening comprehension. If a broader language issue is suspected—for example, if severe naming problems and poor receptive and/or expressive language are observed—referral to a speech and language pathologist is recommended.

Assessment of Adults

Although children with RD can and do learn to read, for most, reading remains effortful and dysfluent in their adult years (B. A. Shaywitz et al., 1995). Such adults are characterized as having partially compensated developmental dyslexia. There is some controversy as to which factors are the best predictors of adult RD; some emphasize continuing deficits in phonological processing (e.g., S. E. Shaywitz et al., 1999), and others suggest that phonological processing only partially explains reading ability in adults, as working memory, listening comprehension, and vocabulary skills also play an important role (Ransby & Swanson, 2003). Thus, in general, when an adult with compensated developmental dyslexia is being tested for problems in reading, a full battery covering phonological processing, word and pseudo-word reading, pseudo-word reading that is timed, reading fluency, comprehension, memory and learning, and executive functioning is recommended.

In adults, reading difficulty can also be the result of brain insult, for example, stroke, traumatic brain injury, or degenerative dementias. In this case, the presentation for the reading disorder is dependent on the location of the lesions, and the reading disorder is referred to as acquired dyslexia. It is important to determine whether acquired dyslexia is a symptom of a broader aphasia. For example, a stroke or brain damage in the region of the brain responsible for the ability to read aloud or speak may selectively affect reading of grammatical words only, or reading for meaning (Weintraub, 2000). Careful evaluation of language fluency, articulation, semantic consistency, and prosody in conversational language prior to reading assessment is indicated in such cases. The third edition of the Boston Diagnostic Aphasia Exam (Goodglass, Kaplan, & Barresi, 2000) is a broad battery of subtests that cover a very wide range of language areas. The entire exam is very long, but several subtests are especially useful for observing language-based problems related to brain injury. The Cookie Theft subtest elicits a sample of storytelling. There are subtests for sentence repetition and confrontation naming (naming words from pictures) as well.

In general, for evaluation of reading disorder, the same areas of evaluation as are used for the assessment of children are recommended, though the number and quality of the available measures are more limited (Lezak et al., 2004). Word reading, fluency, reading and listening comprehension, memory and learning, and additional executive functions are all areas worthy of assessment. In addition, it may be prudent to assess the motivation of the patient, particularly if the case has legal implications.

Word Reading

Several omnibus tests extend normative data to adults. The WJ-III cognitive and academic batteries go to over 90 years of age. The WIAT-II also extends to 85 years of age. These tests can be used to assess word reading, pseudo-word reading, comprehension, and working memory. The WRAT-4 has a similar breadth of age norms, covering real word reading, sentence comprehension, and spelling. The fourth edition of the Gates-MacGinitie Reading Tests (MacGinitie, MacGinitie, Maria, & Dreyer, 2000) is a paper-and-pencil multiple-choice reading test with an adult form for simple word recognition that includes a “generous” time limit (Lezak et al., 2004).

Fluency

Obtaining a timed reading test of fluency is especially important for adults who may be partially compensated. Although they may have developed reasonably good decoding skills, reading generally remains dysfluent and effortful for older disabled readers. Unfortunately, there are few timed reading tests for adults. An exception is the Nelson-Denny Reading Test, which provides a measure of silent passage reading in both normal and extended conditions. The WJ-III has a measure of reading fluency that is timed reading of sentences requiring a yes/no response, but the sentences are very simple and may be easily read by partially compensated RD adults.

Reading Comprehension

If reading is too slow and dysfluent, the adult reader will have difficulty retaining information from longer passages. The Nelson-Denny Reading Test evaluates reading comprehension for long passages under timed conditions. The WIAT-II reading comprehension measure is untimed, as is the WJ-III. Also, the WJ-III comprehension measure is a simple cloze task, which does not assess more dense material, such as paragraphs or essays. The Gates-MacGinitie Reading Tests includes a passage comprehension subtest. There is a reading subtest of the Kaufman Functional Academic Skills Test that is a very brief assessment of life skills such as following directions and reading signs that might be useful in cases where dementia is of concern (Kaufman & Kaufman, 1994).

Listening Comprehension

The Revised Token Test (McNeil & Prescott, 1985) is a test of listening comprehension with norms for adults ages 20 to 80 years old. Like the child version of the test, the Revised Token Test consists of a series of increasingly complex directives requiring the examinee to move small colored tokens. The sentence comprehension subtest of the WRAT-4 has normative data for individuals up to 94 years old. Both the WJ-III and WIAT-II have norms for adults on their listening comprehension subtests. On the WJ-III, there are two subtests. One is a simple single-word receptive language test ("Point to the . . .") and the other is an oral comprehension subtest for which a sentence that must be finished by the examinee is given by the examiner. The WIAT-II has one listening comprehension subtest that asks, "Which picture matches the sentence?" The examinee must point to one of four pictures.

Memory and Learning

In adults, measures of memory and learning can provide insight into the compensatory strategies of the adult compensated RD reader. Memory for auditory information and the ability to develop effective strategies for learning by hearing are two ways that adults can support information acquisition in the absence of strong reading skills. Word list learning is a common way to evaluate this ability, and the second edition of the California Test of Verbal Learning is a list learning task that includes interference and recognition conditions for adults and elderly adults (Delis, Kramer, Kaplan, & Ober, 2000). A list of words is read five times, and the examinee is asked to say as many words from the list as he or she can remember each time. Then another list is given (interference), after which the examinee recalls words from the original list that was read five times. The examinee is then prompted to recall the words based on semantic category (i.e. "furniture"). After 20 minutes of other activity, the examinee tries to recall the words again. A recognition condition, for which the examinee states whether a specific word was on the list or not, is useful to separate encoding problems (word never transferred to memory) from retrieval problems (word is in memory but cannot be retrieved). Auditory working memory measures can be found in the third edition of the Wechsler Memory Scales (WMS-III; Wechsler, 1997b), an extensive memory battery extending to individuals 89 years of age that includes paired associate verbal memory as well as memory for long passages. The two working memory subtests of the Wechsler Adult Intelligence Scale III (Wechsler, 1997a) assesses short-term working memory, for which the examinee must remember and manipulate numbers and letters. The Wechsler Adult Intelligence Scale III provides an overall index for these measures of working memory that can be directly compared to the verbal and nonverbal indices as well as to processing speed to determine relative strengths and weaknesses.

Executive Functions

As in assessing children, the evaluation of executive functioning (in addition to working memory) is important for evaluating the possible comorbid presence of an ADHD, and because deficits in executive functioning subclinical to ADHD can add to reading and other learning problems. All the executive functioning measures of the D-KEFS, discussed above, including a version of the Stroop, Trail Making, Tower, Verbal, and Design Fluency tests have normative data for adults. The Wisconsin Card Sorting Test, a test of mental flexibility and problem solving, is available in both card (Grant & Berg, 1993) and computer forms (Heaton, 2003). On this test, the examinee must sort cards of colored geometric shapes based on four properties. Each time, the examiner provides feedback about whether the card was sorted correctly, but no advice is given. In addition to problem solving, this test can provide insight into strategy development as well as a person's response to negative and positive feedback.

Conclusion

When one is evaluating adults, it is quite important to determine whether the RD in an adult is a continuation of a developmental reading problem or if the reading problem was acquired later in life. In the case of late acquisition, it is important to refer to medical professionals to rule out vascular and neurological causes, if they are not already known. Otherwise, the focus of the assessment should be determining strengths and weaknesses in the individual's profile that can help with putting appropriate supports in place. The next section focuses on interventions for both young and older readers.

INTERVENTIONS

Remediation for Reading Disability in the Young Child

Several neuroimaging studies have found changes in brain activation patterns following language-based remediation in children with RD (e.g., B. A. Shaywitz et al., 2004; Simos et al., 2002; Temple, Deutsch, Poldrack, Miller, Tallal, & Merzenich, 2003). Researchers have found activation patterns to become more normalized, but not fully similar to brain activation in non-RD readers. Although more similar to non-RD readers, RD readers who received intense remediation still lacked the tightly localized reading system of the normally developed reader. The brain's apparent ability to reorganize the neural circuitry for reading with remediation further appears to be related to improvements in actual reading skill.

Dependant on the neural plasticity of the young brain, reading interventions should take place both early and intensely. Most children are not identified in the schools until the age of 9, when they have failed to respond to regular reading programs. The window of opportunity for progress in reading, however, begins to close by about the seventh grade, which leaves only a few years for optimal remediation (Semrud-Clikeman et al., 2005). Further, children who have experienced repeated failure in school may already have begun to develop emotional and motivational problems concerning school and learning, which makes remediation an even more daunting task. Early diagnosis and intense intervention are most likely to yield the most desirable outcomes.

Not surprisingly, attention to phonological processes is the focus in remediation of a phonologically based reading disorder. However, most of the more successful programs utilize multisensory curricula that include reading components as well. The Lindamood-Bell system (Lindamood & Lindamood, 1998) is comprehensive and very intense, usually involving one-to-one instruction 4 hours per day for 6 to 8 weeks. Concentrated instruction in phonemic awareness and phonemic sequencing, visualization techniques, and contextual language training are generally included in the Lindamood-Bell training program.

There are several highly structured, systematic, and multisensory programs based on the Orton-Gillingham method. Phonemic awareness, decoding, and spelling are taught in an intensive fashion. Two such programs are GoPhonics for young readers in kindergarten through second grade, and the Wilson Reading System for older elementary students. The PHAST Track Reading Program is a 70-lesson system developed at the Learning Disabilities Research Program at the Hospital for Sick Children in Toronto, Canada, that teaches phonemic awareness and metacognitive strategies for word recognition.

In schools, remediation usually involves small-group work at a level of intensity that may not help RD readers catch up to their normally developed peers. In order to avoid school failure in areas that depend on reading skills, it is extremely important to recommend classroom accommodations for the child with a reading disability. Such accommodations should include extra time for reading and writing assignments and tests; the opportunity to have assignments, including new information, read to the student; dictation of written assignments and/or use of a computer for producing written work; and the use of Cliffs Notes and books on tape. It is important to remember that even math can rely on reading; a child who excels at math calculation may not be able to read a math word problem.

Remediation Strategies for Older Students With RD

Providing remediation to the older student with RD mostly involves the development of compensatory strategies, such as the accommodations described above. As the student progresses in school, he or she will be expected to read for new information. For the RD student, reading words that he or she has never heard before is extremely challenging. Oral exposure to the material prior to reading is helpful, and the RD student should receive reading assignments far in advance. Before reading a chapter, the student should be prompted to review the questions that will need to be answered from the material. It is advisable for students entering college to consider taking 3 years to accomplish the first 2 years of study. Most importantly, career counseling is strongly suggested for RD students. Jobs requiring heavy reading would be inadvisable, whereas jobs for which oral communication is dominant would be more appropriate.

Students with RD do best in small colleges that are willing to accommodate their needs. Very large schools are not recommended. There are several books on how to find appropriate schools (see Suggested Readings). Once an individual finds a college that may be appropriate, he or she should contact the office of student services to see what resources the college offers, and what documentation is required before services are extended to students. Because the first few years of college are usually large reading-heavy survey courses, it is also wise to anticipate a 5-year plan. The first 2 years should be done in three, and the last 2 years, when courses have a smaller number of students and can be tailored to the student's interests, can be completed in the standard 2 years.

Conclusion

For the older child and adult, setting up the environment for success is most important. Although practice is always good, older readers must learn to accommodate for their disability. Whenever possible, visual aids, condensed versions (e.g., Cliffs Notes), and prepared outlines of material will help. Extended time is almost always necessary. Although the primary disability may be in reading, older children and adults with RD may also struggle with writing, which is the primary means of communicating knowledge in academic environments. Resting on the foundation of reading, the development of spelling and writing skills is typically difficult for the RD individual. Thus, the older RD student may need additional support in the area of written language. The following section discusses written language disabilities in both adults and children.

WRITTEN LANGUAGE DISORDERS

The incidence of written language disorder appears to be approximately 4% and may be as high as 17% (Hooper et al., 1994). Referrals for difficulty with written expression increase around the age of 10, when writing becomes more heavily emphasized in the elementary school curriculum, and continues through high school and into college (Berninger & Amtmann, 2003). Writing is a complex process that involves the ability to plan, translate the plan into words, and then revise as needed (Hayes & Flower, 1980). In the planning stage the child must set the goal for what is being written, generate ideas, and then organize them into a coherent whole (Graham & Harris, 2003). The translation of the plan requires the child to complete the writing. Many children with learning disabilities generate ideas and then write what is recalled from reading and research. Problems are present in that the child with learning difficulties does not go beyond just retelling what he or she has read to interpret and extend upon the materials. In this sense, Graham and Harris (2003) term the writing process "condensed or simplified" (p. 323).

Developmental Aspects of Writing

The ability to write begins to be developed in preschool and continues through adulthood (Gregg, 1991). These skills include handwriting, spelling, and composing. At its earliest stages, writing involves scribbling and copying letters and figures. As the child develops, handwriting becomes more automatic. The brain areas that control visual-spatial and motor systems complete their development around this time. Spelling is an important part of learning to write and generally is emphasized in this early stage. Like other skills, spelling moves from effortful production to automaticity such that the child does not need to think about the sound of each letter. For children with reading problems, the move to automaticity is more problematic, which negatively affects the child's ability to quickly produce writing. Berninger and Fuller (1992) found that the best predictors for written language competency were related to orthographic coding (the ability to recall the spelling of the word), fine motor skills, and the coordination between writing and spelling.

As the child matures, letter and word production become less effortful and the child does not have to work as hard to recall word patterns (McCutchen, 1996). In this manner, the child's working memory becomes freed up for other tasks such as organizing the material and making transitions from one paragraph to the next. Higher-order thinking becomes more developed as specific areas of the brain mature, particularly in the frontal lobes, which are myelinating at that time (Ellison & Semrud-Clikeman, 2007). In middle school, the connections between writing and organization continue to mature for typically developing children. Writing at this point requires the child to be able to organize ideas and sequence them in logical order, pay attention to the reader, and be able to use basic mechanics (spelling, syntax, and handwriting) (Harder, Semrud-Clikeman, & Maegden, 2007).

One of the difficulties for children with learning problems is the reliance of spelling on phonological processing rather than automatic word pattern memory. As such, many children with reading problems experience significant problems with written language. These difficulties continue into adulthood as misspellings, are frequently present, and in many cases the word is spelled with phonetic deficits. Berninger and colleagues (1998, 2002) found that automaticity also enters into difficulty with writing because the effortful recall of basics requires the mental resources usually used for higher-order reading processes, such as writing meaningfully and making smooth transitions. Such effort affects the fluidity of the writing and the cohesion of the manuscript.

For older writers, these difficulties continue to be present and become more problematic. Particular problems for adolescents and young adults are planning, organization, thematic development, and sequencing. These difficulties are related to working memory. Challenges to working memory increase when tasks that usually are automatized by this age remain effortful. Older, more mature writers are particularly challenged because writing expectations increase while basic skills may not. Older writers are expected to move beyond just telling what is to be said to making inferences and conclusions that arise from the context of what is being written. When university students with and without learning disabilities were compared on measures of written language, the participants with LD showed significant difficulties in vocabulary, fluency, grammatical usage, and length of the compositions written. They also had difficulties producing work at the same level as students without learning problems (Harder et al., 2007). For most typically developing adolescents, the written product begins to resemble that produced by adults or skilled writers because of maturation in working memory, planning, and reviewing of work.

Gender differences are also present in writing acquisition (Berninger & Fuller, 1992). Boys have been found to show better ability in verbal fluency than girls. Girls demonstrate better orthographic fluency as well as more words and sentences produced in their writing. Girls continue to improve in orthographic and verbal fluency and surpass boys during the middle school years (Berninger & Swanson, 1994). However, quality of composition has not been found to differ between the genders after middle school and into adulthood.

Issues of Comorbidity

Difficulty with language acquisition has been found to be related to problems with written language. Elementary school children with language impairments were found to produce shorter compositions with poorer sentence structure than their non-language impaired peers (Dockrell, Lindsay, Connelly, & Mackie, 2007). In addition, it was found that their ideas were not as well developed, nor was there sufficient organization of the material. These problems are likely related to difficulties with automaticity as well as with word fluency—both of which are likely compromised in children with language and learning problems.

Children with ADHD and LD appear to be particularly vulnerable to problems with writing. Studies have found difficulties with handwriting, spelling, and composition (Mayes, Calhoun, & Crowell, 2000; Reid & Lienemann, 2006). Working memory is a skill that has been strongly tied to written language production (Berninger, 1999). Working memory allows the writer not only to manage writing and the fundamentals (spelling, etc.) but also to retrieve information from previous paragraphs and tie it to upcoming tasks. Additional studies have found difficulties with working memory and metacognition, and problems with understanding and correcting errors, a skill particularly important for revision in children with and without ADHD (B. J. Zimmerman & Schunk, 2001). Direct evaluation of the writing of children with ADHD has found confusion in the writing that made it hard to understand, writing that provides little information, difficulties with organization and cohesion, and inaccurate spelling and grammar (Tannock, Purvis, & Schachar, 1993). These problems were found to significantly impair the usefulness of the writing and to reduce the understandability of the product.

For many children with ADHD, either comorbid with LD or as a sole diagnosis, problems in retaining what has been said in order to plan for what comes next in the narrative has been found to be particularly problematic (Naidoo, 2006). In addition to working memory, the ability to self-regulate one's writing is very important. These self-regulatory mechanisms require the child or adult to evaluate and monitor the writing as it proceeds. Self-regulation is a developmental process that begins in elementary school and continues into adulthood. For writing, the ability to review what has been said and then to revise the material is particularly crucial in the later years of education. Harder, Semrud-Clikeman, & Magden (2007) found that for college students with and without ADHD, the ability to inhibit responding was essential to good writing ability, particularly on skills requiring attention to detail and in spelling.

Assessment of Written Language

To assess written language, it is important to utilize several different methods. Consistent with the previous discussion, it is important to evaluate different aspects of writing. Some of the beginning aspects that should be measured are handwriting, spelling, punctuation, and grammar. For older children, these measures should be administered with the addition of higher-level measures to evaluate the child's thematic maturity, organizational skills, and writing product. There are several standardized measures on the market for evaluating written language that should be supplemented through the use of informal measures of writing. Most of these specialized measures are not designed for adults. The following section will discuss overall standardized measures that are omnibus in nature as well as tests designed specifically for the assessment of written language. Information about informal measures will also be included.

Standardized Omnibus Measures

Standardized measures that are omnibus in nature, meaning these tests sample the major aspects of achievement, include the Wechsler Individual Achievement Test–II (WIAT-II; Psychological Corporation, 2001), the Woodcock-Johnson Tests of Achievement–III (WJ-III; Mather & Woodcock, 2001), and the Peabody Individual Achievement Test–Revised (PIAT-R; Markwardt, 1997). These measures include assessments of reading, mathematics, and written language. The Kaufman Test of Educational Achievement–II (Kaufman & Kaufman, 1998) only provides a measure of spelling. In most cases the written language subtests include measures of spelling and some type of writing. The writing tests vary in intensity from requiring examinees to complete sentences and paragraphs to instructing them to write a short essay. It is important to recognize that these written language tasks differ in what they measure and that a score on one test may not be consistent with that of another.

The WIAT-II and PIAT-R require the child to write a short essay. A spelling test is also included. The scoring of the essays is fairly subjective and may substantially differ between raters (Sattler, 2001). The age range for the WIAT-II is from 5 to 19 years of age, while for the PIAT-R it is from 5 to 22 years old. The WJ-III has an age range of 2 to over 90 years of age. The WJ-III includes a measure that evaluates spelling as well as punctuation and usage. The second part of the test requires the child to complete sentences or complete a paragraph. This measure is more standardized, and scoring, although somewhat subjective, is more controlled.

M. B. Brown, Giandenoto, and Bolen (2000) compared scores on the WJ-Revised and the WIAT. Sixth graders with learning disabilities were compared to those without learning problems. The WIAT scores were consistently higher than the WJ-R scores in writing, but not on measures of punctuation, spelling, and grammar. Thus, when one is evaluating a child for written language skills, it may be helpful to evaluate the child's ability to write in a more structured style (i.e., by using the WJ-III) as well as evaluate the child's ability to write an essay (i.e., by using the WIAT-II or PIAT-R). The more structured approach may assist in evaluating the child's ability to work with materials that are clearer and perhaps require less independence than is necessary to write an essay. This process may also assist the teacher in developing teaching strategies—possibly juxtaposing structured work with work that is more essay-like in nature.

Direct Measures of Written Language

There are four major measures that directly evaluate a child's writing skills. The Test of Early Written Language–2 (Hresko, Herron, & Peak, 1996) evaluates children's pre-writing skills from ages 3 to 10. The basic writing subtest measures directionality, punctuation, spelling, and construction of sentences. The writing subtest requires the child to write a story about a picture. There are scoring measures of the story's format, cohesion, theme, and structure. This test is one of the few that evaluate early writing abilities in young children.

The Test of Written Language–3 (Hammill & Larsen, 1996) evaluates expressive language as well as written language abilities for children ages 7–6 to 17–11. There are eight subtests that measure writing vocabulary, spelling, sentence construction, and story construction. The child is asked to write a story with a beginning, middle, and end about a picture. Then the child is asked to write sentences using a supplied word, write sentences from dictation to assess spelling, edit sentences, and rewrite two or more short sentences into one sentence. The scoring evaluates the child's use of punctuation, spelling, usage, and sentence construction. This measure shows good psychometric properties. It may also be used as a group writing test as well as for individual use.

The Oral and Written Language Scales (Carrow-Woolfolk, 1995) evaluate the child's listening comprehension, language (expressive and receptive), and written expression. It covers ages 3 to 21. The written expression part of the Oral and Written Language Scales requires the child to write sentences to prompts, and scores range from 0 to 10 points for each item. Psychometric properties for this measure are in the moderate to good range.

Given the finding that children with writing difficulties may have problems with motor control, it would be very helpful to assess their fine motor skills. The use of the Purdue Pegboard and the Finger Tapping Test would be useful adjuncts to the assessment for both children and adults. In addition, parts of the Process Assessment of the Learner (Berninger, 2001) also evaluate motor functioning and would be quite helpful. Although these tasks were developed for children, they are also useful with adults.

Adult Written Language Assessment

For the assessment of adults with possible written language difficulties, these tests—with the exception of the WJ-III—do not provide norms for people above the age of 20 to 22. The assessment of written language in adults is very important, as this skill is quite sensitive to brain injury and damage. Difficulties in written language often accompany aphasia and reading difficulties in patients with brain damage. These deficits may be characterized by an inability to spell nonsense words while real word reading is preserved (this is called phonological agraphia) (Mesulam, 2000). Another type of aphasic writing deficit is lexical agraphia, in which the patient can write nonsense words, but not irregular words. This type of difficulty is interpreted as a problem with orthographic coding but not with phonological coding.

Research has indicated that there may be problems with linguistic processing or with the motor aspects of handwriting. A patient may be able to spontaneously write sentences but be unable to write in response to dictation (Mesulam, 2000). Others may not be able to write spontaneously or from dictation but may be able to directly copy words and sentences. When problems are present with the fine motor aspects of writing, evaluation needs to utilize a computer in order to fully evaluate the person's writing skills apart from handwriting. Lesions of the corpus callosum (the large bundle of fibers that connects the hemispheres) can cause writing disturbances (agraphia) with the left hand, while individuals with hemispatial neglect (damage to one hemisphere) may fail to write on the side of the paper that is associated with visual processes in that hemisphere.

Assessment of adults with possible brain damage should evaluate the patient's ability to copy figures, write sentences spontaneously and from dictation, and also copy sentences. These skills should be evaluated in conjunction with reading ability, which is discussed earlier in this chapter. It is also possible to utilize the tests for writing used with children and adolescents in a diagnostic manner to provide information about the person's ability to write and construct a story. The astute clinician may also use the omnibus measures to obtain standard scores and then also do an informal assessment to determine what areas are problematic. One may also utilize items from the Boston Diagnostic Aphasia Examination (Goodglass & Kaplan, 1983) and a three-part writing test developed by Chedru and Geschwind (1972). In this latter evaluation, the person is asked to write a sentence about the weather and one about his or her job. Then the individual is asked to write sentences using specific words ("business," "president," "finishing," "experience," "physician," "fight") and sentences that describe a picture from the Boston Diagnostic Aphasia Examination. In the evaluation of the paragraph, scores are obtained for overall organization, vocabulary, word usage, grammar, spelling, mechanics, and handwriting (Horner, Heyman, Dawson, & Rogers, 1988). Finally the person is asked to copy a printed sentence in cursive ("The quick brown fox jumped over the lazy dog"). Lezak et al. (2004) suggest that since writing is not an overlearned skill for most of us, problems with writing are diagnostic of difficulty in integration of visual-spatial ability, higher-order thinking, and fine motor skills.

Process Measure

The Process Assessment of the Learner (Berninger, 2001) is useful for children in kindergarten through sixth grade. This measure was designed to evaluate the child's ability in reading and writing as well as for progress monitoring. The test is designed to be tailored to the child's need, and individual subtests can be administered to answer the referral question. For the purposes of this chapter, the review is restricted to the written language subtests. There is a measure of handwriting that begins with alphabet writing and moves to copying of text. In a unique measure, the child is asked to listen to a lecture and to take notes. Later in the session, the child is asked to use these notes to write a paragraph. This measure provides information about the child's ability to listen and process information while writing and then to later retrieve the information and formulate it into a meaningful communication.

Conclusion

Written language learning disabilities, particularly those in more mature writers, have not been studied as often as other types of learning problems (Lyon, 1998). For this reason our understanding of difficulties with working memory, disinhibition, handwriting, and visual-spatial processing in older populations is not as developed as our understanding of these difficulties in elementary school children. With the emphasis on writing increasing, particularly in college, it is important to study writing abilities in college students with and without learning problems and attentional difficulties. There are few measures that directly evaluate written language in adults above the age of 25. The Boston Diagnostic Aphasia Examination and informal measures likely provide the best estimate of skills for these subjects. In addition it would appear important to evaluate fine motor skills as well as executive functioning, given the link between organization and working memory problems and poor writing. These executive function skills are important for the development of appropriate interventions, which are discussed in the following section.

INTERVENTIONS IN WRITTEN LANGUAGE

The number of studies that have sought to evaluate interventions in written language has increased over the past few years. In most cases these interventions have been developed for children and adolescents, not for adults. However, most of these strategies appear to be useful for all age groups and may be adapted for adults, with the caveat that the interventions have not been empirically validated for adult writers. One aspect that has been carefully studied is the ability of students with LD to revise their writing. Revision of writing is an area that children and adults with LD tend to have significant difficulties accomplishing. Research has found that people with LD spend little time planning what they are going to write, and even less time on revisions (Graham & Harris, 2003). MacArthur and Graham (1987) found that older elementary school children with LD did not spend more than 1 minute planning their writing prior to beginning. From additional studies, it was found that most children with LD mostly write using previous memories of text that are interrelated, one sentence to the next. They also have very little consciousness of the needs of the topic, the audience, or the organization of the material (Scardamalia, Breiter, & Goleman, 1982). For this reason, the writing of children with LD is often short and provides few details and very little elaboration (Graham, Harris, MacArthur, & Schwartz, 1991).

Graham and Harris (2003) describe a process that assists children and adolescents with LD where prompts are provided to assist the child in revising and refining his or her writing. This process is termed self-regulated strategy development (SRSD). SRSD is designed to help students learn how to set goals, monitor their writing, give themselves instructions, and reinforce their effort. It not only provides assistance with increasing the amount that is written but increases the child's motivation to write. The process encourages children to establish a goal in writing, to use an outline for their writing, and to continue planning what they are writing as they write. The outline is particularly helpful in that the child is directly taught to link ideas to content. It also assists with transitions throughout the project. In several cases, the teacher would model the process aloud for the students to show her thinking processes by asking herself questions such as "What would I do now?" "What strategies should I use?" and "Did that work for me?" The teachers also modeled good self-reinforcement by saying, "I did a good job," or making similar reinforcing statements.

In SRSD Graham and Harris (2003) suggest five main characteristics of learning strategies for written work. For the first characteristic, children are directly taught self-regulation procedures as well as the content that is needed for the writing. Second, interaction between the teacher and the children where the child is an "active collaborator" in the project is encouraged (Graham & Harris, 2003, p. 329). Third, the work is individualized for the child's needs and skills. Fourth, all these steps are reviewed and practiced until the child shows mastery. Finally, SRSD provides the opportunity for the teacher to continue to introduce new strategies and to review previously taught strategies. Lesson plans that use SRSD can be found at www.vanderbilt.edu/CASL/. The interested reader is referred to that web site for further information about this intervention. This process has also been validated with children with ADHD (Reid & Lienemann, 2006).

Berninger has developed a program to assist children in writing and to both remediate and prevent future writing difficulties (Berninger & Amtmann, 2003; Berninger et al., 1998; Brooks, Vaughan, & Berninger, 1999). In these interventions particular attention is paid to early skills and to providing support in the early grades. One particular aspect that is emphasized is difficulty with handwriting in kindergarten and first grade. Berninger and Amtmann (2003) report on a study in which first graders with handwriting difficulties were provided with intensive assistance to automatize the writing process. It was found that improved handwriting led to improved compositions (Jones & Christensen, 1999). Berninger (1999) suggests that teachers provide instruction on all levels of skills. For example, low-level skills such as copying letters and sentences are paired with composition skills. In this paradigm, the higher-levels skills are motivation for practice in lower-level skills, which are far more boring and routine.

Berninger and Amtmann (2003) suggest that technology is best used with children who cannot automatize such abilities by third grade. It is likely that computers can be readily adapted for use by adolescents and adults. One of the most promising aspects of computers is dictation systems that recognize the person's voice and then transcribe what is being said. Along with this type of intervention is software that can predict the word to be utilized by the first sounds. This word prediction software requires fewer keystrokes and thus can assist the person with the writing. Spell checkers are also provided by most computer programs, as are grammar checkers.

One software program for writers has editions for younger and older writers: Kidspiration (K–grade 5) and Inspiration (grades 6–12). These programs assist with organization and idea development. Users can create idea webs in flowchart form, linking ideas and creating hierarchical relationships graphically. The software then creates an outline and provides a supportive writing environment that helps students to choose appropriate words. The software can assist older students in collecting research from various sources, including the Internet.

Living in a computerized world, adolescents and adults with learning disabilities should be strongly encouraged to utilize computers for their writing. Many computer-based supports are available, as described above. It is important that children and adults be provided with sufficient training in keyboarding, whether or not a writing/reading disability is present.

CONCLUSION

The field is continuing to rapidly develop research in written language, particularly in identifying writing problems in children. Unfortunately, identification and treatment gains have not extended into adolescence or adulthood at the same rate. Further study is sorely needed for older writers, particularly for interventions that are appropriate. Assessment of the needs of adults is still poorly developed. Further refinement of assessment and remediation is an area of significant need.

At the same time, technological advances in computers, voice recognition software, and composition software are encouraging for the older student. Our understanding of the writing process has evolved from a concentration on spelling and handwriting to encouragement of metacognitive strategies, self-reinforcement, and self-monitoring of composition. Programs that directly teach these skills have been found to be quite successful and show empirical promise. Further study of interventions for college-aged adults, as well as improvement in assessment, is needed. The interested reader may wish to obtain the following references.

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SUGGESTED WEB SITES

For information about reading disorder and remediation for school psychologists and teachers: http://www.nasponline.org/resources/reading/index.aspx
For up-to-date information on current research: http://www.ninds.nih.gov/disorders/dyslexia/dyslexia.htm

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11 Brief and Comprehensive Neuropsychological Assessment of Alcohol and Drug Abuse

ARTHUR MACNEILL HORTON JR. AND ARTHUR MACNEILL HORTON III

Alcohol and drug abuse problems have existed since the earliest recorded time. Human beings for centuries have used alcohol and natural substances such as peyote from the cactus and leaves from the opium plant to change their emotions. In recent years, pharmaceutical technology has developed new drugs such as morphine, heroin, cocaine, amphetamines, LSD, PCP, and designer drugs such as ecstasy. Recent research has documented that abusive use of alcohol and illicit drug use can cause significant brain damage (Allen & Landis, 1998). This chapter deals with the use of neuropsychological assessment for individuals who have abused alcohol and drugs. Discussion will cover both brief measures to identify alcohol and drug abusers who have sustained brain damage and also more comprehensive procedures to provide data to identify brain-damaged drug and alcohol abusers. In addition, the chapter will discuss the use of neuropsychological assessment data in treatment planning and intervention for substance abusers.

OVERVIEW

Given the extent of alcohol and drug abuse in the United States, the fact that alcohol and drug abusers may become brain damaged has important implications for the assessment and treatment of drug abusers

(Spencer & Boren, 1990). In an earlier version of this book, Tarter and Edwards (1987) noted that little attention had been devoted to brain-damaged individuals with substance abuse problems. They averred that neuropsychological assessment could be used to measure an individual's organic integrity to provide a prognosis and assess his or her potential for recovery and provide recommendations for treatment planning and intervention.

Because agreement that alcohol and drug abuse causes residual neuropsychological deficits has only recently been reached, research studies assessing the neuropsychological treatment implications in populations of alcohol and drug abusers are in a preliminary stage. This chapter, however, can assist in setting the stage for the planning of future neuropsychological assessment studies of treatment planning and interventions with brain-damaged alcohol and drug abusers.

This chapter also is focused on the neuropsychological deficits caused by alcohol and drug abuse that are relatively enduring (Spencer & Boren, 1990) as opposed to selected drug-related states such as intoxication and withdrawal and delirium, which are considered to be relatively transient. While the neuropsychological effects on learning and memory from intoxication and delirium are very serious, in most individuals, these neuropsychological effects are state dependent rather than enduring after withdrawal from the abused substance or substances. Neuropsychological effects of alcohol and drug abuse to be examined in this chapter are organic syndromes of greater duration than delirium and intoxication.

BRAIN STRUCTURES RELATED TO ADDICTION PROCESSES

The brain is composed of 100 billion cells called neurons that function as an integrated whole through intracellular communication. As a vast network of communication, the brain is also subdivided structurally. The different structures subserve specific functions and interact with one another to subserve more functions and ultimately behaviors. Examples of brain structures that are related to functions are the hippocampus (memory), the visual cortex (sight), and the hypothalamus (homeostasis). Communications between structures rely on neuronal interaction, and these interactions are pathways that allow for the sending and integration of information between brain regions. Information is transmitted via chemical and electrical signals. Reception of information by neurons occurs at the dendrites and soma. The process of communication is repeated to allow information to travel through the brain structures.

Addiction processes in the brain are the result of changes to the reward pathway of the brain when it is exposed to alcohol and drugs such as cocaine, heroin, and marijuana. Absent addictive processes, the reward pathway facilitates positive conditioning by which behaviors that precipitate the experience of pleasure are strengthened. The brain associates the behavior with the pleasurable feeling, and the individual becomes more likely to perform the behavior again when the behavior is rewarded. The neurotransmitter dopamine is particularly relevant to the reward pathway and addiction because of its prevalence in the reward pathway. The reward pathway progresses from the ventral tegmental area to the nucleus accumbens to the prefrontal cortex and is activated when positive reinforcement occurs with specific behaviors or, put another way, when the behaviors are rewarded (Horton & Wedding, 1984). Humans and animals are likely to continue to perform the behavior, assuming a motivational state is present, as long as the reward accompanies the behavior.

The effects of cocaine on the brain reward system might be considered as an example. Research studies have shown that stimulation of the nucleus accumbens or ventral tegmental area by cocaine activates the reward pathway. At the same time, research has shown that activation doesn't occur when cocaine is administered to parts of the brain other than the brain reward system. Addictive drugs possess the capacity to produce strong relationships between intense feelings of pleasure and drug-taking behavior through intense activation of the reward pathway. This activation in some cases can possibly cause drug-taking behavior to be selected over behaviors fundamental to survival such as eating, having sex, or caring for children. Addictive substances yield high concentrations in the ventral tegmental area and nucleus accumbens, where dopamine is heavily used in transmissions between neurons. Addictive substances have the net effect of increased abnormal firing patterns and increased activation of the reward pathway. The activation becomes strongly linked to the reward: the experience of intense pleasure. Maintenance of the reward requires the association to be strengthened. Although the effects on the reward pathway are primarily responsible for the addictiveness of alcohol and psychoactive drugs, the drug, or drugs, may move to other areas of the brain. For example, cocaine disrupts the brain's ability to utilize glucose (i.e., perform its metabolic activity). Glucose is the substance that provides energy for brain functioning. Less effective use of glucose, due to the effects of cocaine, can cause degradation of multiple brain functions. Other areas of the brain affected by addictive drugs are the hippocampus, in which products of multiple abused substances can reduce normal memory function.

PSYCHOACTIVE SUBSTANCE ABUSE RESEARCH ISSUES

There are multiple methodological problems involved with measuring residual neuropsychological effects in human beings who have abused alcohol and drugs. For example, differences in age, gender, education, and ethnicity are potential methodological confounds (Reed & Grant, 1990). It is well known that a large number of neuropsychological tests are correlated with age, gender, education, and ethnicity (Heaton, Miller, Taylor, & Grant, 2004). The recent availability of more accurate and comprehensive age and education norms for a number of neuropsychological tests may help to address this problem area (Heaton et al., 2004), but others have averred there are potential problems with the currently available norms (Reitan & Wolfson, 2005).

The abuse of multiple substances by individuals who abuse alcohol and other drugs is another difficult methodological confound (Reed & Grant, 1990). The reality is that the majority of substance abusers abuse alcohol and other psychoactive drugs. These substance abusers are often referred to as “garbage can” abusers. In short, most substance abusers abuse a wide variety of psychoactive substances. In research studies, substance abusers are most frequently characterized as having a preference for a single substance but, in reality, the daily consumption of addictive substances by an alcohol and drug abuser is primarily a product of alcohol and psychoactive drug availability. The addicted substance abuser wishes to modify his or her current mental and emotional state and will turn to the psychoactive substance available.

The amount of alcohol and psychoactive drugs taken by alcohol and drug abusers is also a potential methodological confound (Reed & Grant, 1990). Most research studies simply ask subjects retrospectively how much of a drug they had abused, as methods for hair and blood analysis are complicated and expensive. Breath alcohol testing is adequate for an individual’s current state but poor for retrospective analysis. In addition, self-reports concerning substance abuse by alcohol and drug addicts are often solicited quite some time after the incident or incidents of substance abuse occurred. Also, patients who abuse drugs and alcohol frequently have impaired short-term memory, and their recall of how much alcohol and how much and what drugs were abused can be confounded by acquired memory deficits. On the other hand, research data demonstrate that most alcoholics and drug abusers are truthful, as far as their memories permit, regarding their alcohol and drug abuse, save for in situations where there would be immediate negative consequences for truthfulness (e.g., jail).

In addition, another methodological confound is that current methods for assessing residual drugs effects based on the mode of consumption are severely limited (Reed & Grant, 1990). Simply put, the ingestion of various psychoactive drugs through needle injection, orally, or through the nose or other means can cause different effects. The immediate action of the drug, the amount of the drug, and how quickly the drug enters the bloodstream are all dependent on the mode of consumption. The mode of consumption is critical to the production of the expected residual neuropsychological impairment.

Other potential methodological confounds are a number of premorbid and concurrent medical risk factors (Reed & Grant, 1990). The premorbid risk factors that can influence a person's susceptibility to developing neuropsychological deficits after alcohol and drug abuse include conditions that usually develop in childhood such as learning disabilities and attention-deficit/hyperactivity disorder, genetic and metabolic disorders, and early brain injuries (Tarter & Edwards, 1987). Traumatic stress experiences such as exposure to violence, rape, and childhood sexual abuse may also make individuals more likely to abuse alcohol and psychoactive drugs. In addition, almost any diagnosable psychiatric condition can occur in the context of an addiction career, and these mental disorders are difficult to diagnose in an addict population (Horton & Fogelman, 1991). Also, the lack of certain nutrients and exposure to neurotoxic substances during child development and in some cases after human development has been completed can impair subsequent neuropsychological functioning. Moreover, various body organ systems can be compromised and organ dysfunction may have negative secondary effects on brain functioning and as a result have effects on a person's neuropsychological ability and susceptibility to the neuropsychological consequences of alcohol and drug abuse (Tarter & Edwards, 1987). Simply put, a wide array of psychological, psychiatric, medical, and nutritional factors can confound the determination of residual neuropsychological effects of alcohol and drugs of abuse in human beings.

ASSESSMENT ISSUES

Clinical neuropsychological assessment procedures are very complex and can be seen as having both general and specific assessment components. Cone's (1978) early conceptualization of behavioral assessment approaches describes a funnel model of assessment. The funnel model of behavioral assessment avers there is a need for assessment procedures to both screen for specific difficulties and assess those difficulties in a comprehensive manner. Screening instruments are very valuable for quickly identifying individuals with difficulties in need of further evaluation. In addition, comprehensive assessment procedures are needed to allow for the full assessment of the difficulties necessary to make very accurate diagnoses, to form prognoses, and to plan effective treatment and intervention programs as well as to provide baseline data and follow-up evaluations to make meaningful comparisons over time to demonstrate changes in the nature, type, and degree of residual difficulties.

In considering assessment procedures, it is important to appreciate that the terms "diagnosis" and "assessment" refer to two separate undertakings. Horton and Wedding (1984) have described diagnosis as a procedure that places an individual in a recognized and/or defined category or class. Assessment has been described rather differently as the categorization of an individual among multiple dimensions of adaptive and maladaptive functioning (Horton & Wedding, 1984). The differences between diagnosis and assessment might be seen as similar to the differences between a photograph and a video. Reliability of judgments, for example, regarding a photograph can be determined with little difficulty, but reliable judgments regarding the content of a video could require one to watch similar sections of the same video. Multiple aspects of the video would be considered and evaluated, and there would be a greater richness of assessment. Simply put, diagnosis is a specific label, and assessment is more open ended. Assessment should always precede a diagnosis, but assessment can provide valuable information in addition to a diagnosis (Horton & Wedding, 1984).

NEUROPSYCHOLOGICAL ASSESSMENT

As is very well known, clinical neuropsychological tests are valid measures of brain behavior relationships (Reitan & Wolfson, 1993). Clinical neuropsychological tests have been accepted as valid measures of brain-behavior relationships because there is empirical proof that these measures can effectively differentiate brain-damaged individuals from normal individuals (Reitan, 1955a). Neurotoxic disorders (i.e., disorders caused by exposure to alcohol and certain psychoactive drugs) and head injury are two neurological conditions for which clinical neuropsychological testing is the best method for assessing very subtle executive functioning, memory, attention, and perceptual-motor changes (Horton & Wedding, 1984).

In terms of a model of clinical neuropsychological assessment, Tarter and Edwards (1987) have averred that neuropsychological assessment consists of three separate domains of neuropsychological functioning: these are cognitive/psychomotor, psychopathological, and social areas. In this chapter, the primary domain of neuropsychological assessment that will be covered is the cognitive/psychomotor area. The assessment of psychopathology and social relationships, however, will not be addressed in detail in this chapter due to space limitations. Tarter and Edwards (1987) strongly advocated, depending on a number of circumstances, the use of either a screening approach or a comprehensive neuropsychological approach with alcohol and drug abusers. The circumstances considered for making a determination of whether a screening or full assessment approach should be used might include the following: available personnel resources and neuropsychological technical expertise, the amount of assessment time available, the financial costs, and the patient's interest in and motivation to undergo the assessment procedure (Tarter & Edwards, 1987). The relative importance of each circumstance would, of course, vary considerably depending upon the setting in which the assessment would take place and administrative issues.

SCREENING ASSESSMENTS

If the neuropsychological assessment task to be accomplished is to very quickly determine the presence or absence of neuropsychological deficits, then screening procedures would appear to be indicated. Screening assessment is most clearly indicated when there are large numbers of patients who need to be examined and the presumed base rate of neuropsychological impairment is relatively low. For example, in an outpatient community drug abuse treatment program that treats affluent young addicts with short histories of substance abuse, it would be unusual to find significant neuropsychological impairment in the majority of the patients. In such a setting, it would be more appropriate to use screening procedures than to administer comprehensive assessments to every patient. Screening procedures are most clearly indicated when there is no significant probability of neuropsychological impairment but the intent is to identify patients at high risk of having neuropsychological impairment and then provide comprehensive assessments. The screening assessment would also have the advantage of quickly identifying patients who would fail to benefit from more cognitively oriented treatment approaches so that more appropriate treatment modalities could be implemented. In addition, patients who would benefit from more comprehensive assessments are quickly identified so that comprehensive assessment services can be provided.

Clinical neuropsychological screening tests have been empirically validated by researchers (McCaffrey, Krahula, Heimberg, Keller, & Purcell, 1988; Mezzich & Moses, 1980; Norton, 1978; Reitan, 1955a, 1958, 1973). While a number of effective screening measures have been identified (e.g., Symbol Digit Modalities Test, Bender Gestalt Test, Hooper Visual Organization Test, Canter Background Interference Procedure, Benton Visual Retention Test), perhaps the most widely used neuropsychological screening measure is the Trail Making Test (Horton, 1979, 1980; Horton & Wedding, 1984; Mezzich & Moses, 1980; Reitan, 1955a, 1958). The Trail Making Test is a very brief and easy-to-administer neuropsychological test that has been used in a wide variety of clinical and treatment settings (Horton, 1979). Similar to the other identified neuropsychological impairment screening tasks, the Trail Making Test assesses a wide range of neuropsychological skills, including letter and number recognition, visual scanning, set shifting, motor speed, and sequencing ability (Horton & Wedding, 1984).

The Trail Making Test has two parts labeled Trail Making A and Trail Making B. The Trail Making task requires the patient to use a pencil to draw a line that connects in numerical order (i.e., 1-2-3) 25 sequentially numbered black circles printed on an 8½-by-11 sheet of white paper. The Trail Making B task requires the patient to complete a more complex task. As in the Trail Making A task, there are 25 circles printed on an 8½-by-11 sheet of white paper. In the Trail Making B task, however, the scheme for connecting the circles is very different. In Trail Making B the symbols in the printed circles on the sheet of paper are of different two series. The two series consist of circles containing numbers (1–13) and circles containing letters (A–L) printed on the page. The patient is required to draw, as rapidly as possible, a line through all the circles by alternately connecting the circles containing numbers and letters (i.e., 1-A-2-B-3-C . . . L-13) until the 25th circle (i.e., number 13) is reached. The final scores for parts A and B are the number of seconds required to complete each task. As the subject completes each Trail Making Test task, errors are immediately pointed out by the examiner, and the subject is redirected to the last correct circle completed while timing continues. Each error increases performance time on the Trail Making Test (Horton & Wedding, 1984). The Trail Making Test is extremely valuable for screening patients for neuropsychological impairment because test administration usually takes less than 5 minutes and the Trail Making Test is in the public domain (the Trail Making Test was originally developed under the auspices of the U.S. government's War Department, now the Department of Defense) and can be administered by a trained neuropsychology technician (Reitan & Wolfson, 1993).

The widespread use of the Trail Making Test is illustrated by the fact that in 1990, the Trail Making Test was adopted as a screening assessment procedure for neuropsychological impairment by a panel of assessment experts formed in connection with the National Institute on Drug Abuse–sponsored drug abuse treatment outcome study titled Drug Abuse Treatment Outcome Study on the recommendation of the first author of this chapter, who was a member of the panel (Horton, 1993). The Drug Abuse Treatment Outcome Study enrolled over 10,000 drug addicts in a nationwide drug abuse treatment outcome sample. The study assessment protocol administered the Trail Making Test as the first neuropsychological impairment screening measure given to study subjects. Depending on the patient's level of performance on Trail Making B, different follow-up neuropsychological assessment measures were given for more detailed assessment of neuropsychological impairment (Horton, 1993).

The method of screening for neuropsychological impairment, of course, was relatively gross and crude, but administration time and study personnel expertise were limited. While there was no reason to suspect neuropsychological impairment in many relatively young patients entering drug abuse treatment, all subjects could be assessed in a time-efficient fashion utilizing inexpensive test materials and a paraprofessional staff. Moreover, as the Trail Making Test is a paper-and-pencil instrument, failure of equipment is very rare. The Trail Making Test is readily available and has been successfully administered by neuropsychological technicians in many research studies and multiple clinical settings. A number of studies have validated the use of the Trail Making Test for assessing alcoholics and various types of drug addicts (Horton & Roberts, 2001; Roberts & Horton, 2001).

COMPREHENSIVE ASSESSMENT

Screening neuropsychological assessment procedures stand in contrast to comprehensive neuropsychological assessment procedures (Horton & Wedding, 1984). Comprehensive neuropsychological assessment procedures are recommended in situations where there is a reason to suspect neuropsychological impairment in patients when screening neuropsychological assessment procedures have indicated a need for comprehensive neuropsychological assessment or there is a history of a neurological condition such as an early head injury or cognitive complaints or a history of mental problems that may have an organic component or other reasons to suspect neuropsychological impairment. In some cases of an unclear diagnostic picture, comprehensive neuropsychological assessment could be used to rule out neuropsychological impairment and hopefully clarify the diagnostic picture.

It is important to appreciate that comprehensive neuropsychological assessment is resource intensive, is time consuming, and requires both greater mental and physical effort on the part of the patient and greater technical expertise in test administration and scoring on the part of the neuropsychologist conducting the assessment. Also, more complex and expensive testing equipment is required for comprehensive assessment. In addition, comprehensive neuropsychological assessment requires specialized training and extensive experience interpreting neuropsychological test results. On the other hand, comprehensive neuropsychological testing is extremely valuable in making an accurate diagnosis, particularly with very complex questions regarding such issues as differential diagnosis among multiple etiologies and the patient's prognosis, suitability for treatment and other interventions, vocation fitness and employability, and need for vocational accommodations.

While there are multiple sets of procedures for comprehensive neuropsychological assessment, no specific set of comprehensive neuropsychological assessment procedures has been developed for alcohol and drug abusers alone. Given the dearth of comprehensive neuropsychological assessment procedures for alcoholics and drug abusers, in this chapter attention will be devoted to the Halstead-Reitan Neuropsychological Test Battery (HRNTB; Reitan & Wolfson, 1993), currently the best-validated and most extensively researched set of neuropsychological assessment procedures available (Horton & Wedding, 1984; Reitan & Davison, 1974). The HRNTB is composed of measures that were empirically validated to be sensitive to the effects of brain damage (Halstead, 1947). The original HRNTB test measures from Halstead's neuropsychology laboratory at the University of Chicago Medical School include the Category Test, a measure of visual abstraction and concept information; the Tactual Performance Test, a measure of psychomotor/tactual-perceptual problem solving; the Speech Sound Perception Test, a measure of the ability to perceive speech sounds; the Rhythm Test, a measure of the ability to discriminate between rhythms; and the Finger Tapping Test, a measure of motor speed. A number of ancillary measures were added to the HRNTB by Reitan at his neuropsychology laboratory at the University of Indiana Medical School (Reitan & Davison, 1974). These include the Reitan-Indiana Aphasia Screening Test, a measure of language functioning; the Reitan-Klove Sensory-Perceptual Examination, a measure of sensory-perceptual functioning; the Trail Making Test; and intelligence testing, academic achievement testing, and objective personality testing. The HRNTB is frequently supplemented with additional measures of language, memory, and attention functioning depending on the needs of the patient (R. M. Reitan, personal communication, December 15, 2005). While the HRNTB was not specifically developed to assess alcohol and drug abusers, there have been many research studies that have comprehensively assessed alcohol and drug abusers with the HRNTB. In a landmark study that used the HRNTB with drug and alcohol abusers, Parsons and Farr (1981) found that alcoholics, but not drug addicts (considered as a heterogeneous group), were significantly impaired with respect to the level of performance criteria. Alcoholics demonstrated particularly neuropsychological difficulties with visual abstraction, set shifting, and visual-spatial skills (Benedict & Horton, 1992). A subset of HRNTB measures has been found to be sensitive to the adaptive abilities of alcoholics (Horton & Anilane, 1986; Schau & O'Leary, 1977).

While drug addicts were not impaired relative to a level of performance model, specific patterns of impairment for drug abusers were identified. Drug abusers demonstrated patterns of impairment on measures of fine motor speed, auditory rhythm pattern recognition, visual abstraction, and set-shifting abilities. Brief selective reviews of the residual neuropsychological impairment that follows abuse of specific psychoactive drugs are presented below.

MARIJUANA (CANNABIS)

Initial research studies of marijuana abusers failed to find significant residual neuropsychological deficits (Carlin & Trupin, 1977; Grant, Rochford, Fleming, & Stunkard, 1973; Mendelson & Meyer, 1972). Better-controlled subsequent research studies of marijuana abusers, however, found that memory functions were impaired after marijuana abuse (Page, Fletcher, & True, 1988; Schwartz, Gruenewald, Klitzner, & Fedio, 1989). The reason that the initial research studies of marijuana abusers failed to find neuropsychological impairment may have been that many of the research studies had poorly chosen samples and inadequate measures of neuropsychological functioning. More recent research found residual neuropsychological effects on measures of memory and executive functioning (Bolla, Eldreth, Matochik, & Cadet, 2005; Horton & Roberts, 2001; Pope & Yurgelun-Todd, 1996).

In a landmark meta-analytic study, Grant, Gonzalez, Carey, Natarajan, and Wolfson (2003) conducted a quantitative synthesis of empirical research pertaining to the residual effects of cannabis on the neuropsychological impairment in adults. They reviewed 1,014 studies and discarded all but 15 research studies because of methodological flaws. The 15 studies provided data on 704 cannabis users and 484 non-users. They found significant neuropsychological effects only for learning and short-term memory domains. They described the effects as small and suggested that where use of marijuana was found to have therapeutic value, its benefits may outweigh the negative side effects. The meta-analysis was, however, limited to adult humans, and children may be more vulnerable than adults to the neuropsychological effects of cannabis. For example, Goldschmidt, Day, and Richardson (2000) and Fried and Smith (2001) published research that reported that neuropsychological impairment was found in the children of mothers who had abused cannabis in both Canadian and U.S. samples.

HALLUCINOGENS/LSD AND ECSTASY

Research studies of neuropsychological impairment in individuals who have abused LSD and other hallucinogens have found unclear results. In very early research studies, McGlothlin, Arnold, and Freedman (1969) and Acord and Barker (1973) reported finding visual abstraction and concept formation deficits, but similar results have not been reported in the research literature. Moreover, the level of neuropsychological impairment found was subtle and could have been due to comorbid factors. Additional well-controlled research is needed to address the issue of neuropsychological impairment in abusers of LSD and other hallucinogens.

3,4-Methylenedioxymethamphetamine, or ecstasy, is considered by some pharmacologists to be a stimulant, but researchers have recently begun to appreciate its hallucinogenic properties (Reneman, Booij, Majoie, van den Brink, & den Heeten, 2001). Ecstasy appears to have different properties from those of other hallucinogens (Parrott, 2001), and published research has found that ecstasy can impair memory functioning in abstinent ecstasy abusers (Bolla, McCann, & Ricaurte, 1998; Zakzanis & Young, 2001).

OPIATES

Opiates have not been found to cause residual neuropsychological impairment. In an initial research study, Fields and Fullerton (1975) didn't find evidence for neuropsychological impairment in a sample of heroin addicts. A more recent study by Rounsaville, Novelly, Kleber, and Jones (1981) reported that heroin addicts who also were polydrug users had neuropsychological impairment. They reported that heroin addicts with the most impairment tend to have a childhood history of hyperactivity and poor academic records. On the other hand, the same group of investigators conducted a follow-up study using the same subjects and found that the sample of heroin users actually performed better than demographically similar controls on neuropsychological tests (Rounsaville, Jones, Novelly, & Kleber, 1982). There has been little subsequent research on neuropsychological impairment in heroin addicts. One possibility is that Rounsaville et al. failed to adequately control for demographic variables in the 1981 study. In addition, it may be that heroin addicts, like professional boxers, are initially physiologically superior individuals and that even with a degree of neuropsychological impairment, they are more able than normal individuals.

SEDATIVES

Neuropsychological impairment in sedative abusers appears to be well supported by research. Judd and Grant (1975) reported an initial study that found sedative abusers had neuropsychological impairment. The study results were limited by the fact that a number of the patients were also abusers of stimulants, alcohol, and opiates. Bergman, Borg, and Holm (1980) better controlled for possible polydrug abuse by using only subjects who were treated for illicit sedative abuse and still found neuropsychological impairments similar to those of Judd and Grant. The evidence for neuropsychological impairment in sedative abusers is well accepted, and the *DSM-IV* contains a category for sedative-hypnotic amnestic impairment.

PHENCYCLIDINE

Research studies have not overwhelmingly demonstrated the presence of neuropsychological impairment organic mental disorder in PCP (or angel dust) users, and a PCP organic mental disorder category that existed in the *DSM-III-R* was dropped from the *DSM-IV*. Carlin, Grant, Adams, and Reed (1979) found very subtle neuropsychological deficits but were able to draw few conclusions regarding the potential effects of PCP use on neuropsychological functioning, as the study used a very small sample size. In addition, the finding of neuropsychological impairment in PCP users hasn't been replicated.

COCAINE AND OTHER STIMULANTS

Research studies have been supportive of findings of neuropsychological impairment in abusers of cocaine and other stimulants. O'Malley and Gawin (1990) found neuropsychological impairment in chronic cocaine users. The level of deficits found by O'Malley and Gawin was mild and similar to the level of deficits found in research studies with polydrug users. A landmark study of neuropsychological impairment with respect to cocaine abusers correlated neuropsychological impairment with single photon emission computerized tomography findings (Strickland et al., 1993). Neuropsychological impairment in cocaine users is likely to be due to small strokes and seizures, and frontal deficits have been found (Volkow, Hitzmann, Wang, Fowler, Wolf, Dewey, & Handlesman, 1992; Volkow, Mullani, Gould, Adler, & Krajewski, 1988). Other research has supported the relationship between neuropsychological impairment and cocaine abuse (Jovanovski, Erb, & Zakzanis, 2005; Simon, Domier, Sim, Richardson, Rawson, & Ling, 2002; Van Gorp, Wilkins, Hinkin, Moore, Horner, & Plotkin, 1999).

There is considerable animal research suggesting neuropsychological impairment as a result of stimulant use, but early human studies didn't find neuropsychological impairment (Reed & Grant, 1990). Well-controlled contemporary research studies, however, have found neuropsychological impairment related to methamphetamine use (Dafters, 2006; Kalechstein, Newton, & Green, 2003; Nordahl, Salo, & Leamon, 2003; Woods, Rippeth, Conover, Gonzalez, Cherner, & Heaton, 2005), and neuroimaging has identified structural abnormalities in the brains of stimulant abusers (Thompson et al., 2004).

INHALANTS AND SOLVENTS

The evidence for neuropsychological impairment from abuse of inhalants and solvents is very well established. An early study demonstrated a generalized pattern of severe neuropsychological deficits (Bigler, 1979). Research on inhalants and solvents includes a study by Korman, Matthews, and Lovitt (1981) that demonstrated clear neuropsychological impairment by inhalant abusers. Similarly, Tsushina, and Towne (1977) reported that glue sniffers were neuropsychologically impaired. In addition, Berry, Heaton, and Kirley (1977) found a group of chronic inhalant abusers were neuropsychologically impaired. As previously mentioned, the evidence of neuropsychological impairment from abuse of inhalents/solvents is very well established.

POLYDRUG ABUSE

Neuropsychological impairment in polydrug abusers is well established. Grant, Mohns, Miller, and Reitan (1976) reported finding neuropsychological impairment in a sample of polydrug users in an early study. Judd and Grant (1975) also reported finding neuropsychological impairment in polydrug abusers. A possible methodological confound to studies of polydrug users with neuropsychological impairment, however, concerns risk factors that are medical and psychiatric in nature. For example, many polydrug abusers studied also abused alcohol, and the neuropsychology impairment seen may be a result of alcohol consumption rather than the effect of illicit psychoactive drugs (Bolla, Funderberk, & Cadet, 2000).

SUGGESTIONS FOR PRACTITIONERS

The evidence for residual neuropsychological impairment from alcohol and drug abuse is well established, but the strength of association varies by substance (Spencer & Boren, 1990). The strongest evidence for neuropsychological impairment from abused substances is for alcohol, inhalant and solvent abuse, cocaine and other stimulants, marijuana, sedatives, and polydrug abuse. In general, neuropsychological impairment from substance abuse is very subtle (Horton, 1996). Substance abuse doesn't impair receptive language skills or motor speed or motor strength or, in many cases, sensory-perceptual functioning. On the other hand, neuropsychological impairment from substance abuse involves higher levels of neuropsychological functions such as short-term memory, complex attention, visual abstract problem solving, and visual-spatial skills (Horton, 1996). In some ways, the general pattern of neuropsychological impairment from substance abuse is more consistent with subcortical deficits than with cortical deficits. Early difficulties in identifying neuropsychological impairments in samples of substance abusers could be due to the fact that neuropsychological assessment procedures have been focused on cortical brain deficits. Future researchers of neuropsychological impairment in substance abusers might consider focusing on neuropsychological assessment of subcortical effects of the residual effects of alcohol and drug abuse on the brain rather than using neuropsychological assessment instruments that are primarily focused on cortical functioning.

CLINICAL CONSIDERATIONS

The day-to-day adaptive abilities of substance abusers who are neuropsychologically impaired are worthy of comment. Substance abusers with neuropsychological impairment can perform relatively well in nondemanding occupational positions but can show difficulties with mentally demanding employment positions. Neuropsychological impairment in a substance abuser may impair social functioning, but it would depend on how demanding the social situation is. Impairment of occupational and social functioning of a neuropsychologically impaired substance abuser is more subtle than that of a patient with severe dementia (Horton & Fogelman, 1991). For a neuropsychologically impaired substance abuser, impairment in social and occupational roles depends on the situational characteristics of the social and occupational roles to be played

(Heaton & Pendleton, 1981). In nondemanding social and occupational situations, the neuropsychological impairment of a substance abuser may not preclude day-to-day functioning. Adequate day-to-day functioning in nondemanding social and occupational roles is of course not a reason to conclude that neuropsychological impairment doesn't exist in substance abusers (Horton & Wedding, 1984). In short, neuropsychological impairment in substance abusers is subtle.

CLINICAL RECOMMENDATIONS FOR TREATMENT PLANNING AND INTERVENTIONS

This chapter has briefly discussed neuropsychological assessment from a screening perspective and also in terms of comprehensive neuropsychological functioning. Difficulties involved in assessing the residual neuropsychological effects of various psychoactive substances were discussed. A selective review of neuropsychological test results with drug addicts was presented. The current research with respect to the neuropsychological effects of abused drugs is composed of a small number of studies, some of which are flawed by methodological confounds. In brief, the neuropsychology of alcohol and psychoactive drug abusers is an area that will require much additional work.

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12

Brief and Extended Neuropsychological Assessment of Aging and Dementia

J. MICHAEL WILLIAMS

Although the aging of the nervous system does not directly result in considerable cognitive loss, many diseases that affect the central nervous system are much more common among the elderly and are often associated with advanced age. For example, cerebral vascular accident and multi-infarct dementia are often associated with arteriosclerosis and chronic heart disease in the advanced stages. As the circulatory system deteriorates, the probability of embolic or thrombotic stroke increases. Of course, most dementing conditions, such as Alzheimer's disease, are almost exclusively confined to the older age groups. Although the deterioration associated with Alzheimer's disease may begin at a relatively early age, the disorder does not reach the stage of diagnosis until advanced age. As the population of the elderly increases over the coming decades, the diagnosis and treatment of these diseases will become increasingly important.

Neuropsychological assessment of the geriatric patient is made difficult by the extreme variability in performance present in the geriatric clinic population. At one extreme, normal aging or depression may result in a mild reduction of cognitive ability. In this situation, the person may be able and willing to take an extended battery of tests. At the other extreme, patients may exhibit the advanced cognitive symptoms of Alzheimer's disease or another dementing condition; the most these patients can tolerate is brief questions as to orientation or a simple three-item memory test that usually includes a 5-minute delay. To add to these problems, most people suffering a dementing illness deny their symptoms and may be resistant to any questioning or testing, even when the clinician applies the kindest entreaties.

Dementia in this context is a relatively specific syndrome referring to the acquired decline of all or most intellectual functions (see Table 12.1). The onset of decline may be acute or insidious. It is primarily characterized by a general cognitive decline rather than the decline of specific cognitive functions that is characteristic of such disorders as aphasia and amnesic syndrome. Although some dementias may begin with a more severe decline in a particular function, such as language, other functions are also affected to some degree. If there is impairment of only a specific cognitive function, then the disorder is not usually classified as a dementia.

Table 12.1

MAJOR DEMENTIA TYPES

Alzheimer's disease. Results in a general decline of cognitive function involving memory, language, spatial abilities, and executive control.

Multiple infarct dementia. Associated with a stepwise inconsistent decline of cognitive function. Cardiovascular disease is usually prominent.

Huntington's Disease. A subcortical dementia involving a general decline of motor function, memory retrieval, attention, problem solving, executive control, and reasoning.

Acute/subacute onset dementia. A number of toxic substances, metabolic deficiencies, and medication side effects may cause a general decline of cognitive abilities. The onset is usually acute, and many of these disorders are treatable.

Progressive frontotemporal dementia, progressive semantic dementia, progressive nonfluent aphasia. These dementias result from an unknown pathological process that produces a selective degeneration of frontal and temporal areas. Progressive frontotemporal dementia has features of frontal lobe syndromes, including impairment of attention, neglect of self-care, apathy, disinhibition, poor insight and abstract reasoning, and loss of empathy. Progressive semantic dementia is associated with word-finding problems, loss of memory for words, and naming disorder. Progressive nonfluent aphasia is associated with reduced speech output, impairment of repetition, naming disorder, and moderate impairment of comprehension and grammar.

Dementia may result from a variety of diseases that affect the central nervous system. These include Alzheimer's disease, multi-infarction, Pick's disease, hypothyroidism, normal pressure hydrocephalus, and Huntington's disease (Joynt & Shoulson, 1979). These all result in generalized cognitive decline. Whether certain cognitive functions typically decline earlier than others is currently unknown, although patients and their families often report memory difficulties as the first sign of the disease. Family members may observe that memory declines first because of the immediate practical consequences of memory disorder. A mild reduction of language output or language errors may not be noticed because the patient can still communicate (Williams, Klein, Little, & Haban, 1986).

Alzheimer's disease is the most common form of dementia and follows a course that is typical of most dementing illnesses. Usually the behavioral manifestations of the disease begin with the observation of relatives that the patient's memory is poor. The patient may forget names, pay bills twice, misplace money, or manifest any of a number of everyday mistakes on tasks that require memory. It is rare for patients to report memory problems. Typically, patients deny any problems and often refuse diagnostic tests of any kind. Most cases have an extremely insidious onset, and patients may well mask their difficulties until the deterioration of thinking and memory is so advanced that it can no longer be hidden. The brain deterioration continues to severely impair all cognitive functions, and such extreme symptoms as ataxia, aphasia, profound anterograde amnesia, and loss of the fundamental reflexes (e.g., swallow reflex) become apparent in the later stages. Often the patient expires because of the loss of the swallow reflex and consequent dehydration or aspiration pneumonia. This progression may take up to 20 years and severely stresses the family and other social institutions not typically designed to handle such chronic problematic illness.

Although this is the usual progression of cognitive symptoms, there is considerable variability. For some, aphasic symptoms appear earlier. Many demented patients lose social inhibitions and become irascible or sexually inappropriate. Others become socially withdrawn and isolated. Finally, some demented patients have a relatively earlier onset with rapid progression of symptoms.

The neuropathology of dementing conditions is also varied. Most cases involve a degenerative process that affects the entire cortex. In the case of Alzheimer's disease, there is widespread cell death with neurotransmitter depletion and the establishment of neurofibrillary tangles and plaques. Possible explanations for these changes include viral infection, toxic agents, and abnormalities in the production of proteins such as amyloid (Coyle, Price, & Delong, 1983; Golde, 2007).

DIFFERENTIAL DIAGNOSIS

The common diagnostic problem in geriatric neuropsychology is the discrimination of these dementing conditions from pseudodementia or psychological depression. Although the elderly are probably no more susceptible to depression than other groups, depressed affect, cognitive complaints, and psychomotor retardation can mimic dementing illnesses, and it is often not immediately clear whether an elderly person is suffering from depression, dementia, or a combination of both. For a younger person, dementia would not be considered a possible explanation for such symptoms.

In the clinical setting, the discrimination of depression from dementia-related illnesses is clear and largely made by the conventional assessment of psychological depression (Kaszniak & Christenson, 1994). Older depressed patients endorse depression symptoms on self-report measures, and family members also rate the patient as depressed (Teri & Wagner, 1991). On neuropsychological tests, depressed patients demonstrate low motivation and a pessimistic view of their performance, and they are quick to say, "I don't know," rather than attempt an answer. They also exaggerate their complaints of cognitive impairment, especially memory complaints. There is a discrepancy between memory complaints and memory test performance: elderly patients with depression report severe memory problems but perform in the normal range on memory tests (Williams, Little, Scates, & Blockman, 1987). Patients with dementia-related illness such as Alzheimer's disease are usually completely unaware of their cognitive problems and rarely endorse depression items on self-report scales or in response to interview questions (Wagner, Spangenberg, Bachman, & O'Connell, 1997).

The discrimination of dementias is accomplished through a wide array of examinations. These include CT scans, thyroid studies, neuropsychological testing, self-report questionnaires, caregiver questionnaires, investigations of medication dosage levels, and, in the case of Huntington's disease, genetic tests and a study of the prevalence and incidence of the disease in the patient's family. When evaluated using neuropsychological tests, these diseases are similar in their cognitive and behavioral manifestations. However, it is important to use a caregiver report scale and clinical interview to examine the history of cognitive symptoms (Williams, 1987). It is here that significant differences emerge. There are three relatively specific patterns of symptom development that characterize these diseases. The first of these results from conditions that have a recent or acute onset, such as hydrocephalus or medication-induced dementia. These conditions often involve the decline of all or most cognitive functions in relative unison; family members usually do not report that one ability declined earlier than another. Onset, and the noticeable progression of cognitive symptoms, can range from a few days up to 6 months, varying with the underlying condition. Many of these conditions are treatable and may resolve within the same time interval in which they developed. Often the proper medication changes or installation of a periventricular shunt will substantially improve the patient's cognitive functioning, and a postintervention neuropsychological assessment can be used to note these changes (Nixon, 1996).

Another major pattern is specific to multi-infarct dementia. This condition results in a stepwise progression of cognitive symptoms. The decline begins with the first stroke. As the patient recovers from this first one, it is apparent that specific cognitive functions have been impaired. This specific disability is associated with the site of the brain lesions. For example, aphasia usually develops if the left hemisphere is affected first. As more infarcts are created, more cognitive abilities become impaired until generalized dementia is present. The important distinction between this form and others is that patients and their relatives report that there were definite points of precipitous decline in the progression of disease. However, this progression is not characteristic of all multi-infarct cases. A subset of these cases have small frequent strokes, an insidious onset, and gradual progression closely resembling other forms of dementia. Hachinski et al. (1975) provide a summary and scoring system for evaluating the signs and symptoms of multi-infarct dementia. Since vascular disease tends to be localized to the right or left hemisphere, measures of lateralized motor and sensory functions may work to discriminate this type of dementia from others (Russell & Polakoff, 1993).

The final pattern of dementia is the most prevalent and most prominently characterizes Alzheimer's disease. In this type of dementia, cognitive symptoms have a very gradual onset and progression paralleling the slow process of cell death and creation of lesions that are typical of these diseases. Relatives of the patient have extreme difficulty placing the onset of thinking and memory difficulties. As months and years pass, the cognitive problems worsen, and it becomes obvious to the family that the patient has serious problems. The patient is referred for assessment at this later point in the progression of the disease. Neuropsychological evaluation usually indicates that all cognitive functions are impaired at this stage. Usually memory scores are lower than measures of language, abstract reasoning, visuospatial processing, and other cognitive functions. As the dementing disease progresses, the patient becomes frankly aphasic, reasons at the most concrete levels, becomes disoriented, and has a complete anterograde amnesia. Remote memories are often preserved but are often disorganized in retrieval. The patient often applies his or her remote memories to current situations. For example, the patient may give the current hospital the name of one in which he or she received treatment many years before. As the patient's cognitive abilities deteriorate, assessment turns from more extended batteries to brief assessment techniques such as the mental status examination.

Huntington's disease is a good example of a unique subcortical dementia that has some features of the other dementia-related illnesses. This disorder has unique signs of motor impairment and choreic movements that are the result of a specific degeneration of the basal ganglia and the frontal lobes (Strub & Black, 1981). However, as the disease progresses, the patient has a general decline of cognitive abilities. These cognitive deficits are associated with poor attention and construction abilities and a unique impairment of memory retrieval. Huntington's disease is also associated with apathy, disinhibition, and behavior problems generally associated with frontal lobe syndrome (Butters, Salmon, & Butters, 1994). The extreme memory and language disorders that characterize Alzheimer's disease are usually not present until the very late stages of the disease. Huntington's disease is also a dementia-related illness that has prominent symptoms at a much earlier age than Alzheimer's disease.

These descriptions of the different dementing illnesses are presented only as a convenient heuristic to aid the clinician in assessment. There are exceptions to these patterns, and certainly such diseases as multi-infarct dementia can follow the same pattern of cognitive decline as Alzheimer's disease. The following is a brief presentation of measures and techniques used in assessing these conditions.

NEUROPSYCHOLOGICAL ASSESSMENT

Aside from measuring a variety of cognitive functions, brief and extended assessment techniques are also characterized by the source of information about the patient. These sources are (1) the patient's family or friends, (2) clinical interviews and rating scales, (3) the self-report of the patient, and (4) the results of formal neuropsychological assessment

(Table 12.2). Another rule of thumb is that the clinician should utilize all these sources of information when making an assessment of cognitive functioning. Often the patient cannot report his or her history of symptoms and is unwilling or unable to take even the briefest neuropsychological tests. At this point, the reports of family members who have observed the progress of the disease and clinical rating scales completed by the clinician are the most important sources of information. Even if the patient is able to provide information, the observations of the clinician and family can corroborate the patient's report and increase the validity and reliability of the assessment (Williams et al., 1986).

Table 12.2

DEMENTIA ASSESSMENT CONSTRUCTS AND METHODS

Brief Assessment Approaches and Dementia Batteries

Bedside Examination

- Hahnemann Orientation and Memory Examination (Williams, 2007)
- Williams Memory Screening Test (Williams, 2007)
- Cognitive Behavior Rating Scales–Caregiver Form (Williams, 1987)

Mental Status Examinations

- Mini–Mental State Examination (Folstein, Folstein, & McHugh, 1975)
- Mattis Dementia Rating Scale (Mattis, 1988)
- CERAD Dementia Battery (Morris et al., 1989)
- Strub and Black Mental Status Examination (Strub & Black, 2000)
- Cognitive Behavior Rating Scales (Williams, 1987)
- Repeatable Battery for the Assessment of Neuropsychological Status (Randolph, 1998)

Extended Assessment

Memory: Memory Assessment Scales (Williams, 1991)

Language: Boston Naming Test (Goodglass & Kaplan, 2000); Reitan-Indiana Aphasia Screening Test, Wechsler Adult Intelligence Scale (Wechsler, 1997a) subtests of Vocabulary, Similarities, and Comprehension

(*Continued*)

Table 12.2

DEMENTIA ASSESSMENT CONSTRUCTS AND METHODS (*Continued*)

Visual Spatial Ability: WAIS Block Design (Wechsler, 1997a), Clock Drawing (Morris et al., 1989)

Executive Control: Letter and Category Fluency (Troster, Salmon, McCullough, & Butters, 1989), Trail Making Tests A and B (Reitan & Wolfson, 1985)

Abstract Reasoning: Wechsler Adult Intelligence Scale Comprehension (Wechsler, 1997a)

Sensory Functions: Sensory Perceptual Examination of the Halstead-Reitan Battery (Reitan & Wolfson, 1985)

Motor Functions: Tapping subtest of the Halstead-Reitan Battery (Reitan & Wolfson, 1985)

Psychological Depression: Beck Depression Inventory (Beck, 1961), Clinical Interview (see Kaszniak & Christenson, 1994), Cognitive Behavior Rating Scale Depression Scale (Williams, 1987)

Daily Living Skills: Instrumental Activities of Daily Living (Lawton & Brody, 1969)

Functional Everyday Behavior & Personality: Cognitive Behavior Rating Scale (Williams, 1987)

Orientation: Hahnemann Orientation and Memory Scale (Williams, 2007)

Competency: Clinical Interview (Grisso, 1994)

Note. The listing here is not intended to be exhaustive. There are many other tests that could be substituted for tests listed above.

BRIEF ASSESSMENT APPROACHES

These brief approaches can be further divided into two levels. The first is a bedside examination and the second corresponds to a mental status examination (MSE). In the end stages of dementia-related illness, usually when the patient is confined to bed, cognitive function will be so degenerated that the patient can only answer general orientation questions and may be able to take a simple memory screening test. This level of assessment is very similar to the basic assessment conducted among patients with severe brain injury who are just recovering from coma

(Williams, 1990). In this phase of the illness, the Hahnemann Orientation and Memory Examination and the Williams Memory Screening Test should be used to examine the patient (Williams, 2007). The Hahnemann Orientation and Memory Examination consists of orientation questions to person, place, and time. The Williams Memory Screening Test is a short 15-item recognition memory test. Both are very easy to complete and were designed for the most extreme levels of impairment. They are available on the Internet from Brainmetric.

In the moderate to severe stages of dementia-related illness, the most popular method of evaluating cognitive function in the geriatric population is the MSE. All forms of the MSE exist as a collection of screening devices for the assessment of different cognitive functions organized into a short battery. For example, a popular mental status exam presented by Strub and Black (2000) consists of a collection of brief approaches for the measurement of orientation, attention, language, memory, construction ability, and other higher cognitive functions. Each subtest consists of simple observations and descriptions of the patient's behavior when confronted by a cognitively demanding task or of actual measurements of certain abilities by quantification of the patient's level of response. For example, the presence of unilateral neglect is simply observed and described in the Strub and Black system, but memory ability is quantified in one test as the number of story segments a patient can recall after hearing a brief three- or four-sentence story. From these observations and measurements, the clinician is able to make a relatively formal appraisal of cognitive ability as it relates to history and other evidence of cerebral integrity.

One feature of the MSE makes it unique among brief assessment approaches and attractive to clinicians assessing geriatric patients: it is directed toward the lower levels of cognitive functioning. The obvious advantage of this approach is that the MSE does not usually confront the older person with tasks that are initially too difficult. The patient can usually perform at some level and provide the clinician with information. The obvious disadvantage is that the patient's functioning is not assessed at the upper levels or across many domains of function and that more subtle aspects of cognitive dysfunction can go unnoticed. If the patient easily completes MSE items and cognitive disability is still suspected, then a more extended assessment should be used. For example, older patients who suffer a mild head injury or manifest milder signs of medication toxicity may experience a cognitive loss that can go unnoticed on the MSE. However, even mild cognitive dysfunction can be distressing to the patient, depending upon the cognitive demands of the patient's occupation and everyday life. Consequently, the full range of cognitive abilities should be assessed.

Brief assessment approaches that allow the clinician to formally test the patient (e.g., the MSE) come in many forms. One easily administered and widely used instrument is the Mental Status Questionnaire (Pfeiffer, 1975). It provides a quick measure of orientation and attention for the patient experiencing severe dementia or confusional state. Another brief approach that relies on the judgment or observation of the clinician is the Brief Cognitive Rating Scale (Reisberg, 1983). This measure requires the clinician to make global ratings of cognitive ability in the areas of concentration, recent memory, past memory, orientation, and self-care.

Among a number of caregiver rating scales, there are two comprehensive scales for assessing the self-report of cognitive problems in the elderly. These are the Cognitive Difficulties Scale (McNair & Kahn, 1983) and the Cognitive Behavior Rating Scale–Self-Report Form (Williams, 1987). Both of these measures allow the patient to report the extent of his or her difficulties in thinking and memory. Finally, the Relative Report Form of the Cognitive Behavior Rating Scale allows the relatives of the patient to rate everyday symptoms of cognitive decline. The relatives of the patient can often provide valuable information about the progression of symptoms and their severity that can supplement the clinician's test results and observations.

There are also several rating scales that enable the clinician to assess depression in the elderly. Certainly the most widely used instrument utilizing the clinician's observations is the Hamilton Rating Scale (Hamilton, 1967). The Beck Depression Inventory (Beck, Ward, Mendelson, Mock, & Erlbaugh, 1961) and the Zung Self-Rating Depression Scale (Zung, 1965) allow the patient to report depressive symptomology. Other related measures that assess a wide range of psychological disorders and somatic concerns are the Brief Psychiatric Rating Scale (Overall & Gorham, 1962), the Inventory of Psychic and Somatic Complaints of the Elderly (Raskin & Rae, 1981), and the Sandoz Clinical Assessment–Geriatric Scale (Shader, Harmatz, & Salzman, 1974). These instruments allow the clinician to measure depressive and other psychiatric disorders in order to discriminate them from dementia-related illness.

EXTENDED NEUROPSYCHOLOGICAL ASSESSMENT

As previously mentioned, the extent and breadth of assessment of the elderly is dependent upon the patient's overall level of functioning. The person must be able to attend and follow instructions, as well as simply cooperate with the examiner. From the initial contact with the patient, great attention must be paid to establishing rapport and eliciting cooperation. The examiner must frequently encourage and reinforce the patient's efforts throughout the examinations. Frequent breaks are important to maintain rapport, although such breaks can often encourage the patient's attention and conversation to wander. Usually the patient can be brought back on track with a firm suggestion or transition to the instructions for the next task. Extended assessment techniques for the geriatric patient must be ranked in order of priority and administered accordingly. There is a limit to the patient's endurance, and a point will be reached at which the patient's fatigue is so great that the test results are invalid.

After the assessment of basic orientation, attention, and global cognitive abilities using a brief assessment approach, the most important cognitive ability to measure in detail is memory functioning. Batteries such as the Memory Assessment Scales (Williams, 1991) are used to measure this. Alternative measures are the Randt Memory Battery (Randt, Brown, & Osborne, 1980), the Cronholm Memory Battery (Cronholm & Ottosson, 1963), the California Verbal Learning Test (Delis, Kramer, Kaplan, & Ober, 2000), and the Wechsler Memory Scale (Wechsler, 1997b). All these techniques allow for the relatively comprehensive measurement of verbal and visuospatial memory ability. In the verbal sphere, the clinician accomplishes this by asking the patient to remember a short list of words or a four- or five-sentence story. Visuospatial memory tasks require the patient to remember geometric designs or pictures of common objects. In order to measure verbal recall, the patient is asked to recite the lists or stories after a delay interval. Recall of visuospatial material most often requires the patient to draw figures presented earlier or to recognize the correct figure out of an array of similar figures. Most of these batteries also include an assessment of immediate recall of verbal information. Elderly patients who have dementing illness have extremely poor long-term memory for all types of information, but immediate recall will be preserved. It is important to note a dissociation between such immediate recall and long-term consolidation of information. Immediate recall is usually assessed with the Digit Span task (Wechsler, 1997b), which requires the patient to immediately repeat successively longer number strings. The longest string the patient can repeat without error is recorded as the digit span.

In addition to memory batteries, there exist several self-report memory problem questionnaires that are helpful in evaluating the extent to which the patient is aware of possible memory difficulties and the manner in which such problems may affect everyday memory tasks. Most prominent among these is the Everyday Memory Questionnaire (Zelinski, Gilewski, & Thompson, 1980).

Extended assessment should also include an examination of basic sensory and motor abilities. Sensory examination is readily accomplished through the use of the sensory-perceptual examination included in most neurological examinations or the Halstead-Reitan Neuropsychological Battery (Reitan & Davison, 1974). These procedures allow for the examination of tactile, visual, and auditory suppressions, graphesthesia, finger agnosia, and tactile form recognition. Motor speed is adequately measured by the Finger Tapping Test of the Halstead-Reitan Battery or the Thumb-Finger Sequential Touch Test of the Luria-Nebraska Neuropsychological Battery (Golden, Hammeke, & Purisch, 1978). Assessment of these abilities allows the examiner to determine the degree to which sensory and motor abilities may be influenced by the disease process and the manner in which the condition may be lateralized. Dementia-related illness that is vascular in origin often affects one hemisphere more than the other. As a result, a difference in sensory or motor abilities across the two hemispheres is a compelling clue that the patient suffers from a vascular dementia rather than Alzheimer's disease (Russell & Polakoff, 1993).

Extended assessment of language abilities can range from an aphasia screening test such as the Reitan-Indiana Aphasia Screening Test (Heimberger & Reitan, 1961) to extended aphasia batteries such as the Boston Diagnostic Aphasia Battery (Goodglass & Kaplan, 1972). Aphasia-related assessment often also includes the measurement of basic arithmetic ability and ideomotor apraxia. All these abilities are often impaired by dominant-hemisphere lesions. Elderly patients with prominent aphasic symptoms who are also generally demented have probably suffered a cerebral vascular accident in the past. Aphasic symptoms, such as anomia, are also prominent in the very late stages of dementing illness.

Abstract reasoning and complex problem solving should also be assessed. This is frequently accomplished through the use of a general intellectual battery like the Wechsler Adult Intelligence Scale (Wechsler, 1997a). In order to measure verbal reasoning, the patient is asked to interpret proverbs, define words, and express the relationship between verbal concepts. In order to measure visuospatial problem solving, the patient is asked to solve puzzles that require sensorimotor manipulation and visuospatial analysis of an arrangement of objects. Additional measures of these constructs are the Raven Progressive Matrices (Raven, 1960) and the Category Test (Reitan & Davison, 1974), which require the patient to form an abstract principle or concept from an arrangement of stimuli and solve problems based upon these abstractions.

A final component of extended assessment should be the measurement of basic activities of daily living. Since the purpose of neuropsychological assessment is often to predict the patient's function in the living environment, the clinician must have some knowledge of the patient's ability to function in everyday life. A popular method used to acquire this information is the clinical interview. Most patients will be able to answer basic questions about mobility in the home, accessibility of the bathroom and kitchen, and their ability to dress and care for themselves. However, often the demented patient will deny or be unaware of his or her everyday problems. For this reason, the interview of the patient should be supplemented with an interview of a reliable observer, such as a spouse or other relative. Such instruments as the instrumental Activities of Daily Living Scale (Lawton & Brody, 1969), the Multilevel Assessment Instrument (Lawton, Moss, Fulcomer, & Kleban, 1982), or the Older Americans Resources and Service Questionnaire (Fillenbaum & Smyer, 1981) should be used to summarize this interview. All these measures require a reliable observer or an interviewer to rate cognitive abilities and skills of everyday living. Such an assessment is necessary in the overall characterization of the patient and should be used whenever disposition or follow-up is important, especially when a brief assessment approach has been used to assess cognitive abilities.

CASE REPORT

The following case illustrates the application of these techniques with the elderly in a rehabilitation setting. Certainly the same techniques can be applied in other inpatient and outpatient settings. This particular example allows for the presentation of the full range of assessment techniques presented in the chapter.

Following admission to the hospital, BW, a 67-year-old woman, was referred for neuropsychological assessment for evaluation of family-reported symptoms of increased moodiness, poor memory, and disorientation. BW had been found by her family wandering in a nearby neighborhood, obviously lost. She was having difficulty managing her money and liked to have large quantities of cash sequestered in hiding places around the house. Since a dementing illness was suspected, a family member familiar with the patient's everyday behavior was interviewed and then asked to complete the Cognitive Behavior Rating Scales. Concurrent with this rating, BW was briefly interviewed and administered the Memory Assessment Scales and the Zung Depression Scale. The patient refused to complete the Wechsler Adult Intelligence Scale and the Cognitive Difficulties Scale but did respond to many items of the mental status examination. She was given a full range of other medical tests while in the hospital. These included a neurological examination, CT scan, EEG, and full hematological examination, all of which were read as essentially normal. She did not have a past history of high blood pressure, heart disease, or stroke.

The neuropsychological examination and interview revealed considerable anterograde memory disorder for verbal as well as nonverbal information. She was unable to remember more than 5% of a three-sentence story after a half-hour delay. She scored very low on tests of memory for geometric designs. She was largely intact on tests of language and higher cognitive functions. She indicated mild depression on the Beck Depression Inventory. When asked about her difficulties in memory and managing money, she denied any problems and expressed some resentment at being asked to come into the hospital and take a lot of tests when there was nothing wrong with her.

The responses of the patient's spouse to items on the Cognitive Behavior Rating Scales revealed a consistent pattern of dementia-related everyday behavior. Most prominent of these behaviors was difficulty remembering the names of friends, misplacing objects, becoming lost in familiar places, losing her train of thought in conversation, and repeating the same story over and over again. The spouse did not indicate that cognitive problems were associated with depressed mood.

Through a combination of medical tests, the major treatable causes of dementia were ruled out. These included depression, hypothyroidism, and medication toxicity. Multi-infarct dementia and Alzheimer's disease were then considered the most likely of the remaining etiological explanations. Because BW had no previous history of stroke or heart disease, the most likely diagnosis was determined to be Alzheimer's disease. The Hachinski et al. (1975) system was used to determine her score, which was 3, an extremely low score. Of course, a definitive diagnosis of Alzheimer's disease can currently be determined only by autopsy examination.

BW was followed after discharge for approximately 9 months. The family was referred to a family support group sponsored by the local chapter of the Alzheimer's Disease and Related Disorders Association. The family was able to learn many practical techniques for the management of dementia-related behavior in the home. At the present time, the patient continues to live at home, and the family is able to manage her current level of everyday problems.

This case illustrates the usual evaluation history of the elderly demented patient. BW's presentation of symptoms was relatively uncomplicated and clear cut. Often such cases present with greater depression, and this complicates the assessment of dementia-related cognitive decline. A great many elderly individuals who are suspected of having dementia by their families are depressed. This is one of the most important aspects to assess because it is imminently treatable. Successful treatment of depression brings an immediate improvement in the patient's overall cognitive and adaptive functioning. Likewise, it is important to distinguish, as clearly as possible, between Alzheimer's disease and multi-infarct dementia, since this has consequences for the management of the patient by the family. Many cases of multi-infarct dementia plateau after a series of strokes and decline no further. Alzheimer's disease involves a progressive decline of cognitive functioning and no marked plateaus. It is important for the families of patients with multi-infarct dementia to know that their family member may not decline in cognitive abilities beyond the present level and will probably recover some abilities as the stroke resolves. There may be more strokes in the future, but a steady pattern of cognitive disability is easier to manage than a persistent decline in functioning. As each month passes, the family of a patient with Alzheimer's disease is confronted with another or worse cognitive symptom to manage.

In summary, dementing conditions of the elderly are a considerable health problem and are difficult to diagnose, treat, and manage. Neuropsychological assessment of some type is important at every step in dealing with these diseases but is probably most important during the diagnostic phase. Dementia in the elderly represents a relatively well-defined syndrome that accompanies many diseases. Diagnosis of the proper etiological process depends greatly upon the history of symptom development as well as other signs unique to a particular disease (e.g., hypertension or low thyroxine level). For this reason, information provided by the family is extremely important in describing the history of dementia-related behavior.

In order to increase the reliability and accuracy of the assessment, information should be collected from many sources: a formal neuropsychological assessment of the patient, observation by family members or other reliable observers, and the self-report of the patient. When necessary information is not available from one source, such as a formal test of the patient, it can be acquired in some form from other sources.

Likewise, there is a spectrum of cognitive and self-care abilities to assess from these main points of view. These range from orientation and memory to activities of daily living. All of these may be assessed in some way by the family report, the formal neuropsychological assessment, or the patient's self-report. Combining these into a brief or extended assessment can render a feasible and comprehensive measurement of the patient's neuropsychological functioning to aid in diagnosis and management of the elderly patient.

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