One

INTRODUCTION TO NEUROPSYCHOLOGICAL ASSESSMENT

OVERVIEW

From the perspective of contemporary psychology's identity as both a biological/neurobiological and social science, it may be hard to imagine that it was only in the 1970s that clinical neuropsychology began its emergence as a clearly defined discipline in private practice and medical settings. Although many of the techniques and concepts that form the basis of modern practice of neuropsychological assessment were established between the World Wars, it is probably not coincidental that clinical neuropsychology saw its emergence as a coherent discipline in parallel with the cognitive revolution in psychology (i.e., the change in focus from behaviorism to cognitivism) and the explosion of the technology of neuroimaging, both of which began in the mid-1970s. In the few decades since that critical period, clinical neuropsychology has matured into a discipline with a number of subspecialties that include pediatrics, geriatrics, rehabilitation, education, and forensics. Its further growth and professional development is supported by a rich network of university-based graduate programs and clinical sites providing pre- and postdoctoral training, boards offering advanced clinical certification, and the increasingly neuroscientific emphasis of basic research in academic psychology. To comprehend the remarkable rate of growth in this field, one needs only to read the foreword of the first general textbook on clinical neuropsychology (Reitan & Davison, 1974). Even in 1974, Reitan and Davison heralded the "large growth in substantive knowledge" in neuropsychology and neurosciences preceding the landmark event of the first American Psychological Association (APA) Symposium on Clinical Neuropsychology in 1970. Their text introduced the power of empirically based approaches to neuropsychological assessment to what was probably the first large postwar wave of clinicians who identified themselves as specialists in neuropsychology. It today seems to be a gentle irony that at the time of that writing, fewer than six journals focused on clinical or experimental neuropsychology and the related medical discipline

of behavioral neurology. Now, nearly 40 years later, more than 100 journals deal with the brain or brain–behavior relationships, and there exist literally hundreds of texts and monographs to support university courses in both clinical and experimental neuropsychology and to summarize research findings for clinical and academic professionals.

HISTORY OF CLINICAL NEUROPSYCHOLOGY

In the early 1970s the professional identity of a neuropsychological specialty was just emerging. In 1967 the International Neuropsychological Society (INS) began its evolution from a few disparate, informal, and geographically scattered groups of psychologists interested in the relationship between brain and behavior into the first scholarly–professional society explicitly dedicated to neuropsychology. By 1973, around the time of the publication of Reitan and Davison's textbook, approximately 350 members of INS represented the United States, Canada, Great Britain, Norway, and a number of other nations. In 2002 INS, the principal scientific society of neuropsychology, had more than 3,000 members (Rourke & Murji, 2000), and by February 2008 INS boasted approximately 4,950 members.

In 1975 a group of clinically oriented neuropsychologists organized the National Academy of Neuropsychology (NAN), largely to help clinicians keep up with the growing number of techniques and findings directly related to clinical practice. As of January 1, 2009, NAN had 3,657 active members from 24 countries (T. Brooks, e-mail communication, January 5, 2009).

By 1980 neuropsychology had become sufficiently established as a specialized area of interest to organize its own division of the American Psychological Association (Division 40), and in 1996 APA officially recognized neuropsychology as a specialty area. Division 40 (Clinical Neuropsychology) consists of a wide variety of psychologists involved in both clinical practice and research and serves to represent neuropsychology within the larger association of psychologists in the United States. Division 40 had approximately 433 members in its charter year and as of this writing has 4,464 members. Although some clinicians are members of more than one group, memberships in INS, NAN, and Division 40 do not completely overlap. As a definitive sign of the establishment of neuropsychology as a recognized clinical specialty, the American Board of Clinical Neuropsychology (ABCN; Meier, 1998) was formed in 1981 and began to offer diplomate status in clinical neuropsychology in 1983, after coming under the auspices of the American Board of Professional Psychology (ABPP). In 1996 the American Academy of Clinical Neuropsychology (AACN) was founded with a principal mission of promoting excellence in clinical neuropsychology. This organization is for

psychologists who have achieved board certification from ABCN (see Yeates & Bieliauskas, 2004, for a review of milestones for ABCN and AACN). As of May 2009, 701 clinical neuropsychologists in the United States, Canada, and Mexico held this board certification, signaling advanced practice competence (Greg Lamberty, e-mail communication, May 13, 2009). Clinical neuropsychology remains the second largest board-certified specialty within ABPP with nearly half as many specialists as clinical psychology. In 1982 the American Board of Professional Neuropsychology (ABN) was also established to award board certification for competence in clinical neuropsychology. As of January 2009, ABN had 230 orally examined diplomates with 17 new diplomates since January 2008 (M. Raymond, e-mail communication, January 21, 2009). Rapid Reference 1.1 provides a brief chronology of the development of clinical neuropsychology as a separate discipline.

Perhaps the emergence of clinical neuropsychology was inevitable, given the increasing centrality of biology and medicine in science itself and what has become an almost universal interest in the problems of neurobiology in such diverse scientific disciplines as physics (e.g., Penrose, 1997) and philosophy (e.g., Churchland, 1989). It is safe to say that a discipline considered only 35 or so years ago as esoteric and arcane as alchemy by many psychologists and physicians is now an established and respected part of the assessment, treatment planning, and

Rapid Reference 1.1

Major Historical Events

- 1967 International Neuropsychological Society formed
- 1970 First American Psychological Association (APA) Symposium on Clinical Neuropsychology
- 1975 National Academy of Neuropsychology formed
- 1980 Division 40 (Clinical Neuropsychology) of APA created
- 1981 American Board of Clinical Neuropsychology formed
- 1982 American Board of Professional Neuropsychology formed
- 1983 ABCN offers diplomate status under ABPP
- 1996 APA recognizes clinical neuropsychology as a specialty area
- 1996 American Academy of Clinical Neuropsychology founded
- 1997 Houston Conference on Specialty Education and Training in Clinical Neuropsychology convened

rehabilitation of children and adults with histories of psychiatric, neurological, or developmental problems, or a combination of these.

Definition of Clinical Neuropsychology

Neuropsychology is usually broadly defined as the study of brain–behavior relationships. Of course, this definition does not capture the multiplicity of questions and approaches that have been used to explore how the central nervous system represents, organizes, and generates the infinite range of human capabilities and actions. Modern neuropsychology includes the study of the classic problems of psychology—attention, learning, perception, cognition, personality, and psychopathology—using techniques that include the methods of experimental psychology as well as the methodologies of test construction and psychometrics. Its scientific palate includes such state-of-the-art technologies as high-resolution structural and functional neuroimaging and other techniques such as computational modeling, and it is beginning to be integrated with genomics and other advanced biological technologies such as proteomics and metabalomics. This book presents some of the core concepts of the particular discipline of clinical neuropsychological assessment. According to a consortium of representatives of a number of professional neuropsychological organizations that convened in 1997 in Houston, Texas, clinical neuropsychology can be defined as "the application of assessment and intervention principles based on the scientific study of human behavior across the lifespan as it relates to normal and abnormal functioning of the central nervous system" (Hannay et al., 1998, p. 161). In practice, this translates into using standardized psychological tests, which are usually designed to assess various aspects of human cognition, ability, or skill, to provide information to a variety of clinical questions about the central nervous system and behavior. Less often, tests of personality or affective behavior have been adapted as neuropsychological instruments.

In practice, the question of "normal versus abnormal functioning of the central nervous system" (Hannay et al., 1998, p. 161) is posed in an extremely broad range of clinical situations that includes not only the assessment of the consequences of diseases and physical damage to the central nervous system, but also the consequences of psychiatric conditions in which central nervous system involvement is assumed but not well defined. In some cases, the central nervous system function in question may be abnormal because of a neurochemical rather than a structural abnormality, as might be the case in some metabolic disorders, or because of the presence of a prescription or street pharmacological agent. Neuropsychological assessment is also increasingly being used to assess variations in early development

DON'T FORGET

Neuropsychology is the study of brain–behavior relationships. Clinical neuropsychology is "the application of assessment and intervention principles based on the scientific study of human behavior across the lifespan as it relates to normal and abnormal functioning of the central nervous system" (Hannay et al., 1998, p. 161).

that may be a reflection of variations in the rate of normal maturational processes rather than definable pathology (at least currently). The latter has become so common as a source of clinical referrals for neuropsychological assessment that a new subspecialty known as educational or school neuropsychology has emerged and is becoming an increasingly important part of the role of school-based practitioners of psychology. To capture the breadth of these clinical questions, we use the term *brain dysfunction* in this book to represent the diverse conditions in which measurable variations in psychological abilities are assumed to be causally related to the operations of the central nervous system. This term is in itself somewhat narrow, because it is probably most accurate to construe neuropsychological test performance to be a reflection of brain "function" and not just the state of abnormality that is the focus of clinical referrals.

Historically, the tests used by neuropsychologists were usually not developed for the purpose of assessing brain dysfunction, and in many cases, they reflect clinical assessment traditions more than basic research in cognition or neuroscience. For example, the Wechsler Adult Intelligence Scale (WAIS; Wechsler, 1955) and its successors were developed as tests of intelligence, primarily to aid in the identification of mental retardation and to facilitate academic, military, or vocational assessment (Kaufman & Lichtenberger, 1999; Matarazzo, 1972). The Seashore Rhythm Test, a traditional component of the Halstead–Reitan Neuropsychological Test Battery (HRB), was part of a test of musical aptitude (Saetveit, Lewis, & Seashore, 1940). What all tests used by neuropsychologists have in common (or should have in common) is known reliability and validity as predictors of the presence of brain dysfunction. Minimum requirements for neuropsychological tests are sensitivity to the presence of brain dysfunction and the ability to distinguish correctly the presence of abnormal brain function from normal brain functioning. Over the years, these basic criteria for neuropsychological tests have grown to include the ability to predict the site and severity of brain dysfunction and, in some cases, the more controversial ability to predict the specific cause or etiology of that dysfunction. During the inception of the first formally validated neuropsychological tests, the sensitivity of neuropsychological instruments was gauged by their agreement with the clinical judgments of neurologists (Reitan &

Davison, 1974). As neuroimaging and other technologies have advanced, so has the expectation that neuropsychological tests will be sensitive to changes observable with increasingly sensitive and detailed views of brain structure and physiology. Today, it is not uncommon to see neuropsychological instruments used to detect the presence of brain dysfunction in both research and clinical settings. As we discuss in Chapter 5, this is a controversial development from which many practitioners distance themselves. Its existence, however, is a reflection of the respect these instruments have gained.

Some clinicians advocate using a fixed battery of tests to anchor and compare observations across different patient populations, whereas other clinicians advocate using a flexible battery of tests that are dictated by the specific referral question or unique presentation of the patient. Clinical neuropsychological assessment may employ clinical interview and behavioral observation techniques that have not necessarily been subject to the usual methodological standards of test construction but are usually considered indispensable in providing rich descriptions of a patient's behavior. In clinical settings, many neuropsychologists employ unique variations on standardized tests or procedures developed on the fly in an attempt to capture qualitative features specific to the patient in question. The advantages and disadvantages of these approaches are discussed later in this chapter.

Uses of Neuropsychological Assessment

One can identify at least seven different but related purposes or uses of neuropsychological assessment. These categories are derived from what are probably the most common clinical referral questions presented to neuropsychologists, as well as from the information presented in many neuropsychological reports. These categories of use can arise in a number of contexts, including medicine, law, education, and research. These categories are presented here in the order reflecting the logic in which clinical inferences are typically made.

1. *Describing strengths and weaknesses and identifying changes and disturbances in psychological functioning (cognition, behavior, emotion) in terms of presence/absence and severity.* Although the raison d'être of clinical neuropsychology may appear to be to predict the presence of brain dysfunction, the ability to describe function is far more important than this seemingly core purpose of neuropsychological tests. Neuropsychologists are usually expected to provide a description of a patient or client by identifying cognitive strengths and weaknesses and then by making the basic inference of whether the patient's current status represents a change

from some previous, usually not precisely defined, baseline or premorbid level of functioning and whether or not any changes rise to the level of dysfunction. Neuropsychological assessment may also be used to infer the presence of congenital or developmental abnormalities that are neuropathologically determined. When children are evaluated and there is little basis to estimate premorbid abilities, clinicians may attempt to infer change from expected developmental milestones and family background. The issues of strengths and weaknesses and the presence or absence of change and abnormality are addressed before any other inferences regarding brain function or recommendations for interventions may be considered. The neuropsychologist must try to infer what part of the current observations reflects the patient's "normal" allocation of intellectual functions versus what parts of the current observations show changes attributable to brain dysfunction. Accurate description and reference to correct normative standards for the individual are the most basic and critical purposes of neuropsychological assessment, and all determinations must be made in the context of the patient's history.

2. *Determining the biological (i.e., neuroanatomical, physiological) correlates of test results: detection, gradation, and localization of brain dysfunction.* After they have described the patient's behavior, neuropsychologists typically try to determine whether the pattern of test results, clinical behavior, and particular historical context of the observations can be attributed to abnormal brain function. Such abnormalities may be the presence of a structural brain lesion, a developmental disorder, or, in some cases, neurochemical lesion. Part of this determination is trying to ascertain which region of the brain is involved. In this era of increasingly sensitive noninvasive neuroimaging techniques, the clinical importance of this traditional function of neuropsychological assessment has somewhat diminished and, in some cases, has become almost vestigial. However, the ability to establish specific causal links between areas of the brain and psychological symptoms may take on fresh importance as new biotechnologies emerge for the treatment and rehabilitation of the consequences of brain abnormalities. For example, an understanding of lesion–behavioral relationships is important in determining treatment targets of transcranial magnetic stimulation (Pascal-Leone et al., 2002). As these technologies develop, it is possible that lesion localization will become integral to the process of rehabilitation planning (see Item 5).

3. *Determining whether changes or dysfunction is associated with neurological disease, psychiatric conditions, developmental disorders, or nonneurological conditions.* The next kind of inference that clinical neuropsychologists often try to make or are asked to make concerns the likely etiology or etiologies that produced the changes or dysfunction described. In the case of neurological disorder and known history, this can sometimes be done accurately. This is particularly true in cases in which the behavioral changes involve unusual and dramatic phenomena that have historically been related to the presence of lesions in specific parts of the brain and are usually caused by a highly limited set of etiologies. For example, nonfluent aphasia symptoms (e.g., hesitant, agrammatic speech) are most likely related to a limited set of diseases that, if present by history, can be considered causative of the observed changes in language. Many changes or apparent abnormalities in neuropsychological functions, however, may be caused by psychiatric, motivational, developmental, or cultural factors and may not be attributable to a specific neurological etiology even when present by history. Often, neuropsychological test findings are nonspecific to etiology and may be related to a host of factors, such as depression, anxiety, sleep deprivation, or even chronic pain. In these instances, the neuropsychologist must work as an investigator to review the test findings thoroughly in the context of the patient's history.
4. *Assessing changes over time and developing a prognosis.* One of the most useful applications of neuropsychological assessment is to track improvements and decrements in performance over time. This helps to determine the etiology and progression of a disease, to develop social or financial plans for a patient, and to track whether treatment or efforts toward rehabilitation are effective.
5. *Offering guidelines for rehabilitation, vocational, or educational planning, or a combination of these.* The ability to provide inferences regarding etiology and descriptive power has made neuropsychological assessment a popular tool in rehabilitation and educational planning. Therapists and teachers can often use a patient's profile of strengths and weaknesses and the manner in which they go about tasks to develop and optimize rehabilitation and educational programs. Knowledge of which problems or weaknesses are attributable to brain dysfunction and which are likely the result of nonneurological sources can help a therapist allocate time and resources toward the treatment priorities that are most likely to be effective.

6. *Providing guidelines and education for family and caregivers.* In a similar vein, neuropsychological data can help families and caregivers to understand the strengths and weaknesses of their loved ones and to cope with patients who may suffer from challenging limitations on independent functioning. Beleaguered family members are less likely to be angry with a patient's behavior when they understand that symptoms that appear to be related to motivation or personality are actually causally related to a disease state. An understanding of the prognosis of the illness can also be invaluable to families who must plan their use of finances and future care.
7. *Planning for discharge and treatment implementation.* Neuropsychological deficits can sometimes be insidious and difficult to describe, even for sophisticated clinicians. An understanding of a patient's capabilities can help the clinician assess the degree to which a patient is going to comply with treatment recommendations and medication use, as well as the extent to which the patient or the patient's family may need continued supervision after discharge.

Rapid Reference 1.2 provides a quick summary of the uses of neuropsychological assessment.

In the ensuing chapters of this book, we review the essential information about neuropsychological assessment techniques that clinicians need to help in the description, diagnosis, and treatment process of patients.

Rapid Reference 1.2

Uses of Neuropsychological Assessment

- Describing strengths and weaknesses and identifying changes and dysfunction in psychological functioning
- Determining the biological correlates of test results
- Determining whether changes or dysfunction are associated with neurological disease, psychiatric conditions, developmental disorders, or nonneurological conditions
- Assessing changes over time and developing a prognosis
- Offering guidelines for rehabilitation, vocational, or educational planning
- Providing guidelines and education to family and caregivers
- Planning for discharge and treatment implementation

THEORETICAL AND RESEARCH FOUNDATIONS OF MODERN NEUROPSYCHOLOGICAL ASSESSMENT

Much of clinical psychology has drawn from the psychology of learning and cognition, developmental psychology, social psychology, and psychodynamic traditions for its scientific paradigms and language. Clinical neuropsychology adds to this mixture the paradigms of biology and medicine to grapple with the problems of human psychopathology.

The problems that are the focus of modern clinical neuropsychology have been described for centuries and have captured the imaginations of physicians and philosophers. A detailed history of neuropsychology is not within the focus of this book (see Benton & Adams, 2000; Meier, 1997), but an examination of several modern conceptual and investigative trends is important to help practitioners understand the source of many of the assumptions and practices currently in use.

Holism Versus Localization

Observations of behavioral changes that occur following injuries to the head can be found in the earliest written records of history, including translations of 5,000-year-old Egyptian medical documents (as described in Finger & Stein, 1982). The idea that thoughts, memories, and sensations somehow originate in the brain, however, did not gain wide acceptance until the beginning of the 17th century, although some still believed Aristotle's declarations regarding the heart's role in understanding human behavior and motivation (Finger & Stein, 1982). By the 19th century, there was little contention with the idea that the brain was the center of consciousness, memory, language, feelings, and passions, but there has never been complete agreement on how these basic categories of psychological function are actually accomplished. Although the levels of technology and sophistication have evolved dramatically over the centuries, the conceptualization of how the brain organizes its task as the organ of the mind boils down to two prevailing views that still guide the organization of research, theory, and clinical practice of neuropsychology.

Perhaps the most intuitively appealing and most clearly stated notion is that of a localized correspondence between structure and function. This idea suggests that different psychological functions are subserved by distinct and separate structures in the brain. The idea of localization found its clearest statement in the writings of the French physician and physiologist Franz Joseph Gall in the latter half of the 18th century. Gall (1835) argued that separate organs within the

brain controlled such faculties as wisdom, poetic ability, religiousness, language, and memory. This position's appeal lies in its ability to account for the countless observations of variations in symptoms accompanying variations in brain lesions. Since Paul Broca (a dedicated follower of Gall) masterfully documented the association of damage to the left frontal cerebral hemisphere of humans with the loss of the capacity to speak, much of neuropsychological research has attempted to document correspondences between other psychological functions and focal brain lesions.

Much of today's research is guided by the doctrine of localizationism, in which the description and localization of function are a primary goal of neuropsychological assessment. This idea has found its most modern form in the relatively new subdivision of neuropsychology, sometimes called cognitive neuroscience, which uses neuroimaging techniques such as magnetic resonance imaging (MRI) and positron emission tomography (PET) to detect minute changes in blood flow to relatively circumscribed areas of the cerebral cortex. Much of the literature using this technology documents increasingly specific localization of blood-flow changes associated with increasingly specific experimental measures of cognition. The goal of much of this research is to create detailed charts of cognitive localization in the brain. The strongest form of localization theory appears in the work of Jerry Fodor (1983), who introduced the concept of *modularity*. Modularity refers to the idea that localization is a necessary consequence of the distinct processing requirements of the sensory systems and such higher order cognitive functions as language. Fodor argued that the physical requirements of processing information in different sensory modalities mandate distinctly adapted and localized neural mechanisms. He proposed that language, which requires the use of specific, automatically accessed rules, also requires specific and localized neural mechanisms.

Localizationism is not the only conceptualization of how the brain is organized. As Pierre-Marie Flourens (1824), Hughlings Jackson (1894), Kurt Goldstein (1939), and Alexander Luria (1966) argued, the localization or correlation of symptoms or behavior with lesions (or even documented changes in blood flow) does not necessarily prove that the function of that behavior is localized in the observed brain structure. Although these writers acknowledged that lesions might have effects that differ as a function of location, they believed that brain function itself always involved multiple structures working together. This position is often associated with Kurt Goldstein's term for this principle: *holism*. The following example illustrates the central principle of holism: Although a loose screw might be responsible for a malfunction that prevents an automobile engine from starting, it would be erroneous to localize the function of locomotion in the screw itself. A

symptom may arise because an important component of a larger network of functions is disrupted or because only the most complicated and susceptible or weak "function" of many functions subserved by the same area is disrupted. Imagine concluding that piano playing (a relatively complex motor skill) was localized in the fingers, but that scratching (a relatively simple motor skill) was not because a sprain disrupted one but not the other. This was essentially Hughlings Jackson's argument regarding Paul Broca's and others' localization of expressive language (a relatively complex cognitive skill) to a specific part of the frontal lobes, when evidence showed that patients with lesions in Broca's area could articulate words in an emotional or even musical context.

In 1929 Karl Lashley published research showing that highly focal ablations of brain tissue had only mild and temporary effects on the recovery of maze learning in rats (Lashley, 1929). As a result, he concluded that the brain followed the principle of mass action and that various brain structures had the potential to take over the same function. His conclusion was a major influence on Ward Halstead's creation of the first psychometrically sound neuropsychological test battery and forms the basis of many of the instruments and standards for test construction used today. For example, the HRB, a widely known and used approach to neuropsychological assessment, is largely based on nonlocalizationist assumptions (Reitan & Wolfson, 1996).

One of the most sophisticated approaches applied to the study of brain–behavior relationships is the development of computer models, constructed out of building blocks that function and interact very much like neurons that imitate cognitive function and dysfunction. There has been remarkable success in making computer models that mimic various aspects of cognition and changes in cognition following brain lesions.

Many of these models do not use the assumptions of modularity or localization of function; instead, they are constructed using assumptions of mass action and equipotentiality (see Anderson, 1995). In the literature of functional neuroimaging, a view is also emerging that most functions should be conceptualized as distributed among neural networks (Damasio, 1995). Some researchers also make arguments against strict localizationism based on the fact that many functions substantially return after brain injury. Such recovery may indicate that other parts of the brain are doing the job of the damaged tissue (Finger & Stein, 1982).

The localizationist view is currently the most popular way of conceptualizing the results of neuropsychological tests. It is common to make the inference that a change in test performance (or pattern in performance across tests) is an indication that some function (presumably measured by the impaired test performance)

is localized in a specific region of the brain. Even the HRB has been adapted to this tradition. However, the clinician should be cautioned (or at least aware) that such direct inferences might be simplistic and inaccurate. Test performance is not necessarily an indication that a function is localized in a specific part of the brain. Moreover, predictions that may be accurate in one context (e.g., during the acute phase of a lesion) may not be accurate in another (e.g., several years after a lesion occurs, in children, or even in older adults). As Luria, Damasio, Finger, and Stein have argued, neuropsychological test performance and symptoms may reflect the disruption of an organized, distributed network of structures that participate in the function in question. The symptoms of brain dysfunction may reflect the disruption of a system rather than a single localized function in a specific circumscribed part of the brain.

Empiricism Versus Cognitivism in Test Construction

Much of the variation in today's approaches to neuropsychological assessment is layered on the foundation of two issues: how behavior should be conceptualized (empiricism or functionalism) and how brain organization should be conceptualized (cognitivism).

Most of the neuropsychological assessment techniques used currently are derived from the psychological–philosophical tradition of empiricism/functionalism. This means that tests are constructed using the ideas that prediction of performance is primary and that test content and psychological meaning are secondary. In contrast, tests from the cognitive tradition are constructed primarily to measure specific psychological, usually intellectual or perceptual functions; clinical prediction is a secondary or derived goal. A detailed discussion of these issues would be too digressive for this text, but neuropsychologists should have some general understanding of the basic interpretative and methodological assumptions that organize contemporary approaches to neuropsychological assessment.

Where do all the tests and measures that are used by neuropsychologists come from? A fair discussion of this seemingly simple question could easily consume this volume and would likely lead to a full-fledged barroom brawl if presented to more than two neuropsychologists at a time. It is raised here just to make the point that clinical neuropsychology derives its techniques in much the same way as do other clinical disciplines. In many cases, tests are used because they work or were thought to work based on previous observations. The term *empiricism,* the idea that knowledge is derived from direct experience, refers to this approach to creating tests. The empirical (or *functional*) approach is perhaps the most easily

defended and the one most identified with the nonlocalizationist approach to neuropsychology. Ward Halstead and his most famous student, Ralph Reitan, adopt (sometimes implicitly) the view that much of the brain follows the principle of mass action; thus, the primary consideration in selecting neuropsychological instruments is their observed sensitivity in detecting brain impairment. After a set of optimal measures is derived, they are used to test a variety of populations; in many cases, the primary goal is the detection of changes associated with brain pathology or dysfunction.

This process represented the primary trend in American neuropsychology well into the 1970s. Today, because localizationism has become the mainstream view of brain function, many of the tests that come from the Halstead–Reitan tradition are used to predict or detect the presence of focal lesions. In most of these cases, empiricism nevertheless rules: The tests themselves (and how they are derived or created) are not as important as their ability to predict the presence of brain dysfunction or their empirically demonstrated validity.

Independently constructed theories of cognitive function or dysfunction, which include sensitivity to brain dysfunction as an important but secondary consideration, provide another source of neuropsychological tests. Many modern tests were created in this way. For example, the Boston Diagnostic Aphasia Exam (Goodglass & Kaplan, 1983) and the California Verbal Learning Test (Delis, Kramer, Kaplan, & Ober, 1987) were created primarily using prevailing theories of language and memory, respectively, and in both cases were created to measure specific aspects of function known to be affected by brain dysfunction. In these cases, the tests' construct validity or theoretical interpretation was as important as their sensitivity to the presence of brain dysfunction. Literature documenting the sensitivity of the tests' tasks to the presence of brain lesions came primarily after their creation. In both cases, the assumption was made (either explicitly or implicitly) that the psychological functions measured were cognitive domains that could be affected independently by brain dysfunction. Further, it was assumed that the functions associated with these tests could be localized.

An understanding of these historical distinctions is helpful in understanding the strengths and weaknesses of neuropsychological tests. Some tests are excellent detectors of brain dysfunction but may be difficult to use as tools for describing abilities or as sources of real-life recommendations. Other tests do not demonstrate sensitivity to brain dysfunction as clearly but may provide clear, descriptive measures of a psychological domain; these measures can then be used to make recommendations for rehabilitation or treatment planning. Ideally, tests should be sensitive to the presence of brain dysfunction and theoretically coherent while also being functionally descriptive and ecologically valid (Sbordone,

1996; Sbordone & Guilmette, 1999; Sbordone, Saul, & Purisch, 2007); however, because of their historical origins, in practice many tests are compromised or limited to one of these two goals.

Ecological Validity: Representiveness, Generalizability, and the Future of Neuropsychological Test Development

Burgess and colleagues (2006) provide an incisive analysis of the consequences of neuropsychology's history of adaptation of assessment instruments from what they term *conceptual and experimental frameworks far removed from those currently in favor*. Using the example of tests of executive function, they argue that neuropsychological tests that focus on constructs that denote basic cognitive functions and that happen to be sensitive to the presence of brain dysfunction are not necessarily informative of how patients will perform in actual situations. They argue that the majority of assessment instruments currently in use by neuropsychologists were developed without regard for how well they predict "observable" adaptive behavior. Adapting concepts from Brunswick's (1956) classic treatise on the development of experimental procedures to test perceptual processes, Burgess et al. (2006) suggest the next generation of neuropsychological assessment instruments should be developed to be both "representative" of actual real-world "functions" and be "generalizable" or predictive of the performance of those functions across a range of situations. Although these criteria could be applied to any domain assessed by neuropsychological instruments, including intelligence and memory tests, Burgess et al.'s (2006) discussion focuses on tests of "executive functions" (examples of which are presented in Chapter 4 of this volume). They point out that the Wisconsin Card Sort Test (WCST), one of the most widely used measures of executive function, was not originally developed as a neuropsychological measure and was preceded by a number of sorting-based measures that were in fact developed around observations of the effects of brain damage (e.g., Weigl, 1927). The WCST, however, became an almost instant benchmark of "frontal lobe function" based on a single study of Brenda Milner (1963), who showed that patients with dorsolateral frontal lobe lesions had greater difficulty with it than patients with orbitofrontal or nonfrontal lesions. Although the WCST may involve "set shifting" and "working memory," data that would allow a clinician to "really know what situations in everyday life require the abilities that the WCST measures" (Burgess et al., 2006) are virtually nonexistent. They advise the next generation of neuropsychological tests should be "function led" rather than purely "construct led." These tests should meet the usual standards of reliability, but validity should be defined by both sensitivity to brain dysfunction and generalizability to real-world function.

THE MAJOR NEUROPSYCHOLOGICAL ASSESSMENT APPROACHES: THEIR HISTORY, DEVELOPMENT, STRENGTHS, AND WEAKNESSES

In this section we briefly review the background of the major testing approaches used in contemporary neuropsychology practice. Rapid Reference 1.3 provides publication information for the HRB, the Luria–Nebraska Neuropsychological Battery (LNNB), and the Boston Process Approach (BPA).

Halstead–Reitan Neuropsychological Test Battery

The discipline of using psychological tests to assess systematically the effects of brain dysfunction originated in the midwestern United States in the late 1930s and early 1940s. In the years between the two World Wars, clinical neurologists in Great Britain (e.g., Hughlings Jackson and the appropriately named Henry Head and W. R. Brain) and Europe (e.g., Constantin von Monakow, Kurt Goldstein, and Rezsö Balint) had already created an extensive history of the effects of brain damage on language, attention, vision, and personality. Ward Halstead, however,

Rapid Reference 1.3

Publication Information for the Three Major Approaches to Neuropsychological Assessment

HRB

Reitan, R. M., & Wolfson, D. (1993). *The Halstead–Reitan Neuropsychological Test Battery: Theory and clinical interpretation.* Tucson, AZ: Neuropsychology Press.

LNNB

Golden, C. J., Purisch, A. D., & Hammeke, T. A. (1985). *Manual for the Luria–Nebraska Neuropsychological Battery: Forms I and II.* Los Angeles: Western Psychological Services.

BPA

Kaplan, E. (1988). A process approach to neuropsychological assessment. In T. Boll & B. K. Bryant (Eds.), *Clinical neuropsychology and brain function: Research, measurement and practice* (pp. 125–167). Washington, DC: American Psychological Association.

worked in relative isolation from these observations and developments. Although his ideas were influenced by Karl Lashley's concepts of mass action and equipotentiality, Halstead started with a relatively blank slate, putting together after much trial and error a battery of psychological tests that, taken together, could be used by clinical neurologists and neurosurgeons to distinguish patients considered to have brain dysfunction from patients with no known history of brain abnormality. After trying and rejecting hundreds of tests that did not perform the basic job of discriminating normal adults from adults with brain dysfunction, he put together a battery of tests originally developed for a variety of purposes. For example, his battery included the Seguin–Goddard Form Board, a test that originated in the mid-19th century as a measure of so-called feeble-mindedness (Seguin, 1907), the Seashore Rhythm Test from the Seashore Test of Musical Aptitude (Saetveit, Lewis, & Seashore, 1940), and modifications of other tests (e.g., Boston University Speech Sound Perception Test) as well as tests that he originated, such as the Finger Oscillation or Finger Tapping Test (Halstead, 1947), and the most original, the Category Test (Halstead, 1947). From these tests, he constructed an index of impairment that could be used to predict the presence of brain dysfunction. In the early 1950s, his former graduate student, Ralph Reitan, continuing in this perfect example of the empiricist tradition, modified and systematized Halstead's original battery to include observations of left- versus right-sided motor performance, a sensory-perceptual examination, and an aphasia screening examination (Reitan, 1955). He also developed a set of test norms for the battery after administering the battery to patients with known focal and diffuse brain dysfunction and to a group of normal control subjects. In addition, he developed indexes of brain impairment, permitting localization and inferred causality. The resulting fixed battery of tests, widely known as the Halstead–Reitan Neuropsychological Test Battery or the Halstead-Reitan Battery (HRB), stimulated a remarkable body of research as Halstead's original methods were applied to different patient populations, such as children and patients with epilepsy psychiatric illness.

The HRB is clearly empiricist with a clearly nonlocalizationist origin. The fixed battery approach pioneered by Halstead and Reitan has the advantage of providing a standard set of measures by which different patients can be compared. After the measures are established, it is easy to extend the scope of the battery to new populations and to collect extensive norms. Although the advantage of stability and comparability is clearly the strength of a fixed battery approach, this particular battery has found itself decreasing in popularity in recent years for a number of reasons. In 2006, a practice survey revealed that only 7% of practitioners used a standardized or fixed battery approach such as the HRB or the LNNB (Sweet et al., 2006). This represents a decline from 18% in 1989. The practical problem

with the purely empiricist approach is that it does not necessarily lead to the most efficient or interpretable measures. The HRB is extremely long and tedious for some patients, leading to reports of noncompliance and discomfort, particularly in older and more impaired patients. In today's environment of limited or capped payment of medical expenses, batteries of this size are difficult to justify economically. In addition, it is sometimes difficult to describe what the constituent tests are measuring other than the obvious intuitive characteristics of the tasks. In many cases, the relevance of task performance is difficult to tie to real-life situations.

Although not strictly antilocalizationist, the research tradition of the HRB has allowed for the prediction of focal lesions only as they emerge from the variables available in the battery. This has led to the development of a variety of prediction formulae and decision rules that have been offered to predict the presence of focal lesions. These formulas, which are difficult to interpret, sometimes appear to be random comparisons of tasks (e.g., Parsons, Vega, & Burn, 1969) or do not generalize beyond the populations in which they were validated. In recent years, as more cognitively based approaches have emerged, some psychologists have attempted to relate the tests and findings of the HRB to the cognitive domains of language, memory and other functions (Reitan & Wolfson, 1996), although such tasks as the Aphasia Screening Test and even the venerable Category Test seem anachronistic in view of the evolution of the concepts of language and executive functions these tests were designed to assess. Still, the wealth of referent validating data, the fact that the battery may be administered by a technician, and the convenience of receiving training in this approach have made the HRB a model for other approaches.

Luria–Nebraska Neuropsychological Battery

Alexander R. Luria, a Russian neuropsychologist, was a contemporary of Ward Halstead. Although Luria worked at roughly the same time as Halstead, he took a different approach from his American colleague to the development of techniques for assessing the effects of brain dysfunction. Luria published in the Soviet Union, where scientists felt great pressure to relate research to the Pavlovian concepts of conditioning and inhibition. He and his mentor, Leon Vygotsky, were staunch cognitivists who concerned themselves with the formulation of rich descriptions of the development and structure of human mental functions. Luria's model of brain organization was a direct reflection of the concept that human mental faculties were composed of elementary intellectual building blocks; these components could be used to solve the problems of action and thought in a variety

of manners. Cognition was a dynamic process that varied as function of development, the demands of a particular problem situation, and, in the case of Luria's neuropsychology clinics, of the presence of brain dysfunction.

Luria described his approach in some detail in his landmark book, *Higher Cortical Functions,* published in English in 1966. He described hundreds of tasks that could be used in a seemingly infinite array of patterns to characterize the details of the effects of brain dysfunction in each particular case. This approach was acknowledged as brilliant and insightful but was seen as forbiddingly complex and impractical for the average clinician, who would not have the mentorship available to develop the skills needed to apply these methods reliably. In addition, the standard set by the Halstead–Reitan approach made many clinicians suspect that Luria's inherently variable methodology could not be subjected to conventional means of assessing reliability and validity.

Although Luria's conception of brain organization and his approach to the development of cognitive theory were remarkable in that they foreshadowed much of what characterizes modern cognitive neuropsychology and experimental psychology research, his approach to assessment would have remained an exotic curiosity if not for a Danish student, Anne-Lise Christensen, who after apprenticing herself to Luria, introduced to the United States a detailed description of Luria's test techniques, titled "Luria's Neuropsychological Investigation," (Christensen, 1974) that included a set of materials (stimulus cards, photographs, etc.) to which Luria alludes in *Higher Cortical Functions*. Charles Golden, a Nebraska-based neuropsychologist who was an expert in the Halstead–Reitan approach, used these materials along with Thomas Hammeke and Arnold Purisch to develop a new battery of tests. Golden hoped both to take advantage of Luria's knack for developing tasks that seemed to reveal the details of basic brain functions and to retain the rigorous empirical tradition of the Halstead–Reitan Battery.

The publication of the LNNB (Golden, Hammeke, & Purisch, 1978) represented a controversial landmark in the development of neuropsychological test methods. Golden's method, which combines items that can discriminate between subjects with brain dysfunction and normal subjects into scales named after various cognitive or functional domains such as reading and writing, was severely criticized for not representing the concepts advocated by Luria. Luria, for example, described a variety of variations of how a seemingly simple function such as writing can break down depending on the specific underlying brain lesion or system that was disrupted. Luria mentioned basic orthography (the development of letters and words as holistically represented symbols), the association of sound with letter and word, and so forth as potential components of writing that may be affected independently as a reflection of the type and localization of a lesion.

According to Golden's critics, combining the tasks that Luria used to develop a description of variations in a function into a single scale subverts Luria's goal of finding the correct descriptive recipe for every variation in performance. The LNNB has also been criticized for its lack of sensitivity to certain problems such as language. Although the LNNB never gained the popularity of the HRB, it developed a loyal following that appreciated its relative brevity and the increasing base of empirical findings to support its validity as a neuropsychological instrument. Although many psychologists would argue that the LNNB represents a failed attempt to make Luria's methods more accessible and reliable, most would admit that it provides some hope that more efficient, empirically based approaches to assessment can be developed.

Boston Process Approach

While the HRB was establishing itself as the benchmark method for assessing brain dysfunction, a critical mass of investigators in the Boston area had begun to work on the problems of brain–behavior relationships. Researchers and clinicians interested in language, memory, perception, and other classic psychological issues coalesced under the charismatic leadership of Norman Geschwind, one of the great behavioral neurologists of the 20th century, and Harold Goodglass, a clinical psychologist who brought the study of aphasia into the realm of psychology. In Boston, American psychology's then-new focus on cognition had begun to revolutionize studies of the brain. Geschwind and Goodglass came from different disciplines, but both researchers approached the task of studying the brain as a process of analysis and reduction to basic elements. Influenced by German neurology, theoretical linguistics, and cognitive psychology, this work used an experimental approach different from that of the Halstead–Reitan tradition. Davis Howes, Jean Gleason, Edgar Zurif, and Sheila Blumstein joined Dr. Goodglass's efforts to adapt the methods of psychophysics, linguistics, and developmental psychology to revolutionize the study of aphasia. At the same time, Nelson Butters's and Laird Cermak's studies of memory and amnesia helped bring the subject of brain dysfunction to the attention of mainstream experimental psychology.

It was in this atmosphere that Edith Kaplan, a graduate student of developmental psychologist Heinz Werner, came to work. Dr. Kaplan, an assistant to Dr. Goodglass, brought to what was then known as the Boston Veterans Administration Hospital an acute eye for observing patients' behavior and Heinz Werner's lesson that different cognitive processes could be used by different individuals to solve the same problem. Werner taught that cognitive development was characterized by changes in the means by which children solved problems. Encouraged

by the sympathies of other clinicians and researchers with whom she worked, Dr. Kaplan applied Werner's ideas to patients who had undergone a newly developed neurosurgical treatment for epilepsy involving the cutting of the corpus callosum, the major neural bridge between the two cerebral hemispheres. She noticed that the patients solved a puzzle construction task called Block Design from the WAIS differently when the task was placed to the right of the patient from when the task was placed to the left of the patient. Over the next 20 years, Kaplan compiled hundreds of such observations, which she imparted to students and other psychologists through supervision and seminars. In 1991 she published a complete modification of the WAIS—Revised (WAIS-R) in the WAIS—Revised Neuropsychological Instrument (WAIS-R NI), reflecting her adaptations and observational recommendations (Kaplan, Fein, Morris, & Delis, 1991). The BPA, as these methods were dubbed in 1986 (Milberg, Hebben, & Kaplan, 2009), has at its core the idea that task performance is more important than the task itself. In practice, although most patients would receive a core battery of tests including the WAIS, the Wechsler Memory Scale, the Rey–Osterrieth Complex Figure, and other tests, Dr. Kaplan would use what would be considered a *flexible battery approach*. This approach adds measures from a long list of tests borrowed from various domains to reflect referral questions and to follow up on the observations made with the initial battery given. At present, 76% of clinical neuropsychologists report using a flexible core battery (i.e., variable core depending on type of patient group) and 18% report using a totally flexible approach (i.e., variable tests depending on the individual case; Sweet et al., 2006).

Initially, the BPA was criticized for not having supporting norms or sufficiently detailed standard methods to assess the psychometric properties of reliability and validity. A growing body of research in the past 20 years, however, supports Kaplan's observations (e.g., Bihrle, Bellugi, Delis, & Marks, 1989; Freedman et al., 1994; Joy, Fein, Kaplan, & Morris, 2001; Wecker, Kramer, Wisniewski, Delis, & Kaplan, 2000). In addition, some researchers have attempted to quantify the BPA (Poreh, 2000, 2006). Nevertheless, the BPA never sparked the explosion of research that the HRB did and still suffers from relatively limited normative information. The WAIS-R NI (Kaplan et al., 1991) was one of the few examples of tests published with some standard information about reliability and standard errors of measurement. Even this landmark test, however, does not provide reliability and validity information for the hundreds of observations that Kaplan and her students used for making clinical inferences. Despite these significant limitations, the approach has gained increasing popularity in recent years because it provides clinicians with much greater descriptive power than either the Halstead–Reitan or Luria–Nebraska batteries. Even the recently released WAIS—Fourth Edition (WAIS-IV) now includes some process

approach variables for which base rate data are available. To many it is seen as a modern version of the methods taught by Luria, using conventional, familiar neuropsychological instruments and techniques that are more readily learned and adapted.

Interestingly, the BPA has also spawned a number of conventional tests for which the structures were derived from Kaplan's and her students' observations of patients' test behavior but without relying on those same observations for scoring or interpretation. A now well-established example of this is the Delis–Kaplan Executive Function test (D-KEFS; Delis, Kaplan, & Kramer, 2001), which takes the approach of breaking down such commonly used tests as the Trail Making Test, into multiple tasks, each of which is designed to be differentially sensitive to the various component "processes" that comprise the original measure.

Rapid Reference 1.4 provides a summary of the principal advantages and disadvantages of the major approaches to neuropsychological assessment.

Rapid Reference 1.4

Advantages/Disadvantages of Major Approaches to Neuropsychological Assessment

Halstead-Reitan Battery

Advantages

- Empirically designed battery with nonlocalizationist origins
- Wealth of validating data
- Reliability and comparability across different patient groups
- Ability to be administered by a technician

Disadvantages

- Length and inefficiency
- Complex measures; difficulty knowing which functions are being measured
- Difficulty of economic justification, often because of length
- Declining in popularity

Luria-Nebraska Battery

Advantages

- Empirically designed battery based on Luria's measures
- Single scales for various functional or cognitive domains
- Relative brevity of administration time
- Increasing base of empirical findings

Disadvantages

- Not an accurate reflection of Luria's method
- Not as popular as Halstead–Reitan Battery
- Single scales inconsistent with Luria's view of individual variation
- Declining in popularity

Boston Process Approach

Advantages

- Frequent use of adaptations of validated measures
- Flexibility in matching tests to referral question
- Great descriptive power in the clinical setting
- As an example of flexible battery, the most commonly used approach

Disadvantages

- Produces a relatively limited set of normative data for qualitative findings
- Depends on observational skills for its use
- Requires specific training

Other Approaches and Contributions

In addition to the HRB, LNNB, and the BPA, a number of laboratories have made significant contributions to test practices, providing tests and clinically available data that have proved useful in a number of settings. In many cases, these laboratories have produced a wealth of supportive data and have made substantial contributions to both experimental and clinical research.

Because of the limits of space in this text, we have painted some of these remaining contributors to clinical neuropsychology with relatively broad strokes, grouping together the work of those who otherwise deserve individual mention:

- *Contributions from Canada.* A number of major contributors to clinical assessment resources have been located in Canada. These contributors include the laboratory of Brenda Milner, who conducted hundreds of studies of the neurosurgery patients at the Montreal Neurological Institute. She and her colleagues and students, including Doreen Kimura and Sandra Witelson, were responsible for producing highly sophisticated tests of executive and motor functions and memory (e.g., Design Fluency Test, Dichotic Listening, and Dihaptic Perception Test).
- *Contributions from Europe.* A number of countries, including France (e.g., Henri Hecaen), Italy (Ennio DeRenzi et al.), Norway (Halgrim Klove),

and Germany (Klaus Poeck), have supported acclaimed laboratories in neuropsychology, contributing important tests of language, memory, and visual functions (e.g., Token Test and the Grooved Pegboard Test), as well as scoring schemes for apraxia (e.g., Poeck, 1986).

- *Contributions from Britain.* Great Britain has supported several internationally famous neuropsychology laboratories. The laboratory of Elizabeth Warrington, for example, has been responsible for several generations of major contributors to clinical and experimental neuropsychology. The group of psychologists working at the Rivermead Rehabilitation Hospital published a number of well-normed tests of functions that are designed to represent real-life situations (e.g., Warrington Recognition Memory Test and the Rivermead Behavioural Memory Test), including a battery of tests to assess memory and attention. These tests, which reflect contemporary ideas derived from cognitive neuropsychology, are highly adaptable to the purposes described earlier in the section titled "Uses of Neuropsychological Assessment." They deserve to be considered by any practicing neuropsychologist and may become (in terms of popularity) the HRB of the future.
- *Contributions of Arthur Benton.* The Arthur Benton Laboratory in Iowa City, Iowa, deserves special mention (Benton, Sivan, deS Hamsher, Varney, & Spreen, 1994). Dr. Benton pioneered the development of highly specific descriptive tests of cognitive functions (e.g., Line Orientation and the Benton Visual Retention Test). It is not clear why these tests have not gained more popularity, other than the sheer force of data supporting the HRB, which appeared contemporaneously with many of Benton's tests. He designed and normed memory and visual functions tests that are still useful in special clinical testing situations.

TEST YOURSELF

1. **The majority of tests used by neuropsychologists were specifically developed for the purpose of assessing brain dysfunction.**
   True or False?
2. **Tests such as the Boston Diagnostic Aphasia Exam and the California Verbal Learning Test were constructed with sensitivity to brain dysfunction as the primary consideration.**
   True or False?

3. **Which neuropsychological test battery is the best example of test development based on an empirical approach?**
   (a) Luria–Nebraska Neuropsychological Battery
   (b) Halstead–Reitan Battery
   (c) Boston Process Approach Battery
   (d) Luria Neuropsychological Investigation
4. **What is a clinical neuropsychologist?**
   (a) A psychologist board certified in clinical neuropsychology by the American Board of Professional Psychology or the American Board of Professional Neuropsychology
   (b) A psychologist with a doctorate in clinical neuropsychology
   (c) A psychologist licensed as a neuropsychologist in his or her state
   (d) All of the above
5. **Holism theory suggests that different psychological functions are subserved by distinct and separate structures in the brain.**
   True or False?
6. **Localization theory holds that brain lesions may have effects that differ as a function of location, but that the brain involves multiple structures working together.**
   True or False?
7. **Ideally, neuropsychological tests should be sensitive to the presence of brain dysfunction and have ecological validity.**
   True or False?

Answers: 1. False; 2. False; 3. b; 4. d; 5. False; 6. False; 7. True