Chapter 1

INTRODUCTION TO PEDIATRIC NEUROPSYCHOLOGY

WHAT IS PEDIATRIC NEUROPSYCHOLOGY?

Neuropsychology has its roots in behavioral neurology. Behavioral neurology, which can be traced back to ancient Greece and Egypt (Zillmer, Spiers, & Culbertson, 2008), is a branch of neurology that deals with disorders of higher cognitive functioning (e.g., language, cognition, visual perception). Aristotle referred to the brain, and Herophilus described hydrocephaly and the ventricles of the brain. Behavioral neurology posits that behavior, at least to some extent, is dependent on the functioning of the central nervous system. Neuropsychology is the clinical application of the understanding of brain-behavior relations as derived from behavioral neurology (Stuss & Levine, 2002); pediatric neuropsychology applies this understanding within the developmental context of children, particularly those with neurodevelopmental disorders. Research in pediatric neuropsychology has not reached its full potential, and research and practice continue to expand (Baron, 2008). Pediatric neuropsychology has applications across neurology, neurosurgery, psychology, psychiatry, family medicine, nursing, and education (Witsken, D'Amato, & Hartlage, 2008).

Children with neurodevelopmental disorders are those who have, or who are at risk for, limitations in some or all life activities as a result of impairments in the central nervous system (Mudrick, 2002; Spreen, Risser, & Edgell, 1995). The possible consequences and limitations range from mild to severe cognitive, sensory, motor, educational, and behavioral/psychological impairments (Mendola, Selevan, Gutter, & Rice, 2002). The major premise of neuropsychological assessment is that the information obtained reflects the integrity of the central nervous system (Stuss & Levine, 2002). Neuropsychologists use their knowledge and understanding of brain-behavior relations in the conceptualization of an individual's functioning in a variety of domains including: cognition ("g"), auditory-linguistic, problem-solving, learning and memory, visual-spatial and constructional areas, academic achievement, and interpersonal/behavioral. Neuropsychologists engage in "hypothesis-driven" assessment that involves integration of all the information obtained in the context of neurodevelopmental systems (Berkelhammer, 2008). The goal of this integration is the generation of recommendations for habilitation, accommodations, or modifications.

Neuropsychology incorporates knowledge of behavioral neurology gained through research in clinical contexts; what is known about brain-behavior relations has changed over time as medical technology has increased. Current perspectives incorporate principles of both equipotentiality and pluripotentiality. The concept of equipotentiality embodies the idea that if sufficient cortical material is intact, this intact material will subsume the functions of the damaged tissue; thus, the size of the injury and not the location determines the effect on brain functioning (Zillmer et al., 2008). Alternatively, the idea of pluripotentiality is that any given area of the brain can be involved in multiple behaviors to varying degrees (Luria, 1980). The principles of equipotentiality and pluripotentiality, as well as plasticity, give rise to the connection between knowledge of brain-behavior relations, assessment of neurocognitive functioning, and rehabilitation/habilitation.

In the interpretation of individual behavior, sometimes inferences are made that seem to draw from localization theory; unfortunately, evidence suggests that brain-behavior relations are not that simplistic; rather, behavior is the result of complex functional systems or networks within the brain (Luria, 1980). Medical findings continue to support and validate localization to some extent while also supporting the widely distributed functional systems of Alexander Luria for more complex behavior. The 20th century saw continued advancement in technology and the ability to examine brain structures through multiple methods. Current technology provides greater insight and information through various functional imaging methods; with this increased technology, understanding of brain behavior relations will continue to improve rapidly. This is the research component to neuropsychology and the means by which neuropsychology seeks to advance the understanding of the effects of neurodevelopmental and genetic disorders (Berkelhammer, 2008).

It is important to remember, however, that overall functioning is not only the result of the integrity of brain function but that brain function is influenced by (and influences) environmental contexts; hence, the context in which the individual functions is also of importance. The invariance hypothesis dictates that brain functions are asymmetrically located in the cerebral hemispheres and that hemispheric dominance is genetically determined, but that each hemisphere has the potential for acquiring various functions. Research suggests that deprivation of stimulation can result in impaired or absent development (e.g., binocular and monocular deprivation in animal studies can result in blindness or optical deficits). The idea of the deprived area being deficient or stimulation relating to increased function is one possible explanation for the inability of humans to perceive certain sounds in languages unfamiliar to us and why children are much better bilingual learners than adults. In effect, the genetic contributions may serve as a predisposition or diathesis that can be altered or modified for better or worse by environmental stimulation or exposure (Asbury, Wachs, & Plomin, 2005; Pennington et al., 2009; Schmidt, Polak, & Spooner, 2005).

Related to diathesis, maturation theory posits that functional asymmetry of the hemispheres develops with age, beginning at conception, and is influenced by environmental events and stimulation. From the time of conception, an interruption in normal development or abnormal development for any of one area of the brain for any reason leads to associated abnormalities at levels of functioning and can potentially affect multiple systems (Zillmer et al., 2008). Neural development does not stop at birth; rather, fine tuning of neural functioning continues throughout the life span and is continuously affected by environmental contexts. From a developmental perspective, notions related to equipotentiality, pluripotentiality, and plasticity serve as the foundation of many early intervention programs. While neuropsychology embraces the idea that the neurological hardware of the individual determines their behavior, there is evidence that failure to stimulate particular areas of the brain will impact on functioning; alternatively, there are indications that stimulation or intervention can result in changes in brain function (Zillmer et al., 2008).

Early intervention efforts are targeting the potential effects of increased stimulation; similarly, many of the rehabilitation efforts for stroke and traumatic brain injury (TBI) are based on the premise that the brain can be "retrained" to some degree.

NEUROPSYCHOLOGICAL ASSESSMENT

When an individual is referred for a neuropsychological assessment, often the primary purpose is to identify (or rule out) pathology. The neuropsychological approach to case conceptualization incorporates information related to various behavioral domains believed to reflect functional neurological systems (Luria, 1980; Riccio & Reynolds, 1998). A major premise of neuropsychological assessment is that different behaviors involve differing neurological structures or functional systems (Luria, 1980); as such, neuropsychological assessment is intended to be sufficiently comprehensive to address all functional systems.

The pathology in question is generally considered to be in the central nervous system or the peripheral nervous system. Typically, the neurologist assesses functioning by looking at what are referred to as "soft signs." These include reflexes (e.g., tapping on knee), balance (e.g., walking a straight line), short-term memory (e.g., recall of digits or unrelated words), mental status (e.g., awareness of time and place), coordination (e.g., touching nose with eyes closed), visual tracking (e.g., following a pencil), verbal skills (e.g., in conversation), and cognitive flexibility (e.g., counting backward by 3s). Neurologists also will verify the functioning of cranial nerves to the extent feasible through observation of the associated behaviors (Zillmer et al., 2008). Neurologists will look at head circumference, height, weight, gait (e.g., toe walking, heel-toe walking), and right versus left differences (e.g., in hand strength). Neuropsychological assessment may include similar tasks but also samples behaviors known to depend on the integrity of the central nervous system through the use of various measures that correlate with cognitive, sensorimotor, and emotional functioning (R. S. Dean & Gray, 1990).

The assessment process is hypothesis driven (Berkelhammer, 2008), to the extent that the methods and measures are selected based on hypotheses regarding the underlying pathology due to the reason for referral, medical history, and developmental information obtained in advance. The assessment incorporates components of a typical psychoeducational or psychological evaluation but extends the scope to other areas of functioning. Neuropsychological assessment includes measures of cognitive ability, achievement, and personality/behavior. It also involves more extensive measures of language, visual spatial perception, visual motor construction, learning and memory of new material (e.g., list learning tasks), fine motor functioning, tactile perception, attention, executive function (problem-solving, abstract reasoning, planning, and organization), and working memory (Riccio & Reynolds, 1998).

Many clinicians use a predetermined battery of tests for neuropsychological assessment of children (Riccio, 2008); this is often referred to as the fixed battery or nomethetic approach. Specific neuropsychological batteries, such as the Halstead-Reitan Neuropsychological Battery (HRNB) (Reitan & Davison, 1974; Reitan & Wolfson, 1985), the Reitan-Indiana Neuropsychological Battery (RINB) (Reitan, 1969), the Luria Nebraska Neuropsychological Battery—Children's Revision (LNNB-CR) (Golden, 1984; Golden, Freshwater, & Vayalakkara, 2000), the Kaplan Baycrest Neurocognitive Assessment (Leach, Kaplan, Rewilak, Richards, & Proulx, 2000), or the Neuropsychological Assessment-Second Edition (NEPSY-2) (Korkman, Kirk, & Kemp, 2007) are often used in neuropsychological assessment in conjunction with intelligence tests, achievement tests, and measures of behavior and personality. These neuropsychological batteries provide a sampling of sensory and motor functions as well as additional information relating to left/right–hemisphere differences and anterior/posterior differences. Of these, the HRNB continues to be one of the most widely used neuropsychological test batteries but may require some updating if it is going to continue to be useful in clinical practice (Sinco, D'Amato, & Davis, 2008).

Alternatively, neuropsychologists may adopt a more idiographic approach and tailor the selection of measures based on the child's presenting problems, with others added based on the child's performance on initial measures (Berkelhammer, 2008; Christensen, 1975; Luria, 1973). This type of approach, often referred to as a deficit approach, is intended to isolate those mechanisms that are contributing to a specific, identified problem as part of hypothesis testing. The deficit-only model may be more cost effective; the emphasis is clearly on understanding deficit systems and not identifying intact functional systems—hypotheses related to intact systems are not addressed. Further, the more idiographic approach may fail to assess domains that are of importance and subsequently impact on rehabilitation efforts (Riccio & Reynolds, 1998).

Traditionally, neuropsychological assessment has focused more on analysis of the functional systems and overall integrity of the central nervous system (CNS) than on the identification of a single neurological disorder (Riccio & Reynolds, 1998). In assessing CNS integrity, it is important to ensure that the results obtained allow for evaluation of the four major quadrants of the neocortex (left, right, anterior, posterior). Therefore, it is important that the assessment sample the relative efficiency of the right and left hemispheres. Similarly, the anterior region of the brain generally is viewed as being associated with different functions (e.g., regulatory) as opposed to the posterior region of the brain (receptivity). Just as lateralization of dysfunction is important, anterior-posterior comparisons can provide important information for treatment planning. The cumulative performances of the individual on neuropsychological measures are seen as behavioral indicators of brain function (Fennell & Bauer, 1997; Stuss & Levine, 2002).

There is no single method to select measures to be included in a neuropsychological assessment that is used across settings or individuals; in fact, the range of measures and methods available is continuously expanding and allows for assessment of a wider range of behaviors. Whether the approach is a fixed battery or a flexible battery, the assessment may or may not include naturalistic observation and informal assessment (Reynolds, 1997). In addition, the approach may be standardized or incorporate a process orientation (Kaplan, 1988, 1990; Milberg & Hebben, 2006). Although some may choose to rely on actuarial or quantitative methods, reliance on qualitative methods is not recommended. Many clinicians prefer a combination of quantitative and qualitative measures to balance the strengths and weaknesses of both approaches. In particular, reliance on a qualitative approach does not allow for verification of diagnostic accuracy and does not allow for formal evaluation of treatment methods; further, it is not easily replicated, and interdiagnostician agreement may be compromised (Poreh, 2006). Regardless of the approach, the influences of child psychology, school psychology, and education are evident in the composition of neuropsychological assessment batteries, procedures, and measures used with children; the variety of perspectives contribute to the variations in methods used (Batchelor, 1996). Various methods that typically are used to evaluate the domains comprising the neuropsychological assessment of children and adolescents are provided in Table 1.1; this table is not, however, intended to be an exhaustive list. Given the variability in test selection possible, the case studies provided in the chapters to

Table 1.1 Possible Components to Pediatric Neuropsychological Assessment

Domain of Functioning	Possible Measure (Battery, if Part of a Battery)
Cognition	Bayley Scales of Infant Development, Second Edition Differential Ability Scales, Second Edition (DAS-II) Kaufman Assessment Battery for Children, Second Edition (KABC-2) Leiter—Revised Ravens Standard Progressive Matrices Stanford-Binet Intelligence Scale, Fifth Edition (SB5) Universal Nonverbal Intelligence Test (UNIT) Wechsler Intelligence Scale for Children, Fourth Edition (WISC-IV) Wechsler Adult Intelligence Scale, Fourth Edition (WAIS-IV) Wechsler Preschool and Primary Scale of Intelligence, Third Edition (WPPSI-III) Wechsler Nonverbal Scale of Intelligence (WNV) Woodcock Johnson Tests of Cognitive Ability, Third Edition (WJ III)
Auditory-Linguistic/Language Function	Aphasia Screening Test from Halstead Reitan Neuropsychological Battery (HRNB) Auditory Attention and Response Set from Neuropsychological Assessment, Second Edition (NEPSY-2) Boston Naming Test California Verbal Learning Test—Children's Version (CVLT-C) Clinical Evaluation of Language Fundamentals, Fourth Edition (CELF-IV) Comprehensive Assessment of Speech and Language (CASL) Comprehensive Receptive and Expressive Vocabulary Test, Second Edition Comprehensive Test of Phonological Processing Comprehension of Instructions (NEPSY-2) Controlled Oral Word Association Test (COWAT) Dichotic Listening Tasks Expressive One-Word Picture Vocabulary Test Expressive Vocabulary Test, Second Edition FAS or other Verbal Fluency Test (e.g., on NEPSY-2) Revised Token Test Peabody Picture Vocabulary Test, Fourth Edition (PPVT-IV) Phonological Processing (NEPSY-2) Pitch Pattern Sequence Test Receptive One-Word Picture Vocabulary Test Speech Perceptions Test (HRNB) Test of Early Language Development (TELD) Test of Adolescent and Adult Language, Third Edition (TAAL-3) Test for Auditory Comprehension of Language, Third Edition (TACL-3) Test of Auditory Perceptual Skills (TAPS) Test of Pragmatic Language, Second Edition (TOPL-2) Vocabulary, Similarities, and Comprehension Subtests of Wechsler Scales
Visual-Perception and Constructional Praxis	Arrows (NEPSY-2) Beery Developmental Test of Visual Motor Integration, Fifth Edition Benton Visual Form Discrimination Test Block Construction (NEPSY-2) Block Design, Matrix Reasoning of Wechsler Scales

(continued)

Table 1.1 ***(Continued)***

Domain of Functioning	Possible Measure (Battery, if Part of a Battery)
	Clock Face Drawing Test Design Copy (NEPSY-2) Rey-Osterreith Complex Figure Test Route Finding (NEPSY-2) Scotopic Form Discrimination
Perceptual/ Sensory Perception	Finger Discrimination (NEPSY-2) Finger Number Writing (HRNB) Sensory Perceptual Examination (HNRB) Tactual Performance Test (HRNB) Tactile Form Recognition (HRNB) Lateral Preference from Dean Woodcock Neuropsychological Battery (DWNB) Palm Writing (DWNB) Finger Identification (DWNB)
Learning and Memory	Benton Visual Retention Test, Fifth Edition Digit Span Forward from Children's Memory Scale (CMS), Wechsler Scales, Test of Memory and Learning –Second Edition (TOMAL-2) List Learning from CMS, CVLT-C, NEPSY-2, Wide Range Assessment of Memory and Learning, Second Edition (WRAML-2, TOMAL-2) Memory for Faces (CMS, NEPSY-2, TOMAL-2) Memory for Names (NEPSY-2) Paired Associate Recall (CMS, TOMAL-2) Rey Auditory Verbal Learning Test Sentence Repetition (NEPSY-2) Serial Digit Learning Spatial Span Forward Story Recall (CMS, WJIII, NEPSY-2, WRAML-2, TOMAL-2) Spatial Location (CMS Dot Locations, TOMAL-2) Tactual Performance Test (HRNB) Complex Figure Recall Tasks n-Back Tasks Digit Span Backward (Wechsler Scales, CMS, TOMAL-2) Letter Number Sequencing Spatial Span Backward Working Memory Battery from Cambridge Neuropsychological Testing Automated Battery (CANTAB)
Processing Speed/ Tracking	Cancellation Tasks Digit Symbol/Coding Rapid Naming Stroop Color Word Test Symbol Search
Executive Function	Behavior Rating Inventory of Executive Function (BRIEF) Card Sorting Tasks Category Test (HRNB) Matching Familiar Figures Test Planning Battery of the CANTAB Tower Tasks (Tower of Hanoi, Tower of London, Tower Task from D-KEFS) Trails (HRNB, Comprehensive Trail Making Test, Color Trails Test)

Domain of Functioning	Possible Measure (Battery, if Part of a Battery)
Attention/ Concentration	Auditory Attention and Response Set (NEPSY-2) Cancellation Tasks Children's Embedded Figures Test Children's Auditory Verbal Learning Test Children's Memory Scale (Attention/Concentration Scale) Continuous Performance Tests Digit Span Tasks Dual Task Paradigms Fluency (Figural, Verbal, COWAT) Matching Familiar Figures Task Stroop Color Word Test Trails (HRNB, Comprehensive Trail Making Test, Color Trails Test) Visual Attention (NEPSY-2) Test of Everyday Attention for Children (TEA-Ch)
Motor Function	Design Copy (NEPSY-2) Finger Oscillation Test (HRNB) or Finger Tapping Test (NEPSY-2; DWNB) Grip Strength Test (HRNB) Grooved Pegboard Test Imitating Hand Positions (NEPSY-2) Manual Motor Sequences (NEPSY-2) Motor Impersistence Test Oromotor Sequences (NEPSY-2) Reaction Time Tasks Beery Developmental Test of Visual Motor Integration, Fifth Edition Visuomotor Precision (NEPSY-2) Bender Visual Motor Gestalt Test II Gait and Station (DWNB) Romberg (DWNB) Construction Test (DWNB) Hand Movements (KABC-2)
Achievement/ Academic Skills	Woodcock Johnson Tests of Achievement, Third Edition Wechsler Individual Achievement Test, Second Edition (WIAT-II) Kaufman Test of Educational Achievement, Second Edition (KTEA-II) Gray Oral Reading Test, Fourth Edition (GORT-4) Test of Written Language, Third Edition (TOWL-3) Wide Range Achievement Test, Fourth Edition (WRAT-4) Curriculum Based Assessment Criterion Referenced Assessment Basic Achievement Skills Inventory
Emotional/ Behavioral Functioning	Achenbach System of Empirically Based Assessment (ASEBA) ADHD Rating Scale, Fourth Edition Behavior Assessment System for Children, Second Edition (BASC-2) Conners' Rating Scales, Third Edition DSM-IV ADHD Checklist Minnesota Multiphasic Personality Inventory—Adolescent Version Personality Assessment Inventory—Adolescent Children's Depression Inventory Vineland Adaptive Behavior Scales

(continued)

Table 1.1 ***(Continued)***

Domain of Functioning	Possible Measure (Battery, if Part of a Battery)
	Adaptive Behavior Assessment Scale, Second Edition (ABAS-2) Social Skills Rating Scale Social Responsiveness Scale ADHD Rating Scale for Adults Personality Inventory for Children, Second Edition Various Structured Diagnostic Interviews (e.g., Diagnostic Interview for Children and Adolescents, Fourth Edition; Diagnostic Interview Schedule for Children, Fourth Edition; Children's Interview for Psychiatric Syndromes [ChIPS] Direct Observation)

Note: This table is not intended to be exhaustive but rather to provide a representative sampling of possible measures.

come do not represent any single perspective but rather provide a sampling of what might be seen in a neuropsychological assessment.

Although there is much variation in neuropsychological assessment, it is important to attend to the psychometric properties and limitations of available measures (Reynolds & Mason, 2009). Historically, neuropsychology has been criticized for its failure to incorporate psychometric advances in test use and construction (Cicchetti, 1994; Reynolds, 1986a; M. D. Ris & Noll, 1994). A second concern has been that neuropsychologists overlook the psychometric concepts of reliability and validity, making interpretations based on the "clinical" nature of the tasks. The need for the establishment of reliability and validity of scores as well as their interpretation related to neuropsychological test performance has been an important issue in the literature (Reynolds, 1982; Riccio & Reynolds, 1998). In particular, reliability is a key component not only in that it is related directly to inter- and intraindividual differences, but also as it serves as the foundation on which validity is founded (Reynolds, 1986b). More recently, there has been greater attention to the psychometrics of measures as well as the reliability and validity for use of these measures across cultures (J. G. Harris, Wagner, & Cullum, 2007; Llorente, 2008; P. Smith, Lane, & Llorente, 2008). Application of the theoretical bases for understanding brain-behavior relations (e.g., the Lurian model) across cultures is also being considered with more and more individuals being seen who come from a variety of cultures and linguistic backgrounds (Kotik-Friedgut, 2006).

Because of the need for adequate normative data, some clinicians advocate the interpretation of traditional measures of cognitive ability (e.g., the Wechsler scales) from a neuropsychological perspective (D'Amato, Rothlisberg, & Rhodes, 1997). Concerns and criticisms of the recategorization of subtests from standardized measures that were not developed based on neuropsychological theory and have not been validated for this purpose are evident in the literature (Kamphaus, Petoskey, & Rowe, 2000; Lezak, 1995; Lezak, Howieson, & Loring, 2004). Finally, it has been suggested that measures used in the neuropsychological assessment process need to vary along a continuum of difficulty, include both rote and novel tasks, and include variations with regard to processing and response requirements within modalities (Rourke, 1994, 2005). These varying concerns and issues have resulted in the development of a number of standardized measures.

INTERPRETATION

Results are interpreted based on functional neuroanatomy and brain development in order to approximate the extent and nature of brain damage or dysfunction; at the same time, context needs to be considered (Berkelhammer, 2008). Inference, or the process of reaching a conclusion by reasoning based on evidence/data, also plays a part in the interpretation process (Fennell & Bauer, 1997). Rules specify what kind of evidence can be used for making inferences, the kind of conclusions that can be reached given the type of evidence, and the set of logical connections between evidence and the conclusions or inferences. The inferential process involves initial development of hypotheses as well as the validation of those hypotheses (Fennell & Bauer, 1997); hence, the hypothesis-driven conceptualization of the assessment process (Berkelhammer, 2008). This inferential process needs to consider not only the type of functional system(s) and the number of systems impaired, but also the characteristics of the impairments (Reynolds & Mayfield, 1999; Riccio & Reynolds, 1998). In neuropsychology, additional assumptions dictate that the measures used as a basis for inference provide valid information (i.e., have demonstrated construct validity) and provide meaningful information on aspects of the individual's functioning (have ecological validity). Based on all of the data generated in the evaluation process and inferences, hypotheses are generated regarding how and why the individual processes information; hypotheses are also offered as to what areas of functioning are likely to be affected (Berkelhammer, 2008; D'Amato et al., 1997; R. S. Dean, 1986). Information on strengths and weaknesses then is used to generate an appropriate rehabilitation or habilitation plan.

The first inference made is a general conclusion about integrity of brain function. This conclusion may be based on overall performance level across tasks (Reitan, 1986, 1987). For example, one method is the use of criterion or cut-off scores such that scores above (or below) criterion are considered indicative of brain damage or impaired function. With increased emphasis on psychometric methods, use of normative data and measures that provide valid and reliable results are emphasized in the contemporary literature; this is particularly critical when working with individuals from diverse backgrounds and those who were not part of the sampling process (Llorente, 2008). With the actuarial or normative model, conclusions are reached based on comparison of the child's overall level of performance to normative data. There are multiple problems with this model, including the variability among typically developing children, insensitivity for individuals with higher cognitive abilities, and a tendency to yield a high number of false positives due to the potential impact of fatigue and motivation on test performance (Nussbaum & Bigler, 1997; Reitan & Wolfson, 1985).

Another model examines performance patterns across tasks (Reitan, 1986, 1987) as a means of differentiating functional from dysfunctional neural systems; this model may incorporate examination of intra-individual differences or asymmetry (i.e., lateralization of function; Reitan, 1986, 1987). Examination of intra-individual differences allows for identification of strengths as well as weaknesses; emphasis on a strength model for intervention planning is viewed as more efficacious than focusing only on deficits (Reynolds, Kamphaus, Rosenthal, & Hiemenz, 1997). Again, this examination usually is addressed in terms of anterior-posterior differences or left-right differences rather than consideration of single scores. Another model of interpretation involves looking for, or identifying, "pathognomonic," or clear, signs of brain damage of some kind (Kaplan, 1988; Lezak et al., 2004; Reitan, 1986, 1987; Spreen et al., 1995). While this method has been used reliably with adult populations, its reliability with children has not been demonstrated (Batchelor, 1996). Similarly, the reliability of profile analysis has not been consistently demonstrated (Iverson, Brooks, & Holdnack, 2008; Reynolds, 2007; M. W. Watkins, Glutting, & Youngstrom, 2005); however, some argue for the usefulness of profile analysis (Gioia, Isquith, Kenworthy, & Barton, 2002; Livingston, Pritchard, Moses, & Haak, 1997). In practice, clinicians use any one or some combination of these features (Reitan, 1986, 1987; Riccio & Reynolds, 1998) in the interpretation process, including clinical judgment. The theoretical model should lead to accurate predictions about the individual's ability to function in multiple contexts and inform intervention planning (Reynolds et al., 1997; Riccio & Reynolds, 1998). This is one of the core assumptions of the Cognitive Hypothesis Testing model (Hale & Fiorello, 2004; Hale, Fiorello, Bertin, & Sherman, 2003).

WHY NEUROPSYCHOLOGICAL ASSESSMENT?

Anyone who works with children with disabilities will likely, at some point, work with a child who is identified as having a "neurological impairment," "traumatic brain injury," "other health impairment," or is identified with a neurodevelopmental or genetic disorder. Understanding how neurology relates to higher cognitive function is important in appreciating the neurocognitive and behavioral impairments of individuals with brain-based disorders (Berkelhammer, 2008). One of the major purposes of both neurological and neuropsychological evaluation is to document the impact of brain abnormality, damage, or dysfunction. The wider range of behavioral domains sampled facilitates differential diagnosis among disorders with similar symptom presentations (Reynolds & Mayfield, 1999; Riccio & Reynolds, 1998), and neuropsychological perspectives provide a foundation for better integration of behavioral data that ultimately leads to a more unified or holistic picture of a child's functioning (Riccio & Reynolds, 1998). Neuropsychological assessment may be appropriate to establish initial functioning as well as to track progress; it may serve to clarify intervention needs and result in referrals to other specialists (Berkelhammer, 2008).

A key concept is the link between the neuropsychological assessment and intervention. Enhanced understanding of the neurological correlates of various skills, in conjunction with knowledge of instructional methods, can assist in the formulation of hypotheses regarding potential instructional methods/materials for a particular child (Reynolds & Mayfield, 1999). To inform intervention efforts, results are integrated with information regarding the type and number of functional system(s) that are impaired as well as the nature and characteristics of the functional systems that remain intact. Identifying deficits in working memory, for example, may necessitate specific compensatory skills or accommodations in school settings; further, these accommodations or compensations will continue to be needed as the child develops and contextual demands increase. Thus, inferences are made not only regarding specific behaviors that are assessed but also, through the use of information about how various skills correlate in the developmental process, about skills that have not been evaluated. Ultimately, data generated from the neuropsychological assessment process are used to develop recommendations regarding whether the individual would profit from compensatory strategies, remedial instruction, or a combination (Gaddes & D. Edgell, 1994; Riccio & Reynolds, 1998).

With a medical model and emphasis on pathology, historically, there has been a tendency to focus on identifying deficits. More recently, however, it is seen as imperative to the development of effective treatment programs that the child's strengths and intact systems also be identified. Identifying both strengths and weaknesses provides a more in-depth understanding of the types of accommodations or modifications that may be appropriate. Identification of intact functional systems enables rehabilitation and remediation programs that are based on individual strengths to be implemented (Reynolds, 1986b; Silver et al., 2006). The intact systems that have been identified can be used to develop compensatory behaviors as part of the rehabilitation program; for example, an individual who has difficulty with manipulating information mentally, but who has good visual memory, may be able to use visual imagery to support memory function. Finally, identification of intact systems suggests a more positive outcome and increases the likelihood of motivated support systems (home and school) for the child (Riccio & Reynolds, 1998).

LINKING ASSESSMENT TO INTERVENTION

Neuropsychological assessment is generally considered appropriate whenever a child is suspected of having a neurological disorder or when it is believed that the integrity of the central nervous system has been compromised. In general, indications are that parents are satisfied with the diagnostic or assessment component but may not be as satisfied with information on next steps or treatment approaches to address the difficulties identified (Bodin, Beetar, Yeates, Boyer, & Colvin, 2007). As previously stated, the intent should not be for diagnostic purposes alone but for identification of individual strengths and weaknesses with the intent to inform rehabilitation efforts. The ultimate goal of the assessment should be to develop an intervention or rehabilitation plan. One component of developing the intervention plan is the determination of target areas.

The second component to intervention or rehabilitation planning is the selection of evidence-based practices to address those target areas. Generally speaking, evidence-based decision making takes into account research evidence, clinical expertise, and client preference (Chambliss & Ollendick, 2001; Simpson, 2005b; Spirito, 1999). More and more, from both a forensic and an ethical perspective, it is important to critically examine the research evidence as it relates to a given treatment component or program. Levels of evidence range from randomized clinical trials (Level I) to case studies and anecdotal evidence (Level IV) with multiple subcategories. Different terms and labels for the current state of evidence are used in the research; in some cases, no comprehensive review of an intervention may exist as yet, and evidence is limited to the available published literature. The various definitions and levels of evidence can be subdivided in multiple ways. (See Table 1.2 for the descriptors that will be used in this volume.)

Interventions must be considered separately for each target area. For example, one intervention for autism may be effective for interpersonal skills but not in reducing stereotypy. Similarly, what is effective as an intervention may vary depending on the strengths and weaknesses of the individual child. For each chapter, to the extent feasible, the research base relating to interventions by domain and disorder is summarized. Unfortunately, there exists minimal evidence bases or empirical support specific to neurodevelopmental and genetic disorders (Gingras, Santosh, & Baird, 2006). Providing an evidence base for programs across disorders is an area clearly in need of additional

Table 1.2 Descriptors for Evidence-Based Practice

Term Used	Alternate Terms	How Determined/Criteria Applied
Positive practice	Scientifically based, empirically supported, well-established	Significant empirical efficacy and support as in randomized clinical trials; treatment manuals; comparison to placebo or alternative treatment
Promising practice	Probably efficacious, possibly efficacious, established	Evidence for efficacy and utility as compared to placebo or alternative but further replication and objective verification needed
Emerging		Insufficient studies or replication; small samples
Inconclusive		Results are equivocal or methodological flaws prevent conclusions from being drawn
Ineffective	Not recommended	No available evidence to support use; some evidence that intervention did not have any effect
Adverse effects	Not recommended	Evidence suggests that intervention has potential to be harmful

research; the intent here is to synthesize the available research based on existing reviews or studies identified in the existing research base.

CONCLUDING COMMENTS

A major premise of neuropsychological assessment and the resulting case conceptualization is that not only is information gained related to the individual's functioning at a given point in time but that, based on the knowledge base (i.e., the neuroscience), programs can be developed and implemented to address the anticipated problems associated with a given disorder (Nilsson & Bradford, 1999; Riccio & Reynolds, 1998). With variability in test selection, administration, approach to interpretation, and approaches to intervention or treatment planning, ethical issues are likely to arise and need to be considered (T. M. Wong, 2006). At the same time that there are concerns with the measurement aspect of neuropsychological assessment (Reynolds & Mason, 2009), there are concerns that there is a lack of agreement on what constitutes the standards of practice (T. M. Wong, 2006). These concerns go beyond the issues of release of raw data (Rapp, Ferber, & Bush, 2008) and confidentiality (Bush & Martin, 2008) to determination of what should or should not be included in a neuropsychological setting. Questions have been raised, for example, with regard to how to consider culture or ethnicity/race (Brickman, Cabo, & Manly, 2006), but no standard means for accomplishing this has been determined. Specific methods for training may be helpful in establishing standards of practice as well as for determining level of competence in neuropsychology (Boake, 2008; Hannay et al., 1998; Moberg & Kniele, 2006).

A second issue of importance is the extent to which the components of neuropsychological assessment reflect brain function. Several studies have investigated the research behind the use of specific measures (Riccio & Hynd, 2000; Riccio, Reynolds, Lowe, & Moore, 2002). At the same time, there are concerns that even if the measures reflect integrity of brain function (or atypicality in brain function), the information obtained may not reflect the individual's day-to-day functioning, or what has been referred to as *ecological validity* (Rabin, Burton, & Barr, 2007; Ready, Stierman, & Paulsen, 2001; Sbordone, 2008). These issues will continue to be discussed and new measures will be developed as standards for measurement, the need for real-world outcomes, and standards for practice collide with the evidence-based practice movement in the 21st century. In part, the next chapters provide a review of the scientific literature as a foundation along with the review of research on the clinical implications and evidence-based practices to foster the bridging of science and practice. The case studies in the chapters highlight some of the differences that exist in the field, in part driven by philosophical or theoretical perspectives and in part dictated by the developmental and real-world nature of the individuals with neurodevelopmental and genetic disorders.