CHAPTER
14

Neuropsychological Assessment of Children

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INTRODUCTION AND HISTORICAL OVERVIEW

In recent years, there has been a growing interest in the neuropsychological assessment of children (Taylor & Fletcher, 1990). Many clinical neuropsychologists focus exclusively on children and adolescents (Putnam & DeLuca, 1990; Slay & Valdivia, 1988; Sweet & Moberg, 1990), and there is an extensive literature devoted specifically to the field of child neuropsychology (e.g., Baron, Fennell, & Voeller, 1995; Pennington, 1991; Reynolds & Fletcher-Janzen, 1997; Rourke, Bakker, Fisk, & Strang, 1983; Rourke, Fisk, & Strang, 1986; Spreen, Risser, & Edgell, 1995; Yeates, Ris, & Taylor, 2000).

The history of child neuropsychology can be divided into three eras. The first, which has been called the medical era, lasted until about 1940 (Kessler, 1980). This era involved observations of children with various medical conditions by physicians who theorized about possible relationships between the status of the central nervous system and behavior. This era was hampered by the anecdotal nature of clinical reports.

The second era of child neuropsychology began around the time of World War II, when A. A. Strauss, Heinz Werner, and their colleagues began using experimental techniques to study the behavior of children with purported brain injuries. They also coined the term "minimal brain injury" to describe a

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cluster of behaviors that they believed were generally characteristic of brain-injured children (Strauss & Lehtinen, 1947; Strauss & Werner, 1941). This era was hampered by the limited knowledge base and methods available for assessing brain function in children. Clinicians often assumed that the presence of cognitive or behavioral deficits characteristic of children with documented brain injury were indicative of brain abnormalities, even in children without any known injury (Fletcher & Taylor, 1984).

The advent of modern neuroimaging technology and other advances in cognitive neuroscience signaled the beginning of the third and current era of child neuropsychology. This era involves a more sophisticated approach to the study of brain-behavior relationships, not only in children with neurological disease, but also in those with other systemic medical illnesses, developmental disorders such as learning disabilities and attention deficit disorder (ADD), and psychiatric disorders (Dennis & Barnes, 1994; Fletcher, 1994).

The current era of child neuropsychology is characterized by broader conceptual models of neuropsychological assessment (Bernstein & Waber, 1990; Taylor & Fletcher, 1990; Yeates & Taylor, 1998). These models capitalize on the existing knowledge base in developmental psychology (Fischer & Rose, 1994; Welsh & Pennington, 1988) and on recent advances in developmental cognitive neuroscience (Diamond, 1991; Elman et al., 1996; Johnson, 1997; Tager-Flusberg, 1999; Temple, 1997). According to these conceptual models, the goal of neuropsychological assessment is not simply to document the presence of cognitive deficits and their possible association with known or suspected brain impairment. The goal, rather, is to describe cognitive and behavioral functioning and relate it both to biological, brain-based constraints and to environmental forces in a way that enhances children's adaptation.

This chapter provides a general introduction to the neuropsychological assessment of school-age children and adolescents. We begin by describing four general principles that help to conceptualize neuropsychological assessment. We then describe neuropsychological assessment procedures, discuss some common patterns of results and associated interpretive hypotheses, and present an illustrative case study. We next discuss the benefits and limitations of neuropsychological assessment, and examine its reliability and validity. Finally, we conclude with comments regarding the future prospects for neuropsychological assessment.

PRINCIPLES OF NEUROPSYCHOLOGICAL ASSESSMENT

We believe that the neuropsychological assessment of children and adolescents is not defined by specific test instruments, which are simply tools that should evolve substantially over time. Instead, child neuropsychological as-

sessment is based on a broad conceptual foundation and knowledge base regarding brain-behavior relationships that can be applied to enhance children's adaptation. Recent models of child neuropsychological assessment (Bernstein, 2000; Bernstein & Waber, 1990; Taylor & Fletcher, 1990; Yeates & Taylor, 1998) share several general principles that reflect this belief.

Adaptation

The first principle is that the major goal of neuropsychological assessment is to promote children's adaptation, rather than to document the presence or location of brain damage or dysfunction. Adaptation results from interactions between children and the contexts in which they develop. In other words, adaptation reflects the functional relationship between children and their environments. Failures in adaptation, such as poor school performance or unsatisfactory peer relationships, are usually why children are brought to the attention of clinical neuropsychologists. To be useful, neuropsychological assessment must explain failures in adaptation and facilitate future outcomes, not only in the immediate contexts of school and home but also in terms of long-term adaptation to the demands of adult life.

Brain and Behavior

The second principle is that an analysis of brain-behavior relationships is a complex undertaking that can provide insights into children's adaptation. Simplistic notions of localization have been superseded by more dynamic models involving the interaction of multiple brain regions (Cummings, 1993; Derryberry & Tucker, 1992; Mesulam, 1998). Neuropsychology has begun to move beyond the uncritical application of adult models of brain function to children (Fletcher & Taylor, 1984). The assessment of brain-behavior relationships in children must take into account many factors, such as the child's age and particular medical or developmental disorder, the specific cognitive skills and behaviors assessed, and the nature of the documented or hypothesized brain impairment (Dennis, 1988).

Context

The third principle is that environmental contexts help to constrain and determine behavior. Neuropsychologists cannot determine whether brain impairment contributes to failures of adaptation without examining the environmental variables that also influence behavior. An assessment of the situational demands placed on the child is necessary to rule out alternative explanations for adaptive failures. More broadly, neuropsychological

assessment not only must measure specific cognitive skills, but also must determine how children apply these skills in their specific environments. By examining how children's cognitive and behavioral profiles match the contextual demands of their environments, neuropsychologists can characterize the developmental risks facing children, and thereby make more informed recommendations for intervention (Bernstein, 2000; Bernstein & Waber, 1990).

Development

The final guiding principle is that assessment involves the measurement of development across multiple levels of analysis. Brain development is characterized by multiple processes (e.g., cell differentiation and migration, synaptogenesis, dendritic arborization and pruning, myelinization), each with its own timetable (Nowakowski, 1987). Although less is known about developmental changes in children's environments, there is nevertheless a natural history of environments characteristic of most children in our culture (Holmes, 1987). Cognitive and behavioral development results from the joint interplay of these biological and environmental timetables (Greenough & Black, 1992), and involves the emergence, stabilization, and maintenance of new skills such as language abilities, as well as the loss of earlier ones such as primitive reflexes (Dennis, 1988).

Summary

The neuropsychological assessment of children requires a model that acknowledges the role played by developmental changes in brain, behavior, and context as determinants of children's adaptation. Failures in adaptation frequently result from asynchronies between different developmental timetables (e.g., biological and environmental) that result in mismatches between children's competencies and the situational demands with which they must cope. The expression of brain impairment can vary substantially as a function of factors such as the developmental timing of a brain lesion, the age at which a child is assessed, and the environmental demands and resources impinging on a child (Taylor et al., 1995).

METHODS OF NEUROPSYCHOLOGICAL ASSESSMENT

The four general principles outlined above—adaptation, brain and behavior, context, and development—provide a foundation for the specific methods of assessment used by child neuropsychologists. Although neuropsychological assessment is usually equated with the administration of a battery of tests designed to assess various cognitive skills, in actual practice most neuropsychologists draw on multiple sources of information and do not rely solely

on the results of psychological tests. The most typical combination of methods involves the collection of historical information, behavioral observations, and psychological testing, which together permit a broader and more detailed characterization of neuropsychological functioning.

History

The careful collection of historical information using structured questionnaires and parent interviews is an essential part of neuropsychological assessment. A thorough history clarifies the nature of a child's presenting problems, and also can help to determine if a child's presenting problems have a neuropsychological basis or if they are related primarily to psychosocial or environmental factors. A detailed history begins with simple demographic information, such as a child's age, sex, and race, but extends to a variety of other topics, including birth and early development, past or current medical involvement, family and social circumstances, and school history.

Birth and Developmental History

Neuropsychologists typically inquire about a mother's pregnancy, labor, and delivery, as well as about the child's acquisition of developmental milestones. Information about such topics is useful in identifying early risk factors as well as early indicators of anomalous development. The presence of early risk factors or developmental anomalies makes a stronger case for a constitutional, or neuropsychological, basis for a child's failures in adaptation. For example, perinatal complications such as prematurity and low birthweight are often associated with later neuropsychological deficits (Taylor, Klein, & Hack, 2000).

Medical History

A child's medical history often contains predictors of neuropsychological functioning, the most obvious of which are documented brain abnormalities or insults. For instance, closed-head injuries during childhood can compromise cognitive and behavioral function (Yeates, 2000). Other aspects of a child's medical history can be linked in a more indirect fashion to neuropsychological deficits. For example, chronic ear infections are occasionally linked with cognitive delays, due perhaps to the effects of the infections on hearing during language acquisition (Kavanagh, 1986). Another critical piece of medical information is whether the child is taking any medications. Anticonvulsants (Trimble, 1987), stimulants (Brown & Borden, 1989), and other psychotropic medications (Cepeda, 1989) are especially likely to affect children's performance on tests of cognitive skills.

Family and Social History

Neuropsychologists typically collect information regarding the family's history of learning and attention problems, language disorder, psychiatric disturbances, and neurological illnesses. A positive family history can signal a biological foundation for later neuropsychological deficits (Lewis, 1992). A review of family history should also attend to socioeconomic factors. Parental education and occupation are related to the developmental stimulation and learning opportunities provided for children, as well as to later childhood intellectual functioning (Yeates, MacPhee, Campbell, & Ramey, 1983).

Information regarding peer relationships and a child's capacity for sustained friendships is also extremely important in neuropsychological assessment. Poor social skills are sometimes associated with nonverbal learning problems, and may be linked with a particular neuropsychological profile (Rourke, 1989). In other instances, difficulties with peer relationships may be a sign of the psychological distress that is secondary to other difficulties, such as academic failure (Taylor, 1988).

School History

A complete school history includes information regarding current grade and school placement, any history of grade repetition or special education services, and the results of any prior testing. Information about school history is usually available from parents, but also should be sought from school personnel. School reports often corroborate parental information, but sometimes provide new or even contradictory information.

If a child has been referred for special education services in the past, the timing of those services often serves as a clue to the nature of a child's academic difficulties (Holmes, 1987). The results of prior testing can be compared to the child's current test performance to assess change or stability in neuropsychological functioning across time. Descriptions of educational interventions are also valuable, as they can help to gauge the academic demands placed on a child as well as the nature of available support. Information about previous services is also needed to make practical recommendations, if only to avoid repeating interventions that have already failed.

Behavioral Observations

Behavioral observations are the second critical source of information for child neuropsychologists. Behavioral observations are critical for interpreting the results of neuropsychological testing (Kaplan, 1988) and for judging the adequacy of certain skills that are less amenable to being measured by standardized testing. A child's behavior is often noteworthy when it requires

the examiner to alter his or her usual responses (Holmes, 1988). For instance, changes in the clinician's style of speaking may be one signal that the child has a language disorder.

Rigorous observation extends across several domains of functioning. A typical list of domains includes mood and affect; motivation and cooperation; social interaction; attention and activity level; response style; speech, language, and communication; sensory and motor skills; and physical appearance.

Mood and affect often color the entire assessment process. If a child is depressed and withdrawn, or angry and oppositional, then he or she is likely to be difficult to engage in testing. A lack of cooperation does not necessarily invalidate psychological testing, but it may influence the interpretation of test results. In some cases, a lack of motivation may reflect brain impairment. A child who is compliant but unenthusiastic, who follows directions but does not initiate many actions spontaneously, may be demonstrating signs of frontal lobe pathology (Stuss & Benton, 1984). Alternatively, a lack of enthusiasm about testing, or even outright resistance, often characterizes children with learning disabilities.

Observations of social interactions with parents and the examiner are useful as well. For instance, a child who interacts appropriately with parents but is socially awkward or even inappropriate with the examiner may have a subtle nonverbal learning disability that only becomes evident in unfamiliar settings (Rourke, 1989).

A child's capacity to regulate attention and activity level also warrants appraisal. Observations of inattention and motor disinhibition during an evaluation provide important information regarding the capacity to regulate behavior under the stress of performance demands. Another strategy for assessing self-regulation is to observe a child's responsiveness to various contingencies designed to increase on-task behavior.

A child's response style or approach to tasks is likewise important. Qualitatively different errors on the same task have been associated with different types of cognitive deficits or brain pathology (Kaplan, 1988). For instance, a child who orients individual blocks incorrectly on a block design task may have a different underlying impairment than a child who does not maintain a square arrangement of the blocks. More generally, a child's responses to different test demands offer valuable clues regarding the nature of the child's cognitive deficits. Observations of a child's response style also can reveal strategies that the child uses to compensate for specific neuropsychological deficits.

Speech, language, and communication skills are also deserving of close observation. Language disorders often are associated with failures in the acquisition of basic academic skills. Neuropsychologists usually monitor the ease with which children engage in spontaneous conversation, their level

of comprehension, the quality of their language expression in terms of both grammatical/syntactic form and lexical/semantic content, and the occurrence of more pathognomonic errors such as naming problems and paraphasias. Even when speech is fluent and language expression is appropriate, children may display deficits in pragmatic language, such as poor discourse skills, an inability to maintain a topic of conversation and engage in reciprocal turn-taking, and a lack of appreciation for paralinguistic features such as intonation, gesture, and facial expression (Dennis & Barnes, 1993).

Gross disturbances in sensory and motor functioning may interfere with the standardized administration of psychological tests. These disturbances also are important because of the purported association between neurological "soft signs" and cognitive functioning (Shaffer, O'Connor, Shafer, & Prupis, 1983; Taylor, 1987). Asymmetries in sensory and motor function can sometimes assist with the localization of brain dysfunction, and also may provide support for the notion that a child's adaptive difficulties have a neurological basis.

The final category of observation is physical appearance. Physical dysmorphology is frequently associated with specific neuropathological syndromes. The more mundane aspects of a child's appearance, such as their size, dress, and hygiene, can likewise be important. For example, being taller than one's peers is typically an advantage, especially for boys, and may buffer children from the potential negative psychosocial consequences of neuropsychological deficits, whereas being smaller than one's peers may increase the risk of adverse social interactions.

Psychological Testing

Psychological testing is the third source of information on which child neuropsychologists rely, and the source most often equated with neuropsychological assessment. Formal testing permits normative comparisons, and also provides a standardized context for making qualitative observations of response styles and problem-solving strategies.

Some child neuropsychologists administer standardized test batteries, such as the Halstead-Reitan Neuropsychological Test Battery (Reitan & Wolfson, 1992a) or NEPSY (Korkman, Kirk, & Kemp, 1998). Other neuropsychologists administer fixed batteries using tests drawn from various sources. In still other cases, neuropsychologists adopt a flexible approach to assessment, and select tests for each individual patient based on specific referral questions. Each approach has its own strengths and weaknesses (Fletcher, Taylor, Levin, & Satz, 1995). Table 14.1 lists some of the tests commonly used by child neuropsychologists.

Regardless of whether a neuropsychologist administers a fixed battery or adopts a more flexible approach to test selection, most test batteries are selected to assess several core neurobehavioral domains: general cognitive

TABLE 14.1
Selected List of Tests Commonly Used in Child Neuropsychological Assessment

Test domain/Test name	Age range (years)
General neuropsychological test batteries	
Halstead-Reitan Neuropsychological Test Battery for Older Children (Reitan & Wolfson, 1992a)	9 to 15
NEPSY—A Developmental Neuropsychological Assessment (Korkman, Kirk, & Kemp, 1998)	3 to 12
Reitan-Indiana Neuropsychological Test Battery (Reitan & Wolfson, 1992b)	5 to 8
General cognitive ability	
Cognitive Assessment System (Naglieri & Das, 1997)	5 to 17
Differential Abilities Scale (Elliott, 1990)	2.6 to 17
Stanford-Binet Intelligence Scale—Fourth Edition (Thorndike, Hagen, & Sattler, 1986)	2 to adult
Wechsler Abbreviated Scale of Intelligence (Psychological Corporation, 1999)	6 to adult
Wechsler Adult Intelligence Scale—Third Edition (Wechsler, 1997a)	16 to adult
Wechsler Intelligence Scale for Children—Third Edition (Wechsler, 1991)	6 to 16
Wechsler Preschool and Primary Scales of Intelligence—Revised (Wechsler, 1989)	3 to 7
Memory abilities	
Children's Memory Scale (Cohen, 1997)	5 to 16
California Verbal Learning Test (Delis, Kramer, Kaplan, & Ober, 1994)	5 to 16
Test of Memory and Learning (Reynolds & Bigler, 1994)	5 to 19
Wechsler Memory Scale—Third Edition (Wechsler, 1997b)	16 to adult
Wide Range Assessment of Memory and Learning (Sheslow & Adams, 1990)	4 to adult
Language skills	
Boston Naming Test (Kaplan, Goodglass, & Weintraub, 1983)	5 to 13
Clinical Evaluation of Language Fundamentals—Third Edition (Semel, Wiig, & Secord, 1995)	6 to 21
Neurosensory Center Comprehensive Examination for Aphasia (Spreen & Benton, 1969)	6 to 13
Peabody Picture Vocabulary Test—Fourth Edition (Dunn & Dunn, 1997)	2.6 to adult
Test of Language Competence (Wiig & Secord, 1989)	5 to 18
Visual-perceptual and visual-motor skills	
Benton Visual Retention Test—Fifth Edition (Benton, 1992)	8 to adult
Developmental Test of Visual-Motor Integration—Fourth Edition (Beery, 1996)	2 to 18
Hooper Visual Organization Test (Western Psychological Services, 1983)	5 to 13
Judgment of Line Orientation Test (Benton, Sivan, Hamsher, Varney, & Spreen, 1994)	7 to 14
Rey-Osterrieth Complex Figure (Bernstein & Waber, 1996)	5 to 18
Attention and executive functions	
Gordon Diagnostic System (Gordon, 1996)	4 to 16
Children's Category Test (Boll, 1992)	5 to 16
Contingency Naming Test (Taylor, Albo, Phebus, Sachs, & Bierl, 1987)	6 to 17
Test of Variables of Attention (Greenberg & Dupuy, 1993)	4 to adult
Tower of London (Anderson, Anderson, & Lajoie, 1996; Krikorian, Bartok, & Gay, 1994)	7 to 13

(*continues*)

Table 14.1—*Continued*

Test domain/Test name	Age range (years)
Trail Making Test (Reitan & Wolfson, 1992a)	9 to adult
Wisconsin Card Sorting Test (Heaton, Chelune, Talley, Kay, & Curtiss, 1993)	6.6 to adult
Motor skills	
Bruininks-Oseretsky Test of Motor Proficiency (Bruininks, 1978)	4.6 to 14.5
Finger Tapping Test (Reitan & Wolfson, 1992a, 1992b)	5 to adult
Grooved Pegboard (Matthews & Kl¸ve, 1964)	5 to adult
Purdue Pegboard (Gardner & Broman, 1979)	5 to 15
Academic skills	
Comprehensive Test of Phonological Processing (Wagner, Torgeson, & Rashotte, 1999)	5 to adult
Kaufman Test of Educational Achievement (Kaufman & Kaufman, 1997)	6 to adult
Peabody Individual Achievement Test—Revised (Markwardt, 1992)	5 to adult
Test of Word Reading Efficiency (Torgeson, Wagner, & Rashotte, 1999)	6 to adult
Test of Written Language—Third Edition (Hammill & Larsen, 1996)	7.5 to 17
Wechsler Individual Achievement Test (Psychological Corporation, 1992)	5 to 19
Wide Range Achievement Test—Third Edition (Wilkinson, 1993)	5 to adult
Woodcock-Johnson Tests of Achievement—Revised (Woodcock & Mather, 1989)	5 to adult
Adaptive behavior	
Scales of Independent Behavior—Revised (Bruininks, Woodcock, Weatherman, & Hill, 1996)	0 to adult
Vineland Adaptive Behavior Scales (Sparrow, Balla, & Ciccetti, 1984)	0 to 18
Behavioral adjustment	
Behavior Assessment System for Children (Reynolds & Kamphaus, 1992)	2.6 to 18
Child Behavior Checklist (Achenbach, 1991)	2 to 18
Conners' Rating Scales—Revised (Conners, 1997)	3 to 17
Personality Inventory for Children—Revised (Wirt, Seat, Broen, & Lachar, 1990)	3 to 16

ability; language abilities; visuoperceptual and constructional abilities; learning and memory; attention and executive functions; corticosensory and motor capacities; academic skills; and emotional status, behavioral adjustment, and adaptive behavior. In the following sections, we describe examples of tests and briefly examine the rationale and limitations of measurement in each domain.

General Cognitive Ability

General cognitive ability is usually assessed using standardized intelligence tests, such as the Wechsler Intelligence Scale for Children—Third Edition (WISC-III; Wechsler, 1991; see also Chapter 1), the Stanford-Binet Intelligence Scale—Fourth Edition (Thorndike, Hagen, & Sattler, 1986), or the Differential Abilities Scale (Elliott, 1990; see also Chapter 3). Intelligence tests are well-

standardized measures that assess a broad range of cognitive skills. These tests typically have excellent psychometric properties in terms of both reliability and validity (Sattler, 1992). They provide an estimate of a child's overall functioning, which can be useful in justifying placement recommendations in clinical practice.

On the other hand, intelligence tests are not, as often supposed, measures of learning potential. Moreover, the tests were designed primarily to predict academic achievement, and in many cases their subtests were not developed to assess distinct or unitary mental abilities. Intelligence tests also fail to measure many important skills, as reflected in the robust relationship between academic achievement and neuropsychological test performance, even after IQ is controlled statistically (Taylor, Fletcher, & Satz, 1982). Thus, intelligence tests are helpful in neuropsychological assessment, but they do not capture all relevant cognitive abilities.

Some attempts have been made to develop or modify standardized intelligence tests to be more informative neuropsychologically. For instance, the Cognitive Assessment System (Naglieri & Das, 1997; see also Chapter 2) is predicated on a Lurian model of neuropsychological functioning. Similarly, the modifications that are incorporated in the WISC-III as a Process Instrument (WISC-III PI; Kaplan, Fein, Kramer, Delis, & Morris, 1999) permit a more detailed analysis of the cognitive components of a child's test performance, and are based on the so-called process approach to neuropsychological assessment (Kaplan, 1988). Neither of these tests, however, examines the full breadth of neurocognitive skills of interest to most neuropsychologists.

Language Abilities

The study of aphasia was one of the driving forces in the growth of neuropsychology. Thus, when testing language abilities, child neuropsychologists often draw on aphasia batteries such as the Neurosensory Center Comprehensive Examination of Aphasia (Gaddes & Crockett, 1975; Spreen & Benton, 1969) or associated tests such as the Boston Naming Test (Kaplan, Goodglass, & Weintraub, 1983; Yeates, 1994). Neuropsychologists also make use of other tests used by speech pathologists, such as the Clinical Evaluation of Language Fundamentals—Third Edition (Semel, Wiig, & Secord, 1995). The goal typically is to assess functions such as comprehension, repetition, naming, and other receptive and expressive skills.

Language skills are a critical determinant of academic success and social competence, and children with learning disorders and brain injuries frequently display language deficits (Ewing-Cobbs, Levin, Eisenberg, & Fletcher, 1987). Performance on language measures, however, often reflects skills other than those that the tests purport to assess. For example, attention problems rather than comprehension deficits may interfere with a child's ability to follow oral directions, and cultural differences rather than retrieval problems

may hamper performance on a picture naming test. As is often true in neuropsychological assessment, the interpretation of language test performance must take into account competencies in other domains.

Most formal language tests do not tap the communication skills that are of particular relevance to a child's adaptive functioning. Specifically, there is a paucity of measures designed to assess pragmatic language skills such as discourse, the ability to maintain a topic of conversation and engage in reciprocal turn-taking, and the understanding of paralinguistic features such as intonation, gesture, and facial expression (Dennis & Barnes, 1993). As already noted, pragmatic language is typically assessed through observation of informal conversations with children or through qualitative analysis of language samples provided on other tasks, such as the Vocabulary subtest of the WISC-III or story recall measures on tests of verbal memory.

Visuoperceptual and Constructional Abilities

Tests of nonverbal skills typically are of two sorts. One sort draws on visuoperceptual abilities without requiring any motor output, and the other demands constructional skills and involves motor control and planning. Common tests of visuoperceptual skills include the Hooper Visual Organization Test (Kirk, 1992; Western Psychological Services, 1983) and the Judgment of Line Orientation Test (Benton, Sivan, Hamsher, Varney, & Spreen, 1994). Tests of constructional skills include the Developmental Test of Visual-Motor Integration (Beery, 1996), the Rey-Osterrieth Complex Figure (Bernstein & Waber, 1996), and the Block Design and Object Assembly subtests of the WISC-III.

Nonverbal deficits predict poor performance in certain academic domains, particularly arithmetic, and also are associated with a heightened risk for psychosocial maladjustment, including poor peer relationships (Rourke, 1989). In addition, nonverbal deficits are common in children with brain injuries and other acquired neurological insults, suggesting that nonverbal skills are especially vulnerable to being affected by brain damage in children (Taylor, Barry, & Schatschneider, 1993). Tests of nonverbal abilities also draw on other skills, however, such as attention and organization, and many of the tests demand substantial motor dexterity. Thus, test interpretation must take into account a child's overall neuropsychological test profile.

Learning and Memory

Despite the obvious importance of learning and memory for children's adaptation, and especially their school performance, there were until recently few instruments available for assessing these skills. Fortunately, a variety of measures now are available, including the California Verbal Learning Test—Children's Version (Delis, Kramer, Kaplan, & Ober, 1994), the Children's Memory Scale (Cohen, 1997), the Test of Memory and Learning (Reynolds & Bigler,

1994), and the Wide Range Assessment of Memory and Learning (Sheslow & Adams, 1990).

Children with brain impairment typically do not demonstrate the dense amnesia characteristic of adults with neurological disorders such as Alzheimer's disease, but they do show distinct deficits on tests of learning and memory (Yeates, Blumenstein, Patterson, & Delis, 1995; Yeates, Enrile, Loss, Blumenstein, & Delis, 1995). Tests of children's learning and memory only recently have begun to reflect advances in the neuroscience of memory (Squire, 1987; Butters & Delis, 1995), however, and substantially more research is needed to examine their predictive validity (Loring & Papanicolau, 1987). Clinically, performance on tests of memory and learning is multiply determined. For example, story recall is affected by children's language competencies and attention skills. Once again, test interpretation cannot proceed without a broader understanding of a child's abilities.

Attention

Attention is a multidimensional construct that overlaps with the domain of executive functions discussed below (Mesulam, 1981; Mirsky, Anthony, Duncan, Ahearn, & Kellam, 1991; Taylor, Schatschneider, Petrill, Barry, & Owens, 1996). Neuropsychologists typically assess various aspects of attention, such as vigilance, selective and divided attention, the ability to shift set, and cognitive efficiency (Cooley & Morris, 1990). Relevant tests include the Gordon Diagnostic System, one of several continuous performance tests (Grant, Ilai, Nussbaum, & Bigler, 1990); the Contingency Naming Test (Taylor, Albo, Phebus, Sachs, & Bierl, 1987); the Trail Making Test (Reitan & Wolfson, 1992a); and the Arithmetic, Digit Span, Coding, and Symbol Search subtests from the WISC-III (Wechsler, 1991).

Attention problems are a common reason for referral to child neuropsychologists, and are central to the diagnosis of attention-deficit/hyperactivity disorder (ADHD; Barkley, 1990). However, the relationship between formal tests of attention and the behaviors about which parents and teachers complain is modest at best (Barkley, 1991). The weak relationship reflects the complex nature of attention as a cognitive construct (Cooley & Morris, 1990), as well as the multifactorial nature of behavioral problems such as inattention and hyperactivity. Despite their lack of diagnostic utility, tests of attention remain an important component of neuropsychological assessment. The tests permit assessment of the cognitive construct of attention, which not only moderates performance on many other psychological tests but also is selectively affected by early brain insults (Taylor, Hack, & Klein, 1998).

Executive Functions

Executive functions are involved in the planning, organization, regulation, and monitoring of goal-directed behavior (Denckla, 1994). The assessment of

these skills and related abilities, such as problem solving and abstract reasoning, has often been conducted informally, by examining the quality of performance on tests in other measurement domains. More recently, tests have been developed specifically to assess executive functions. Such tests include the Wisconsin Card Sorting Test (Heaton, Chelune, Talley, Kay, & Curtiss, 1993), the Tower of London (Anderson, Anderson, & Lajoie, 1996; Krikorian, Bartok, & Gay, 1994), and the Children's Category Test (Boll, 1992).

Executive functions are a critical determinant of a child's adaptive functioning. Deficits in executive functions are ubiquitous in children with documented brain dysfunction, as well as in those with developmental learning disorders. Despite recent research devoted to clarifying the relevant constructs and their assessment, however, the nature of executive function in children remains uncertain (Levin et al., 1991; Taylor et al., 1996; Welsh, Pennington, & Groisser, 1991). Of particular concern in the context of clinical assessment is the paucity of studies examining the ecological validity of purported measures of executive function.

Corticosensory and Motor Capacities

Tests of corticosensory and motor capacities usually involve standardized versions of components of the traditional neurological examination. Relevant corticosensory skills include finger localization, stereognosis, graphesthesia, sensory extinction, and left-right orientation. A variety of standardized assessment procedures are available to assess corticosensory skills (Benton et al., 1994; Reitan & Wolfson, 1992a, 1992b). In the motor domain, tests such as the Grooved Pegboard (Matthews & Kløve, 1964), Purdue Pegboard (Rapin, Tourk, & Costa, 1966), and Finger Tapping Test (Reitan & Wolfson, 1992a, 1992b) typically are used to assess motor speed and dexterity, although batteries such as the Bruininks-Oseretsky Test of Motor Proficiency (Bruininks, 1978) are also available. In addition, tests of oculomotor control, motor overflow, alternating and repetitive movements, and other related skills are often used to assess "soft" neurological signs (Denckla, 1985).

Tests of corticosensory and motor capacities are sensitive to neurological disorders and can provide useful confirmatory evidence of localized brain dysfunction. These tests also may help to predict learning problems in younger children and to differentiate older children with different types of learning disorders (Casey & Rourke, 1992). However, many children perform well on sensory and motor tasks despite clear evidence of learning disorders or neurological impairment. Moreover, the assessment of sensory and motor abilities often is hampered by inattention or poor cooperation, especially among young children.

Academic Skills

Academic underachievement is one of the most common reasons that children are referred for neuropsychological assessment. Several test batteries

are available for assessing academic achievement, including the Wide Range Achievement Test—Third Edition (Wilkinson, 1993), the Woodcock-Johnson Tests of Achievement—Revised (Woodcock & Mather, 1989; see also Chapter 5), the Wechsler Individual Achievement Test (The Psychological Corporation, 1992; see also Chapter 6), Kaufman Test of Educational Achievement (Kaufman & Kaufman, 1997), and the Peabody Individual Achievement Test—Revised (Markwardt, 1992).

The assessment of academic skills provides information on the nature and severity of underachievement. Selective problems in achievement, such as deficits in reading but not math, can provide evidence of specific learning disabilities. Thus, achievement test results often are used to determine whether a child is eligible for special education services, and may also carry more specific treatment implications. However, patterns of performance on standardized achievement tests afford limited insight into the cognitive processes underlying underachievement.

Recently, the assessment of academic skills has begun to incorporate the measurement of the specific cognitive processes that underlie those skills. For example, the assessment of reading now often includes measures of phonological awareness and rapid naming (Torgeson, Wagner, & Rashotte, 1999; Wagner, Torgeson, & Rashotte, 1999; see also Chapter 7). Similarly, the assessment of math may include measures of math fact retrieval and an analysis of arithmetic procedural errors (Sokol, Macaruso, & Gollan, 1994; Temple, 1991; see also Chapter 8). In the future, this broader approach also may be incorporated in the assessment of other pertinent academic abilities, such as study habits and the use of strategies for remembering and problem solving.

Emotional Status, Behavioral Adjustment, and Adaptive Behavior

Adaptive failures frequently occur in domains other than academic performance. These failures may be manifest in psychological distress, inappropriate or otherwise undesirable behavior, or deficits in everyday functioning, including poor daily living skills or social skills. A wide variety of formal checklists are available to assess emotional status and behavioral adjustment, including the Child Behavior Checklist (Achenbach, 1991; see also Chapter 10), the Behavior Assessment System for Children (Reynolds & Kamphaus, 1992; see also Chapter 9), the Personality Inventory for Children (Wirt, Seat, Broen, & Lachar, 1990), and the Conners' Rating Scales—Revised (Conners, 1997). Rating scales also are available to assess various aspects of adaptive behavior, such as the Scales of Independent Behavior—Revised (Bruininks, Woodcock, Weatherman, & Hill, 1996), as are detailed semistructured interview procedures, such as the Vineland Adaptive Behavior Scales (Sparrow, Balla, & Ciccetti, 1984).

The assessment of emotional and behavioral adjustment and of adaptive

functioning is crucial. A careful analysis of deficits in adjustment and adaptive behavior can help to define the mismatch between a child's neuropsychological profile and the environmental demands placed on the child. However, the relationship between neuropsychological skills and adjustment problems or deficits in adaptive behavior is complex. For example, premorbid behavior problems and adaptive deficits may increase the risk of traumatic brain injury. Adjustment problems and adaptive difficulties also may be an indirect result of the frustration associated with consistent failures to cope with environmental demands. In other cases, behavioral difficulties or adaptive deficits may be a more direct manifestation of neuropsychological deficits (Rourke & Fuerst, 1991).

CLINICAL INTERPRETATION OF ASSESSMENT RESULTS

The final step in assessment involves the integration of historical information, behavioral observations, and test results. The integration of these diverse sources of data results in a diagnostic formulation of a child's presenting problems from a neuropsychological perspective. Treatment recommendations follow from this formulation, based on impressions regarding the reasons for the child's current adaptive problems and predictions regarding the adaptive risks anticipated in the future.

The process by which neuropsychologists integrate diverse pieces of information is difficult to describe in explicit terms. Indeed, the ability of neuropsychologists to utilize the myriad pieces of information generated in neuropsychological assessment has been called into question (Dawes, Faust, & Meehl, 1989). Research on clinical judgment suggests that clinicians rely on a limited amount of information in their decision making and cannot use additional information when it is available to them (Garb, 1998). Nevertheless, systematic research indicates that neuropsychologists can use the information they gather to generate diagnostic formulations in a reliable fashion (Brown, Del Dotto, Fisk, Taylor, & Breslau, 1993; Waber, Bernstein, Kammerer, Tarbell, & Sallan, 1992).

Neuropsychologists attempt to integrate historical information, behavioral observations, and test results by searching for converging findings that are consistent with current knowledge regarding brain function in children and the nature of cognitive-behavioral relationships across development (Bernstein, 2000; Bernstein & Waber, 1990). Neuropsychologists typically evaluate test results in terms of level of performance on each task, pattern of performance across tasks, and strategies or processes used to attempt each task. However, diagnostic formulations do not depend solely on an analysis of test scores, but instead involve the integration of multiple sources of data in light of a broad conceptual foundation and knowledge base.

For clinical purposes, brain function is usually defined in general terms, with reference to the three primary neuroanatomic axes: left-hemisphere/right-hemisphere; anterior/posterior; and cortical/subcortical (Bernstein, 2000; Bernstein & Waber, 1990). The three-axis model is used as a organizational heuristic that helps to integrate the data gleaned from neuropsychological assessment, including test results, behavioral observations, and historical information. The overarching concerns of the neuropsychologist are whether the findings can be interpreted in terms of brain-behavior relationships and whether they can be determined to have a neurological basis. Whether or not the findings raise concerns about actual brain damage is a distinct issue.

Certain patterns lend themselves to specific interpretations (Baron, 2000). For instance, a constellation of specific delays in the acquisition of language milestones, poor performance on language and reading tests, configurational approaches on constructional tasks, and right-sided sensorimotor deficits might be conceptualized as implicating the left hemisphere, without necessarily assuming that there is any focal brain lesion. In contrast, the presence of language and reading deficits in isolation would be more difficult to interpret, because isolated deficits in those domains have many other potential explanations, such as a lack of appropriate environmental stimulation.

Similarly, a long-standing history of difficulties with attention and organization in school and at home, a disinhibited response style, and poor performance on tests of attention and executive functions, expressive language, complex constructional skills, processing speed, and fine-motor skills might be interpreted as implicating the brain's frontal-subcortical axis. This interpretation would gain credence if functions usually associated with posterior brain regions (e.g., receptive language, visuoperceptual, and corticosensory skills) were intact. In contrast, the interpretation would be more difficult to entertain if the findings were characterized by more generalized impairment.

Frequently, the findings from a neuropsychological assessment are interpreted only in terms of whether they are likely to have a biological or constitutional basis, because they do not lend themselves to more specific brain-related interpretations. For instance, a family history of reading problems increases the likelihood that a child's own reading problems have a genetic basis, but does not necessarily suggest relatively greater involvement of any particular brain system. Similarly, unexpectedly low performance across a variety of neuropsychological domains may suggest a biological basis for a child's adaptive difficulties, but generalized impairment usually does not support more specific brain-related interpretations.

In addition to making brain-related interpretations of their findings, neuropsychologists employ the knowledge base about cognitive and behavioral development to characterize what Taylor and Fletcher (1990) refer to as "behavior-behavior" relationships. For example, neuropsychologists may draw distinctions between verbal and nonverbal skills, perceptual input and

behavioral output, or automatic and effortful processing. Similarly, they may correlate reading disabilities with deficits in phonological awareness or arithmetic disabilities with poor visuospatial skills.

After constructing a diagnostic formulation, neuropsychologists typically evaluate the fit between a child's neuropsychological profile and the child's environmental context. The child's current adaptive failures can then be explained in terms of a poor fit, and the nature of the poor fit can be used to forecast the risks faced by the child in the future. The assessment of risk must take into account both a child's neuropsychological profile and the particular features of the child's environment, including his or her family, school, and community (Rourke, Fisk, & Strang, 1986). Recommendations for management do not arise directly from test results, but instead from an evaluation of the risks associated with neuropsychological profiles and environmental demands.

CASE STUDY

To illustrate neuropsychological assessment procedures, we present the case study of "John," a 7-year, 1-month-old white male. John sustained a closed-head injury in a motor vehicle accident about 3 years prior to being referred for a neuropsychological evaluation. He was referred to the senior author by the attorney representing him in litigation regarding the circumstances of his injury. The attorney wished to document John's current neuropsychological functioning, the relationship of the neuropsychological findings to his head injury, and the implications of the findings for his quality of life.

Relevant information was obtained from hospital medical records, including two previous neuropsychological evaluations, and through an interview with John's mother. She also completed the Scales of Independent Behavior—Revised and the Child Behavior Checklist. John's special education teacher completed the Teacher's Report Form. This information was supplemented by detailed observations of John's behavioral repertoire and his performance on a variety of psychological tests, the results of which are listed in Table 14.2.

At the time of the evaluation, John lived with his parents and sister in a middle-class home. Family history was significant for the appearance of seizures, migraine headaches, learning problems, and depression in the extended maternal family. Birth history was unremarkable. Developmental milestones were acquired within normal limits.

Medical history was unremarkable until John sustained a severe closed-head injury in the motor vehicle accident when he was 4 years of age. Neuroimaging documented widespread injuries in the subcortical and cortical regions of the brain, predominantly in the anterior regions (see Figure 14.1). John was in a coma for several days after the accident. After regaining consciousness, he demonstrated a left-sided partial paralysis and left-sided

TABLE 14.2
Case Study Test Results

Wechsler Intelligence Scale for Children—Third Edition			
Full Scale IQ	95		
Verbal Scale IQ	90		
Performance Scale IQ	102		
Verbal Comprehension Index	93		
Perceptual Organization Index	99		
Freedom from Distractibility Index	90		
Processing Speed Index	104		
Subtest scaled scores:			
Information	7	Picture Completion	9
Similarities	11	Picture Arrangement	9
Arithmetic	6	Block Design	10
Vocabulary	7	Object Assembly	11
Comprehension	10	Coding	12
Digit Span	10	Symbol Search	9
NEPSY—A Developmental Neuropsychological Assessment			
Language core (St)	95		
Visuospatial core (St)	124		
Attention/executive function core (St)	85		
Sensorimotor core (St)	82		
Subtest scaled scores:			
Phonological Processing	8	Tower	6
Speeded Naming	10	Auditory Attention and Response Set	10
Comprehension of Instructions	10	Visual Attention	8
Sentence Repetition	8	Fingertip Tapping	7
Verbal Fluency	6	Imitating Hand Positions	5
Design Copying	15	Visuomotor Precision	11
Arrows	14		
Children's Memory Scale			
Visual Immediate Index (St)	100		
Visual Delayed Index (St)	94		
Verbal Immediate Index (St)	88		
Verbal Delayed Index (St)	91		
General Memory Index (St)	90		
Attention/Concentration Index (St)	94		
Learning Index (St)	106		
Delayed Recognition Index (St)	97		
Subtest scaled scores:			
Stories Immediate	6	Dot Locations Learning	12
Stories Delayed	7	Dot Locations Long Delay	11
Stories Delayed Recognition	9	Faces Immediate	8
Word Pairs Learning	10	Faces Delayed	7
Word Pairs Long Delay	10	Numbers	10
Word Pairs Delayed Recognition	10	Sequences	8
Wide Range Achievement Test—Third Edition			
Reading (St)	81		
Spelling (St)	77		
Arithmetic (St)	97		
Boston Naming Test			
Total correct	R: 20	T: 18	
California Verbal Learning Test			
List A, trial 1	R: 1	z: −2.5	
List A, trial 5	R: 5	z: −1.5	
Total list A, trials 1–5	R: 16	T: 25	

(*continues*)

Table 14.2—*Continued*

List B	R: 2	z: −1.5
Free recall short delay	R: 2	z: −2.0
Cued recall short delay	R: 3	z: −2.0
Free recall long delay	R: 3	z: −2.0
Cued recall long delay	R: 3	z: −2.0
Recognition hits	R: 9	z: −1.5
False positives	R: 2	z: −0.5
Discriminability	R: 82%	z: −0.5
Perseverations	R: 1	z: −1.0
Intrusions	R: 22	z: +1.0
Hooper Visual Organization Test		
Total correct	R: 17	T: 34
Gordon Diagnostic System		
Delay task		
Total correct	R: 40	T: 50
Efficiency ratio	R: .77	T: 47
Wisconsin Card Sorting Test		
Categories completed	R: 6	WNL
% conceptual responses	R: 73	St: 113
% perseverative errors	R: 9	St: 115
Failures to maintain set	R: 3	WNL
Children's Category Test		
Total errors	R: 16	T: 54
Sensory-Perceptual Examination		
Double-simultaneous visual stimulation		
Right errors	R: 0	WNL
Left errors	R: 0	WNL
Tactile finger identification		
Right errors	R: 3	Impaired
Left errors	R: 4	Impaired
Finger Tapping Test		
Right	R: 31	T: 57
Left	R: 23	T: 43
Grooved Pegboard		
Right	R: 42"	T: 49
Left	R: 88"	T: 25
Scales of Independent Behavior—Revised		
Motor (St)	115	
Social Interaction & Communication (St)	117	
Personal Living (St)	133	
Community Living (St)	102	
Broad Independence (St)	119	
Child Behavior Checklist		
Parent		
Total T	42	
Internalizing T	43	
Externalizing T	38	
Teacher		
Total T	31	
Internalizing T	36	
Externalizing T	39	

Note: R = raw score, T = T score (M = 50, SD = 10), Sc = Scaled score (M = 10, SD = 3), St = Standard score (M = 100, SD = 15), z = z score (M = 0, SD = 1), WNL = within normal limits. Qualitative levels are provided when published norms do not permit conversion.

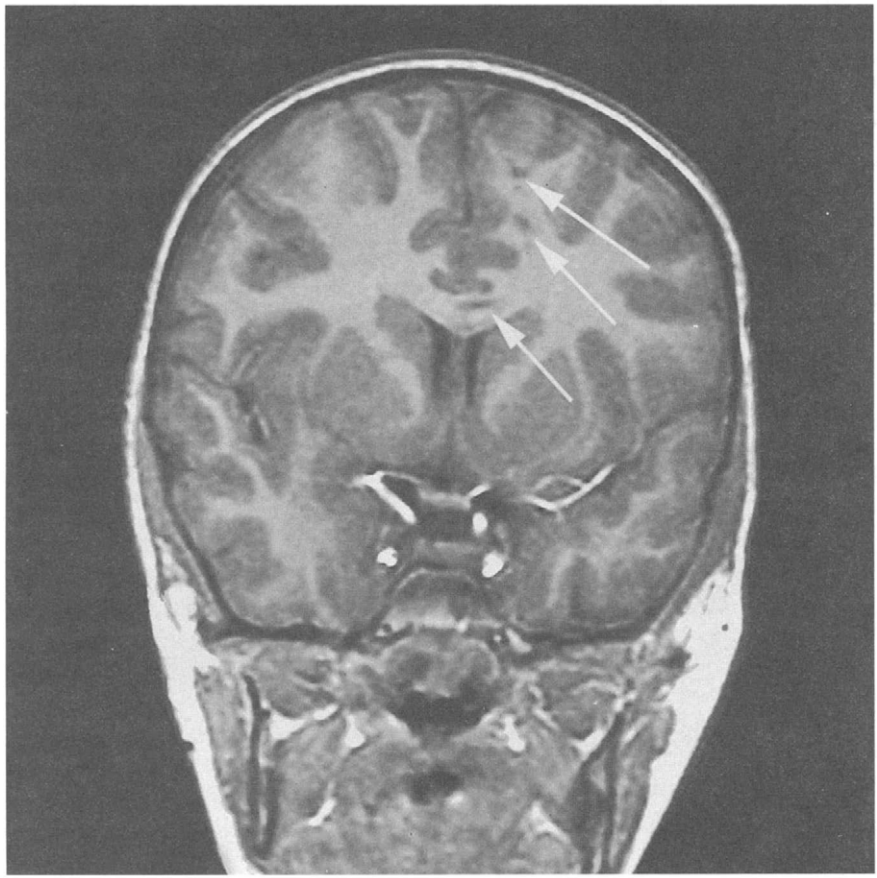

FIGURE 14.1
Coronal MRI scan showing lesions in left frontal lobe and corpus callosum of brain in child with severe closed-head injury at age 4 (see white arrows).

visual neglect. He was transferred to a rehabilitation program 1 week after his injury, and discharged about 1 month later.

John attended a parochial preschool program for 2 years, and also attended kindergarten in a parochial school. He had difficulty expressing himself in class and acquiring early school-related skills. He participated in speech/language therapy and also received private tutoring for his academic skills. Because of his academic difficulties, John's parents transferred him to public school for first grade. At that time, he began to receive special education services under the Traumatic Brain Injury (TBI) classification. John also continued participating in speech/language therapy and private academic tutoring.

John was completing first grade in a local public school system. He received most of his academic instruction in a resource room. His teacher described his academic performance as far below grade level in language arts, and at grade level in mathematics, social studies, and science. She described John as a hard worker with a positive attitude, and characterized him as responsible, helpful, attentive, motivated, friendly, and an excellent role model.

John's mother reported that the provision of special education services had resulted in a significant improvement in John's academic performance. She stated that his attention had improved, but that he remained more forgetful than his peers. John's mother also described improvements in his personality and behavior. He was less withdrawn than before, and he socialized more readily with other children. He was not as anxious or easily frustrated.

John had participated in two previous neuropsychological evaluations. The first one took place about 1 month after his head injury. At that time, his IQ was below average. He displayed deficits in nonverbal skills and motor output. By contrast, his language skills were generally secure. A second evaluation was completed about 1 year after the injury. At that time, John's IQ remained below average. He displayed deficits in verbal and nonverbal memory, as well as in executive functions such as attention, behavioral regulation, and abstraction. His psychomotor speed was also below average. In contrast, his language skills, visuoperceptual skills, and constructional abilities were generally intact, as was his corticosensory functioning.

During testing, John interacted appropriately with the examiner. He approached testing more cooperatively than he had previous evaluations, and he was motivated to perform well. His attention was generally well sustained, at least in the structured, one-on-one testing sessions. His activity level was not well regulated, however, and he was quite fidgety. In addition, his response style was disinhibited. For instance, he tended to begin responding before task instructions were completed.

Spontaneous conversation was not difficult to elicit. In conversation with John, his comprehension was intact. His language expression was appropriate in form and content, without overt aphasic errors. His speech was clearly articulated and intelligible. His language pragmatics were intact, aside from occasional interruptions of the examiner, which were secondary to his disinhibition. John also demonstrated a satisfactory appreciation of paralinguistic features such as gesture, intonation, and facial expression.

John's physical appearance was unremarkable, as were his gait and balance. His graphomotor skills were still somewhat insecure. He preferred his right hand for writing and drawing. He employed an awkward tripod grip, but produced legible print.

Test results are presented in Table 14.2. Overall performance on the WISC-III was average, and reflected substantial improvement compared to the previous neuropsychological evaluation. All four index scores were in the average range, and they did not differ significantly. Several qualitative obser-

vations were noteworthy on the WISC-III. Latencies to response were longer than expected on Information. Definitions on Vocabulary frequently included nonessential information, and in several cases he received no credit despite apparent word knowledge. John was able to repeat a maximum of five digits forward and three backward on Digit Span. He frequently made irrelevant comments during Picture Arrangement. He used his right hand almost exclusively during Block Design. He was unable to complete any Block Design items that did not include internal guidelines, and he broke the square matrix on such items.

Formal language testing revealed expressive deficits that were more pronounced than during the previous neuropsychological evaluation. John performed adequately on tests assessing comprehension and repetition. His phonological skills also were intact. In contrast, he displayed mild to moderate deficits on measures of confrontation naming and rapid word generation.

Verbal memory was hampered by retrieval deficits. On a word-list learning task and a story recall task, delayed recall was below average, but recognition was average, suggesting retrieval difficulties. Performance was average on a paired-associates learning task.

Nonverbal skills were intact, and somewhat improved compared to previous testing. John performed average on tests of spatial judgment and drawing skills, but somewhat below average on a test of perceptual recognition. Nonverbal memory was intact, again representing some improvement compared to previous testing. John performed at an average level on tests of facial memory and spatial location memory.

Tests of executive functions revealed persistent deficits in focused attention and planning, with some improvement in abstract reasoning. John displayed some difficulties on complex measures of sustained attention and response inhibition, one of which had to be discontinued. He performed at an average level on measures of working memory and response speed, as well as on measures of concept formation and cognitive flexibility. His planning skills were in the low-average range.

Tests of sensorimotor functioning revealed persistent deficits. John demonstrated bilateral errors in tactile finger recognition. Simple motor speed was intact, but complex motor speed fell below expectations on the left side. Manual coordination was below average bilaterally. Graphomotor skill was average.

On tests of academic skills, John's performance continued to be poorer than expected in reading and spelling, despite some improvement in word recognition. Arithmetic skills had improved substantially.

John's mother described his overall adaptive functioning as in the high-average range. She characterized John's motor skills and social/communication skills as in the high-average range, his personal living skills as above average, and his community living skills as average. She did not report significant maladaptive behavior.

John's mother and special education teacher rated his behavioral adjustment. Neither of them reported a significant overall level of behavioral disturbance or any significant elevations on specific problem scales.

In summary, the evaluation indicated that general intellectual functioning was average. Within that context, the neuropsychological protocol revealed specific deficits in expressive language and verbal memory, as well as more general deficits in certain executive functions, including focused attention, response inhibition, and planning. Deficits in sensorimotor skills also were evident bilaterally. In contrast, nonverbal skills were generally intact, as were some other executive functions, such as cognitive flexibility and abstraction.

From a neuropsychological perspective, the findings suggested relatively greater deficits in functions usually associated with left-hemisphere and anterior brain regions. In other words, the deficits in expressive language, verbal memory, and reading and spelling implicated the left hemisphere, while those in focused attention, response inhibition, and planning implicated the frontal-subcortical axis.

Compared to previous evaluations, the findings reflected substantial improvement in overall cognitive ability. Improvements also were apparent in specific cognitive functions, including nonverbal skills and abstraction. Academic skills also had improved, especially in arithmetic. By contrast, expressive language skills had shown a relative decline, and verbal memory remained poorer than expected. Executive functions were less globally impaired than they were in previous evaluations, but deficits in attention and planning still were apparent.

Thus, despite improvements over time, John continued to show persistent neuropsychological deficits that probably were attributable to his head injury. His neuropsychological profile reflected the sorts of deficits in memory and executive functions that commonly occur following severe traumatic brain injuries (Yeates, 2000). In John's case, his neuropsychological deficits also were consistent with the multifocal lesions documented by neuroimaging.

Because of his persistent deficits, John continued to be at-risk for learning problems in school. His expressive language and verbal memory difficulties were likely to hamper his participation in classroom activities, limit his retention of novel information, and slow his acquisition of basic academic skills. In addition, because of his deficits in executive functions, his work was likely to be inefficient and disorganized.

The risks associated with John's neuropsychological profile extended to his psychosocial adjustment. Children with traumatic brain injuries often demonstrate difficulties such as poor judgment, emotional lability, and behavioral disinhibition. These difficulties can create behavior management problems for parents and other adult caregivers, and can also interfere with peer relationships.

Fortunately, several factors were working in John's favor. His overall cognitive ability was average, as were many of his specific cognitive skills. In addi-

tion, John's behavior had improved significantly over time, and he no longer displayed the adjustment problems that were apparent soon after his injury. Moreover, his adaptive functioning was in the high-average range.

Based on these considerations, the neuropsychologist made recommendations for the provision of ongoing special education services. Specific suggestions included a combination of classroom accommodations and individualized instruction in academic skills. Based on his medical history, John was felt to qualify for special education services under the TBI classification.

Because of John's deficits in attention and executive functions, it was recommended that he be seated near his instructor and preferably where there were few potential distractions. Teachers were encouraged to monitor him closely to ensure that he stayed on task and used appropriate strategies to complete tasks. They also were encouraged to remind him to "stop and think" before responding to task demands. In addition, it was suggested that he would benefit from a reduction in time constraints, so that he was not penalized for the inefficiency that sometimes characterized his work.

Specific accommodations also were suggested to address John's deficits in expressive language. It was recommended that verbal instruction be supplemented with graphic materials, demonstrations, and models, and that John be presented with other hands-on experiences to capitalize on his relatively stronger nonverbal skills. It also was suggested that classroom discussions be broken into small groups to give him a greater opportunity to participate, and that John be encouraged to demonstrate his knowledge nonverbally, through multimedia projects, drama, and other related means that do not depend entirely on oral communication.

Additional accommodations were suggested because of John's difficulties with verbal memory. He was likely to need more repetition and review of unfamiliar material. Teachers were encouraged to present novel information in close relationship to previous lessons, to help link it to what John already knew. It also was suggested that John was likely to benefit from various forms of cueing, to help overcome his retrieval difficulties. On formal testing, for instance, he would probably perform better on multiple-choice, true-false, and matching items than on short answer or essay questions, which require spontaneous recall. In addition, it was recommended that John be taught simple mnemonic techniques (e.g., rehearsal) to help improve recall.

Along with classroom accommodations, John warranted specialized instruction in reading and writing. Based on current research (Fletcher & Lyon, 1998), it was recommended that he be taught to read using a structured multisensory approach that emphasized phonological skills, but that also included substantial practice in the application of those skills while reading actual text. It was further suggested that writing be taught using a systematic approach that included separate instruction in the mechanics of writing and in composition. John also was likely to benefit from being taught to use word-processing software, which can make the process of revision less onerous and can assist with the mechanical aspects of writing.

Finally, teachers and school personnel were encouraged to seek additional information regarding the educational implications of traumatic brain injuries. Recommended resources included *Head Injury in Children and Adolescents*, published by Clinical Psychology Publishing (Begali, 1992); the *Educator's Manual*, published by the Brain Injury Association (Savage & Wolcott, 1995); and *Traumatic Brain Injury in Children and Adolescents*, published by Pro-Ed (Tyler & Mira, 1999).

At the time of the evaluation, John did not appear to require substantial additional support outside of school. The personality and behavior changes that he displayed previously had largely resolved. The improvement probably reflected both recovery from the brain injury and the salutary effects of the special education assistance he had been receiving on his academic performance.

BENEFITS AND LIMITATIONS OF NEUROPSYCHOLOGICAL ASSESSMENT

Neuropsychological assessment can provide several advantages compared to traditional psychoeducational testing. Neuropsychological test batteries are generally broader in scope and more in-depth than traditional batteries, and hence provide a more thorough and detailed description of a child's cognitive strengths and weaknesses. Traditional psychoeducational testing, for example, often does not include measures of memory or executive functions, despite the potential importance of such measures as predictors of academic performance and other adaptive outcomes.

Neuropsychological assessment also can play a critical role in clarifying the etiology of a child's adaptive difficulties. Neuropsychologists are trained specifically to determine whether behavior arises as a result of brain impairment or from other causes such as various environmental factors. Additionally, neuropsychological assessment can help to resolve diagnostic uncertainties. For example, traumatic brain injuries are associated with deficits in attention, memory, and executive functions (Yeates, 2000). The detection of deficits in those domains in a child with documented head trauma increases the likelihood that the child suffered a traumatic brain injury. Finally, neuropsychological assessment can have substantial prognostic value. For instance, the severity of neuropsychological deficits associated with traumatic brain injury predicts longer-term adaptive outcomes.

Thus, child neuropsychologists are distinguished by their ability to characterize children's cognitive functioning in considerable detail and to render complex etiological, diagnostic, and prognostic judgments, especially as the judgments are related to brain function. These clinical judgments depend on neuropsychologists' expertise and knowledge base rather than the tests that they use. Indeed, many of the tests mentioned in this chapter can be used by psychologists from other specialties to broaden their assessment repertoire,

even if their training does not prepare them to make neuropsychological inferences.

The aforementioned benefits suggest that neuropsychological assessment is indicated when children have medical or neurological disorders that are likely to affect their adaptive functioning. Neuropsychological assessment also is likely to be useful for children with developmental or psychiatric disorders who warrant more in-depth assessment than that afforded by traditional psychoeducational testing. Finally, it warrants consideration when children display learning difficulties, behavior problems, or other adaptive failures that are suspected of having a biological basis.

Despite its virtues, neuropsychological assessment is subject to at least two limitations. First, the relevance of assessment results to children's functional adaptation remains unclear. The ecological validity of neuropsychological assessment is receiving increased attention (e.g., Sbordone & Long, 1995), but there still is much to learn, particularly in terms of outcomes other than academic achievement. Relevant areas for future research will include the prediction of social competence, daily living skills, and long-term vocational attainment.

Second, the contention that neuropsychological test findings contribute to more effective educational planning also has little empirical support (Reschly & Graham, 1989). There have been few experimental research studies designed to test the hypothesis that children with distinct neuropsychological profiles profit from different instructional techniques (Lyon & Flynn, 1991). However, recent studies of different types of reading instruction have been based in part on neuropsychological analyses of the cognitive processes involved in reading, and provide a template for future research that extends to other academic skills and adaptive domains.

RELIABILITY AND VALIDITY OF NEUROPSYCHOLOGICAL ASSESSMENT

Psychological tests are evaluated in terms of essential psychometric properties such as reliability and validity. A review of the reliability and validity of the specific tests used in neuropsychological assessment is beyond the scope of this chapter (for comprehensive reviews, see Lezak, 1995; Spreen & Strauss, 1998). A reasonable synopsis, however, is that the psychometric properties of neuropsychological tests often are poorly documented, even for some of the most widely used instruments, such as the Halstead-Reitan Neuropsychological Test Battery (Reynolds, 1989; Brown, Rourke, & Cicchetti, 1989; Leckliter, Forster, Klonoff, & Knights, 1992).

A concern that extends beyond the psychometric properties of specific tests is the reliability and validity of the neuropsychological assessment process as a whole (Matarazzo, 1990). In other words, the integrity of the assessment enterprise depends on the consistency with which neuropsychologists

interpret test results and the extent to which the results of neuropsychological assessments are related both to underlying neurological impairment and to children's adaptive functioning. The key questions are: Can clinicians agree on the nature of a child's neuropsychological profile, and does that profile have both neurological and ecological validity (Taylor & Schatschneider, 1992)?

Two recent studies examined the consistency with which child neuropsychologists interpret test results. Brown et al. (1993) asked three neuropsychologists to rate the functioning of normal and low-birthweight children in seven neuropsychological domains: intelligence; auditory-perceptual/language functioning; visual perceptual/visuomotor functioning; haptic perceptual functioning; memory; attention; and global functioning. Raters were blind to each other's ratings and to birthweight status. The results revealed good to excellent agreement between raters, with intraclass correlations of ratings within domains ranging from .53 to .85.

Another investigation examined the ability of clinicians to make reliable neuropsychological diagnoses (Waber et al., 1992). Two judges were asked to make neuropsychological diagnoses based on test data and behavior ratings derived from assessments of children treated for either acute lymphoblastic leukemia or Wilm's tumor. The former disease is likely to be associated with central nervous system impairment, but the latter is not. Neuropsychological diagnoses were structured in terms of the three axes of brain function described above. For each axis, raters were asked if a localizing discrimination could be made and, if so, in what direction (i.e., left or right hemisphere, anterior or posterior, cortical or subcortical). Raters were blind to each other's ratings and to medical diagnosis. The reliability of neuropsychological diagnoses was also satisfactory in this study. The results from these two studies suggest that clinicians can make reliable ratings of neuropsychological test performance and its presumed neural substrates.

The validity of neuropsychological assessment was examined by Taylor and Schatschneider (1992). They wanted to determine if neuropsychological test results were related to the integrity of the central nervous system and if the results also would predict adaptive outcomes such as academic skills and behavioral adjustment. Their sample consisted of 113 school-age children who had been hospitalized early in life with *Haemophilus influenza* type b meningitis. The children's medical records pertaining to their acute-phase illness provided measures of the degree of brain insult (e.g., presence/absence of neurological complications). Social variables also were assessed (e.g., family socioeconomic status). The children were administered a neuropsychological test battery, which included measures of academic skills, and their parents provided ratings of behavioral adjustment and adaptive behavior. Even after controlling for social factors, acute-phase medical variables accounted for a significant proportion of variance in performance on a variety of neuropsychological tests. Similarly, although social factors accounted for a signifi-

cant proportion of variance in functional outcomes, significant additional variance was explained by neuropsychological test results.

Thus, the results indicated that child neuropsychological assessment is sensitive to neurological insult, even when it occurs at a time far removed from the actual assessment. The results also indicated that neuropsychological test performance predicts meaningful variations in children's academic skills, behavioral adjustment, and adaptive functioning. Interestingly, the tests that were most sensitive to neurological insult were not always the same as those that were most predictive of functional outcomes. Effective neuropsychological assessment depends on the selection of tests with both neurological and ecological validity. Neurological validity is necessary to determine whether cognitive deficits are related to variations in brain status, whereas tests with ecological validity have more immediate implications for clinical management.

PROSPECTS FOR NEUROPSYCHOLOGICAL ASSESSMENT

The interest in and demand for neuropsychological assessment likely will continue to grow. In the future, neuropsychologists are increasingly likely to integrate their assessments with the results of neuroimaging (Bigler, 1994). The correlation of volumetric neuroimaging analyses with neuropsychological functioning already has provided interesting insights into brain-behavior relationships during childhood and adolescence. The relevance of neuroimaging to neuropsychological assessment is likely to remain relatively obscure, however, unless the brain can be studied "on line," in terms of its functional activity. As functional magnetic resonance imaging and related techniques become more widely available, the integration of assessment and imaging should become more feasible.

Child neuropsychologists also are likely to pay increasing attention to the environment as a determinant of children's neuropsychological functioning. Detailed analyses of the tests that comprise neuropsychological assessment batteries can help clarify how different test characteristics, including the manner in which they are administered, affect performance. At a more macroscopic level, examination of children's environments is critical in determining how those environments constrain and moderate neuropsychological functioning. In this regard, procedures for evaluating children's environments also warrant consideration by clinicians (Friedman & Wachs, 1999; Wachs & Plomin, 1991).

The dynamic nature of the interaction between brain, behavior, and context during childhood and adolescence highlights the importance of a developmental approach to child neuropsychology (Dennis & Barnes, 1993). In clinical practice, neuropsychological tests developed for use with adults

often have been applied unthinkingly to children, as have adult models of brain-behavior relationships. In the future, child neuropsychologists will seek a rapprochement with both developmental neuroscience (Diamond, 1991; Elman et al., 1996; Johnson, 1997; Tager-Flusberg, 1999; Temple, 1997) and developmental psychology (Fischer & Rose, 1994; Welsh & Pennington, 1988). Contributions from those disciplines will provide the foundation for a more precise characterization of children's neuropsychological functioning in their everyday environments.

References

Achenbach, T. M. (1991). *Integrative guide for the* 1991 CBCL/4–18, YSR, *and* TRF *profiles*. Burlington, VT: Univ. of Vermont Department of Psychiatry.

Anderson, P., Anderson, V., & Lajoie, G. (1996). The Tower of London test: Validation and standardization for pediatric populations. *The Clinical Neuropsychologist*, 10, 54–65.

Barkley, R. A. (1990). *Attention deficit hyperactivity disorder: A handbook for diagnosis and treatment*. New York: Guilford.

Barkley, R. A. (1991). The ecological validity of laboratory and analogue assessment methods of ADHD symptoms. *Journal of Abnormal Child Psychology*, 19, 149–178.

Baron, I. S. (2000). Clinical implications and practical applications of child neuropsychological evaluations. In K. O. Yeates, M. D. Ris, & H. G. Taylor (Eds.), *Pediatric neuropsychology: Research, theory, and practice* (pp. 439–456). New York: Guilford.

Baron, I. S., Fennell, E., & Voeller, K. (1995). *Pediatric neuropsychology in the medical setting*. New York: Oxford Univ. Press.

Beery, K. E. (1996). *Developmental Test of Visual-Motor Integration—Fourth Edition*. Parsipanny, NY: Modern Curriculum.

Begali, V. (1992). *Head injury in children and adolescents: A resource and review for school and allied professionals* (2nd ed.). Branton, VT: Clinical Psychology.

Benton, A. L. (1992). *Benton Visual Retention Test—Fifth Edition*. San Antonio, TX: The Psychological Corporation.

Benton, A. L., Sivan, A. B., Hamsher, K. deS., Varney, N. R., & Spreen, O. (1994). *Contributions to neuropsychological assessment: A clinical manual* (2nd ed.). New York: Oxford Univ. Press.

Bernstein, J. H. (2000). Developmental neuropsychological assessment. In K. O. Yeates, M. D. Ris, & H. G. Taylor (Eds.), *Pediatric neuropsychology: Research, theory, and practice* (pp. 405–438). New York: Guilford.

Bernstein, J. H., & Waber, D. P. (1990). Developmental neuropsychological assessment: The systemic approach. In A. A. Boulton, G. B. Baker, & M. Hiscock (Eds.), *Neuromethods: Vol. 17, Neuropsychology* (pp. 311–371). New York: Humana Press.

Bernstein, J. H., & Waber, D. P. (1996). *Developmental scoring system for the Rey-Osterrieth Complex Figure*. Odessa, FL: Psychological Assessment Resources.

Bigler, E. D. (1994). Neuroimaging and neuropsychological assessment. In C. R. Reynolds (Ed.), *Cognitive assessment: A multidisciplinary perspective* (pp. 1–34). New York: Plenum.

Boll, T. (1992). *Children's Category Test manual*. New York: The Psychological Corporation.

Brown, G., Del Dotto, J. E., Fisk, J. L., Taylor, H. G., & Breslau, N. (1993). Analyzing clinical ratings of performance on pediatric neuropsychology tests. *The Clinical Neuropsychologist*, 7, 179–189.

Brown, R. T., & Borden, K. A. (1989). Neuropsychological effects of stimulant medication on children's learning and behavior. In C. R. Reynolds & E. Fletcher-Janzen (Eds.), *Handbook of clinical child neuropsychology* (pp. 443–474). New York: Plenum.

Brown, S. J., Rourke, B. P., & Cicchetti, D. V. (1989). Reliability of tests and measures used in the neuropsychological assessment of children. *The Clinical Neuropsychologist*, 3, 353–368.

Bruininks, R. H. (1978). *Bruininks-Oseretsky Test of Motor Proficiency*. Circle Pines, MN: American Guidance Service.

Bruininks, R. H., Woodcock, R. W., Weatherman, R. F., & Hill, B. K. (1996). *Scales of Independent Behavior—Revised comprehensive manual*. Chicago: Riverside Publishing.

Butters, N., & Delis, D. C. (1995). Clinical assessment of memory disorders in amnesia and dementia. *Annual Review of Psychology*, 46, 493–523.

Casey, J. E., & Rourke, B. P. (1992). Disorders of somatosensory perception in children. In I. Rapin & S. J. Segalowitz (Eds.), *Handbook of neuropsychology (Vol. 6): Child neuropsychology* (pp. 477–494). Amsterdam: Elsevier.

Cepeda, M. L. (1989). Nonstimulant psychotropic medication: Side effects on children's cognition and behavior. In C. R. Reynolds & E. Fletcher-Janzen (Eds.), *Handbook of clinical child neuropsychology* (pp. 475–488). New York: Plenum.

Cohen, M. J. (1997). *Children's Memory Scale manual*. San Antonio, TX: The Psychological Corporation.

Conners, C. K. (1997). *Conners' Rating Scales—Revised technical manual*. North Tonawanda, NY: Multi-Health Systems.

Cooley, E. L., & Morris, R. D. (1990). Attention in children: A neuropsychologically based model for assessment. *Developmental Neuropsychology*, 6, 239–274.

Cummings, J. L. (1993). Frontal-subcortical circuits and human behavior. *Archives of Neurology*, 50, 873–880.

Dawes, R. M., Faust, D., & Meehl, P. E. (1989). Clinical versus actuarial judgment. *Science*, 243, 1668–1674.

Delis, D. C., Kramer, J. H., Kaplan, E., & Ober, B. A. (1994). *Manual for The California Verbal Learning Test for Children*. New York: The Psychological Corporation.

Denckla, M. B. (1985). Revised neurological examination for soft signs. *Psychopharmacology Bulletin*, 21, 733–800, 1111–1124.

Denckla, M. B. (1994). Measurement of executive function. In G. R. Lyon (Ed.), *Frames of reference for the assessment of learning disabilities* (pp. 117–142). Baltimore: Paul H. Brookes.

Dennis, M. (1988). Language and the young damaged brain. In T. Boll & B. K. Bryant (Eds.), *Clinical neuropsychology and brain function: Research, measurement, and practice* (pp. 85–123). Washington, DC: American Psychological Association.

Dennis, M., & Barnes, M. (1993). Oral discourse skills in children and adolescents after early-onset hydrocephalus: Linguistic ambiguity, figurative language, speech acts, and script-based inferences. *Journal of Pediatric Psychology*, 18, 639–652.

Dennis, M., & Barnes, M. (1994). Developmental aspects of neuropsychology: Childhood. In D. Zaidel (Ed.), *Handbook of perception and cognition* (pp. 219–246). New York: Academic Press.

Derryberry, D., & Tucker, D. M. (1992). Neural mechanisms of emotion. *Journal of Clinical and Consulting Psychology*, 60, 329–338.

Diamond, A. (1991). Some guidelines for the study of brain-behavior relationships during development. In H. Levin, H. Eisenberg, & A. Benton (Eds.), *Frontal lobe function and dysfunction* (pp. 189–211). New York: Oxford Univ. Press.

Dunn, L. M., & Dunn, L. M. (1997). *Peabody Picture Vocabulary Test-Fourth Edition*. Circle Pines, MN; American Guidance Service.

Elliott, C. (1990). *Differential Abilities Scale administration and scoring manual*. San Antonio, TX: The Psychological Corporation.

Elman, J. L., Bates, E. A., Johnson, M. K., Karmiloff-Smith, A., Parisi, D., & Plunkett, K. (1996). *Rethinking innateness: A connectionist perspective on development*. Cambridge, MA: MIT Press.

Ewing-Cobbs, L., Levin, H. S., Eisenberg, H. M., & Fletcher, J. M. (1987). Language functions following closed-head injury in children and adolescents. *Journal of Clinical and Experimental Neuropsychology*, 9, 575–592.

Fischer, K. W., & Rose, S. P. (1994). Dynamic development of coordination of components in brain and behavior: A framework for theory and research. In G. Dawson & K. W. Fischer (Eds.), *Human behavior and the developing brain* (pp. 3–66). New York: Guilford.

Fletcher, J. M. (1994). Afterword: Behavior-brain relationships in children. In S. H. Broman & J. Grafman (Eds.), *Atypical cognitive deficits in developmental disorders: Implications for brain function* (pp. 297–326). Hillsdale, NJ: Erlbaum.

Fletcher, J. M., & Lyon, G. R. (1998). Reading: A research-based approach. In W. Evers (Ed.), *What's gone wrong in America's classrooms* (pp. 49–90). Stanford, CA: Hoover Institution Press.

Fletcher, J. M., & Taylor, H. G. (1984). Neuropsychological approaches to children: Towards developmental neuropsychology. *Journal of Clinical Neuropsychology, 6,* 39–56.

Fletcher, J. M., Taylor, H. G., Levin, H. S, & Satz, P. (1995). Neuropsychological and intellectual assessment of children. In H. I. Kaplan & B. J. Saddock (Eds.), *Comprehensive textbook of psychiatry* (Vol. 1, 6th ed.) (pp. 581–601). Baltimore: Williams & Wilkins.

Friedman, S. L., & Wachs, T. D. (Eds.) (1999). *Measuring environment across the life span.* Washington, DC: American Psychological Association.

Gaddes, W. H., & Crockett, D. J. (1975). The Spreen-Benton aphasia tests: Normative data as a measure of normal language development. *Brain and Language, 2,* 257–280.

Garb, H. N. (1998). *Studying the clinician: Judgment research and psychological assessment.* Washington, DC: American Psychological Association.

Gardner, R. A., & Broman, M. (1979). The Purdue Pegboard: Normative data on 1334 school children. *Journal of Clinical Psychology, 1,* 156–162.

Gordon, M. (1996). *The Gordon Diagnostic System.* DeWitt, NY: Gordon Systems.

Grant, M. L., Ilai, D., Nussbaum, N. L., & Bigler, E. D. (1990). The relationship between continuous performance tasks and neuropsychological tests in children with attention deficit hyperactivity disorder. *Perceptual and Motor Skills, 70,* 435–445.

Greenberg, L. M., & Dupuy, T. R. (1993). *Test of Variables of Attention.* Los Alamitos, CA: Universal Attention Disorders.

Greenough, W. T., & Black, J. E. (1992). Induction of brain structure by experience: Substrates for cognitive development. In M. R. Gunnar & C. A. Nelson (Eds.), *The Minnesota symposia on child psychology: Vol. 24, Developmental behavioral neuroscience* (pp. 155–200). Hillsdale, NJ: Erlbaum.

Hammill, D. D., & Larsen, S. C. (1996). *Test of Written Language—Third Edition.* Austin: Pro-Ed.

Heaton, R. K., Chelune, C. J., Talley, J. L., Kay, G. G., & Curtiss, G. (1993). *Wisconsin Card Sorting Test manual, revised and expanded.* Odessa, FL: Psychological Assessment Resources.

Holmes, J. M. (1987). Natural histories in learning disabilities: Neuropsychological difference/environmental demand. In S. J. Ceci (Ed.), *Handbook of cognitive, social, and neuropsychological aspects of learning disabilities* (pp. 303–319). Hillsdale, NJ: Erlbaum.

Holmes, J. M. (1988). History and observations. In R. Rudel (Ed.), *Assessment of developmental learning disorders: A neuropsychological approach* (pp. 144–165). New York: Basic Books.

Johnson, M. H. (1997). *Developmental cognitive neuroscience.* Cambridge, MA: Blackwell.

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. 125–168). Washington, DC: American Psychological Association.

Kaplan, E., Fein, D., Kramer, J., Delis, D., & Morris, R. (1999). *Wechsler Intelligence Scale for Children—Third Edition as a Process Instrument manual.* San Antonio, TX: The Psychological Corporation.

Kaplan, E., Goodglass, H., & Weintraub, S. (1983). *Boston Naming Test (Revised 60-item version).* Philadelphia: Lea & Febiger.

Kaufman, A. S., & Kaufman, N. (1997). *Kaufman Test of Educational Achievement—Normative update.* Circle Pines, MN: American Guidance Service.

Kavanagh, J. F. (Ed.) (1986). *Otitis media and child development.* Parkton, MD: York.

Kessler, J. W. (1980). History of minimal brain dysfunctions. In H. E. Rie & E. D. Rie (Eds.), *Handbook of minimal brain dysfunction: A critical view.* New York: Wiley.

Kirk, U. (1992). Evidence for early acquisition of visual organization ability: A developmental study. *The Clinical Neuropsychologist, 6,* 171–177.

Korkman, M., Kirk, U., & Kemp, S. (1998). NEPSY, *A Developmental Neuropsychological Assessment, manual.* San Antonio, TX: The Psychological Corporation.

Krikorian, R., Bartok, J., & Gay, N. (1994). Tower of London procedure: A standard method and developmental data. *Journal of Clinical and Experimental Neuropsychology, 16,* 840–850.

Leckliter, I. N., Forster, A. A., Klonoff, H., & Knights, R. M. (1992). A review of reference group data from normal children for the Halstead-Reitan Neuropsychological Test Battery for Older Children. *The Clinical Neuropsychologist, 6,* 201–229.

Levin, H. S., Culhane, K. A., Hartmann, J., Evankovich, K., Mattson, A. J., Harward, H., Ringholz, G., Ewing-Cobbs, L., & Fletcher, J. M. (1991). Developmental changes in performance on tests of purported frontal lobe functioning. *Developmental Neuropsychology*, 7, 377–395.

Lewis, B. A. (1992). Pedigree analysis of children with phonology disorders. *Journal of Learning Disabilities*, 25, 586–597.

Lezak, M. D. (1995). *Neuropsychological assessment* (3rd. ed.). New York: Oxford Univ. Press.

Loring, D. W., & Papanicolau, A. C. (1987). Memory assessment in neuropsychology: Theoretical considerations and practical utility. *Journal of Clinical and Experimental Neuropsychology*, 9, 340–358.

Lyon, G. R., & Flynn, J. M. (1991). Educational validation studies of subtypes of learning-disabled readers. In B. P. Rourke (Ed.), *Neuropsychological validation of learning disability subtypes* (pp. 233–242). New York: Guilford.

Markwardt, F. C. (1992). *Peabody Individual Achievement Test-Revised manual*. Circle Pines, MN: American Guidance Service.

Matarazzo, J. D. (1990). Psychological assessment versus psychological testing: Validation from Binet to the school, clinic, and courtroom. *American Psychologist*, 45, 999–1017.

Matthews, C. G., & Kløve, H. (1964). *Instruction manual for the Adult Neuropsychology Test Battery*. Madison, WI: Univ. of Wisconsin Medical School.

Mesulam, M-M. (1981). A cortical network for directed attention and unilateral neglect. *Annals of Neurology*, 10, 309–325.

Mesulam, M-M. (1998). From sensation to cognition. *Brain*, 121, 1013–1052.

Mirsky, A. F., Anthony, B. J., Duncan, C. C., Ahearn, M. B., & Kellam, S. G. (1991). Analysis of the elements of attention: A neuropsychological approach. *Neuropsychology Review*, 2, 109–145.

Naglieri, J., & Das, J. P. (1997). *Cognitive Assessment System administration and scoring manual*. Chicago: Riverside.

Nowakowski, R. S. (1987). Basic concepts of CNS development. *Child Development*, 58, 568–595.

Pennington, B. F. (1991). *Diagnosing learning disorders: A neuropsychological framework*. New York: Guilford.

Psychological Corporation. (1992). *Wechsler Individual Achievement Test manual*. San Antonio, TX: Author.

Psychological Corporation. (1999). *Wechsler Abbreviated Scale of Intelligence*. San Antonio, TX: Author.

Putnam, S. H., & DeLuca, J. W. (1990). The TCN professional practice survey: Part I. General practices of neuropsychologists in primary employment and private practice settings. *The Clinical Neuropsychologist*, 4, 199–244.

Rapin, I., Tourk, L. M., & Costa, L. D. (1966). Evaluation of the Purdue Pegboard as a screening test for brain damage. *Developmental Medicine and Child Neurology*, 8, 45–54.

Reitan, R. M., & Wolfson, D. (1992a). *Neuropsychological evaluation of older children*. South Tuscon, AZ: Neuropsychology Press.

Reitan, R. M., & Wolfson, D. (1992b). *Neuropsychological evaluation of young children*. South Tucson, AZ: Neuropsychology Press.

Reschly, D. J., & Graham, F. M. (1989). Current neuropsychological diagnosis of learning problems: A leap of faith. In C. R. Reynolds, & C. Fletcher-Janzen (Eds.), *Handbook of clinical child neuropsychology* (pp. 503–520). New York: Plenum.

Reynolds, C. R. (1989). Measurement and statistical problems in neuropsychological assessment of children. In C. R. Reynolds, & C. Fletcher-Janzen (Eds.), *Handbook of clinical child neuropsychology* (pp. 147–166). New York: Plenum.

Reynolds, C. R., & Bigler, E. D. (1994). *Test of Memory and Learning examiner's manual*. Austin: Pro-Ed.

Reynolds, C. R., & Fletcher-Janzen, E. (Eds.). (1997). *Handbook of clinical child neuropsychology (2nd ed.)*. New York: Plenum.

Reynolds, C. R., & Kamphaus, R. W. (1992). *Behavior Assessment System for Children manual*. Circle Pines, MN: American Guidance Service.

Rourke, B. P. (1989). *Nonverbal learning disabilities: The syndrome and the model*. New York: Guilford.

Rourke, B. P., Bakker, D. J., Fisk, J. L., & Strang, J. D. (1983). *Child neuropsychology: An introduction to theory, research, and clinical practice*. New York: Guilford.

Rourke, B. P., Fisk, J. L., & Strang, J. D. (1986). *Neuropsychological assessment of children: A treatment-oriented approach*. New York: Guilford.

Rourke, B. P., & Fuerst, D. R. (1991). *Learning disabilities and psychosocial functioning*. New York: Guilford.

Sattler, J. M. (1992). *Assessment of children* (3rd ed., revised). San Diego: Jerome M. Sattler.

Savage, R. C., & Wolcott, G. F. (Eds.) (1995). *An educator's manual: What educators need to know about students with brain injury (3rd ed.)*. Washington, DC: Brain Injury Association.

Sbordone, R. J., & Long, C. J. (Eds.) (1995). *Ecological validity of neuropsychological testing*. Delray Beach, FL: St. Lucie Press.

Semel, E., Wiig, E. H., & Secord, W. (1995). *Clinical Evaluation of Language Fundamentals—Third Edition manual*. New York: The Psychological Corporation.

Shaffer, D., O'Connor, P. A., Shafer, S. Q., & Prupis, S. (1983). Neurological "soft signs": Their origins and significance. In M. Rutter (Ed.), *Developmental neuropsychiatry* (pp. 144–163). New York: Guilford.

Sheslow, D., & Adams, W. (1990). *Wide Range Assessment of Memory and Learning administration manual*. Wilmington, DE: Jastak.

Slay, D. K., & Valdivia, L. (1988). Neuropsychology as a specialized health service listed in the National Register of Health Service Providers in Psychology. *Professional Psychology: Research and Practice*, 19, 323–329.

Sokol, S. M., Macaruso, P., & Gollan, T. H. (1994). Developmental dyscalculia and cognitive neuropsychology. *Developmental Neuropsychology*, 10, 413–441.

Sparrow, S. S., Balla, D. A., & Ciccetti, D. V. (1984). *Vineland Adaptive Behavior Scales*. Circle Pines, MN: American Guidance Service.

Spreen, O., & Benton, A. L. (1969). *Neurosensory Center Comprehensive Examination for Aphasia—1977 revision*. Victoria, BC: Univ. of Victoria Press.

Spreen, O., Risser, A. H., & Edgell, D. (1995). *Developmental neuropsychology*. New York: Oxford Univ. Press.

Spreen, O., & Strauss, E. (1998). *A compendium of neuropsychological tests: Administration, norms, and commentary (2nd ed.)*. New York: Oxford Univ. Press.

Squire, L. R. (1987). *Memory and brain*. New York: Oxford Univ. Press.

Strauss, A. A., & Lehtinen, L. (1947). *Psychopathology and education of the brain-injured child*. New York: Grune & Stratton.

Strauss, A. A., & Werner, H. (1941). The mental organization of the brain-injured mentally defective child. *American Journal of Psychiatry*, 97, 1194–1203.

Stuss, D. T., & Benton, D. F. (1984). Neuropsychological studies of the frontal lobes. *Psychological Bulletin*, 95, 3–28.

Sweet, J. J., & Moberg, P. J. (1990). A survey of practices and beliefs among ABPP and non-ABPP clinical neuropsychologists. *The Clinical Neuropsychologist*, 4, 101–120.

Tager-Flusberg, H. (Ed.) (1999). *Neurodevelopmental disorders*. Cambridge, MA: MIT Press.

Taylor, H. G. (1987). The meaning and value of soft signs in the behavioral sciences. In D. E. Tupper (Ed.), *Soft neurological signs: Manifestations, measurement, research, and meaning* (pp. 297–335). New York: Grune & Stratton.

Taylor, H. G. (1988). Learning disabilities. In E. J. Mash & L. G. Terdal (Eds.), *Behavioral assessment of childhood disorders* (2nd ed., pp. 402–450). New York: Guilford.

Taylor, H. G., Albo, V. C., Phebus, C. K., Sachs, B. R., & Bierl, P. G. (1987). Postirradiation treatment outcomes for children with acute lymphocytic leukemia. *Journal of Pediatric Psychology*, 12, 395–411.

Taylor, H. G., Barry, C., & Schatschneider, C. (1993). School-age consequences of *Haemophilus influenzae* Type B meningitis. *Journal of Clinical Child Psychology*, 22, 196–206.

Taylor, H. G., Drotar, D., Wade, S., Yeates, K. O., Stancin, T., & Klein, S. (1995). Recovery from traumatic brain injury in children: The importance of the family. In S. Broman & M. Michel (Eds.), *Traumatic brain injury in children*. New York: Oxford Univ. Press.

Taylor, H. G., & Fletcher, J. M. (1990). Neuropsychological assessment of children. In M. Hersen

& G. Goldstein (Eds.), *Handbook of psychological assessment* (2nd ed., pp. 228–255). New York: Plenum.

Taylor, H. G., Fletcher, J. M., & Satz, P. (1982). Component processes in reading disabilities: Neuropsychological investigation of distinct reading subskill deficits. In R. N. Malatesha & P. G. Aaron (Eds.), *Reading disorders: Varieties and treatments*. New York: Academic Press.

Taylor, H. G., Hack, M., & Klein, N. (1998). Attention deficits in children with <750 gm birth weight. *Child Neuropsychology*, 4, 21–34.

Taylor, H. G., Klein, N., & Hack, M. (2000). School-age consequences of <750 g birth weight: A review and update. *Developmental Neuropsychology*, 17, 289–321.

Taylor, H. G., & Schatschneider, C. (1992). Child neuropsychological assessment: A test of basic assumptions. *The Clinical Neuropsychologist*, 6, 259–275.

Taylor, H. G., Schatschneider, C., Petrill, S., Barry, C. T., & Owens, C. (1996). Executive dysfunction in children with early brain disease: Outcomes post *Haemophilus Influenzae* meningitis. *Developmental Neuropsychology*, 12, 35–51.

Temple, C. M. (1991). Procedural dyscalculia and number fact dyscalculia: Double dissociation in developmental dyscalculia. *Cognitive Neuropsychology*, 8, 155–176.

Temple, C. M. (1997). *Developmental cognitive neuropsychology*. East Sussex, UK: Psychology Press.

Thorndike, R. L., Hagen, E. P., & Sattler, J. M. (1986). *Stanford-Binet Intelligence Scale* (4th ed.). Chicago: Riverside.

Torgeson, J. K., Wagner, R. K., & Rashotte, C. A. (1999). *Test of Word Reading Efficiency examiner's manual*. Austin: Pro-Ed.

Trimble, M. R. (1987). Anticonvulsant drugs and cognitive function: A review of the literature. *Epilepsia*, 28 (supplement 3), 37–45.

Tyler, J. S., & Mira, M. P. (1999). *Traumatic brain injury in children and adolescents: A sourcebook for teachers and other school personnel* (2nd ed.). Austin: Pro-Ed.

Waber, D. P., Bernstein, J. H., Kammerer, B. L., Tarbell, N. J., & Sallan, S. E. (1992). Neuropsychological diagnostic profiles of children who received CNS treatment for acute lymphoblastic leukemia: The systemic approach to assessment. *Developmental Neuropsychology*, 8, 1–28.

Wachs, T. D., & Plomin, R. (Eds.) (1991). *Conceptualization and measurement of organism-environment interaction*. Washington, DC: American Psychological Association.

Wagner, R. K., Torgeson, J. K., & Rashotte, C. A. (1999). *Comprehensive Test of Phonological Processing examiner's manual*. Austin: Pro-Ed.

Wechsler, D. (1989). *Wechsler Preschool and Primary Scales of Intelligence—Revised*. San Antonio, TX: The Psychological Corporation.

Wechsler, D. (1991). *Wechsler Intelligence Scale for Children—Third Edition*. San Antonio, TX: The Psychological Corporation.

Wechsler, D. (1997a). *Wechsler Adult Intelligence Scale—Third Edition*. San Antonio, TX: The Psychological Corporation.

Wechsler, D. (1997b). *Wechsler Memory Scale—Third Edition*. San Antonio, TX: The Psychological Corporation.

Welsh, M. C., & Pennington, B. F. (1988). Assessing frontal lobe functioning in children: Views from developmental psychology. *Developmental Neuropsychology*, 4, 199–230.

Welsh, M. C., Pennington, B. F., & Groisser, D. B. (1991). A normative-developmental study of executive function: A window on prefrontal function in children. *Developmental Neuropsychology*, 7, 131–149.

Western Psychological Services. (1983). *Hooper Visual Organization Test—1983 edition*. Los Angeles: Author.

Wiig, E. H., & Secord, W. (1989). *Test of Language Competence-Expanded Edition*. San Antonio, TX: The Psychological Corporation.

Wilkinson, G. S. (1993). *Wide Range Achievement Test—Revision 3 manual*. Wilmington, DE: Jastak Associates.

Wirt, R. D., Seat, P. D., Broen, W. E., & Lachar, D. (1990). *Personality Inventory for Children—Revised*. Los Angeles: Western Psychological Services.

Woodcock, R., & Mather, N. (1989). *Woodcock-Johnson Tests of Achievement—Revised standard and supplemental batteries*. San Antonio, TX: The Psychological Corporation.

Yeates, K. O. (1994). Comparison of developmental norms for the Boston Naming Test. *The Clinical Neuropsychologist*, 8, 91–98.

Yeates, K. O. (2000). Closed-head injury. In K. O. Yeates, M. D. Ris, & H. G. Taylor (Eds.), *Pediatric neuropsychology: Research, theory, and practice* (pp. 92–116). New York: Guilford.

Yeates, K. O., Blumenstein, E., Patterson, C. M., & Delis, D. C. (1995). Verbal learning and memory following pediatric closed-head injury. *Journal of the International Neuropsychological Society*, 1, 78–87.

Yeates, K. O., Enrile, B. E., Loss, N., Blumenstein, E., & Delis, D. C. (1995). Verbal learning and memory in children with myelomeningocele. *Journal of Pediatric Psychology*, 20, 801–815.

Yeates, K. O., MacPhee, D., Campbell, F. A., & Ramey, C. T. (1983). Maternal IQ and home environment as determinants of early childhood intellectual competence: A developmental analysis. *Developmental Psychology*, 19, 731–739.

Yeates, K. O., Ris, M. D., & Taylor, H. G. (2000). *Pediatric neuropsychology: Theory, research, and practice*. New York: Guilford.

Yeates, K. O., & Taylor, H. G. (1998). Neuropsychological assessment of older children. In G. Goldstein, A. Puente, & E. Bigler (Eds.), *Human brain function, assessment and rehabilitation: Vol. III, Neuropsychology* (pp. 35–61). New York: Plenum.