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Neuropsychological Assessment of Developmental and Learning Disorders

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INTRODUCTION

Neuropsychological assessment plays an important role in the diagnosis and treatment of children with developmental and learning disorders. A neuropsychological evaluation can provide critical information regarding the integrity of the central nervous system and give a detailed picture of a child's neurocognitive functioning[i] across a wide range of abilities. Notably, neuropsychological assessment can contribute to a functional developmental approach by elaborating upon a child's unique profile of strengths and weaknesses and the particular component skills and processing deficiencies that may be contributing to developmental, learning, and social-emotional adaptation or difficulty. Neuropsychological assessment can help distinguish neurogenic (brain-based) from psychogenic (psychological) conditions, sort out how problems in one domain of functioning may impact on another, and guide educational, remedial, and psychotherapeutic interventions. Neuropsychological assessment can also be used for monitoring progress or deterioration over time, and for refining our understanding of the diversity and commonalities that may be inherent to a given developmental disorder across children.

In what follows, a summary description of what is involved in neuropsychological evaluations of children with developmental or learning disorders will be offered. The chapter will review some basic issues in child neuropsychological assessment, offer some guiding principles and procedures for the assessment process, and give an overview of a format for a comprehensive assessment.

To be noted is that the evaluation approach to be sketched here is not a conventional one: For one, as neuropsychological, it uses knowledge of brain-behavior relationships to orient its assessment and interpretation procedures. Moreover, it goes beyond a primary focus on standardized procedures, structured tests, and quantitative levels of performance that may characterize more traditional psychometric approaches in psychological or educational testing. These may fall short of capturing who the child with a developmental or learning disorder may inherently be because not exploratory nor flexible enough, nor focused sufficiently on the dynamic process of how the child learns and the ways in which he can and cannot demonstrate what he knows. An evaluation must, importantly, capture the impact that any handicapping condition may have on the child's ability to participate in the assessment process, perform on any test, or function

adequately in life. For many children, especially those with disorders in relating and communicating, a more therapeutic, flexible, and clinically insightful approach must also be adopted in order to woo the child into performing in a way commensurate with what he can do, or in order to find out what strategies will work to enhance functional developmental capacities, adaptation, and learning. In addition, the approach outlined here is an integrative one: It integrates neuropsychological assessment with clinical understanding of the child's inner world, as well as family and school system issues, in order to provide a more powerful diagnostic procedure that can also disclose the possible interweaving of both psychological and neuropsychological issues in the subjective experience and behavior of the child.

The aim of this chapter is to provide an overview of an approach to neuropsychological evaluation that can serve as a guide to assessing children with *a wide range of developmental and learning problems.* Its focus is not limited to children with the more severe disorders, such as autism or pervasive developmental disorders (PDD) (see, for example, Lord, 1997; Sparrow et al, 1997). Yet, the principles to be reviewed here can be applied to assessment of children who show overt, severe difficulties as well as more hidden ones. For young children on the spectrum of disorders in relating and communicating, these guidelines may be particularly relevant for those children who show characteristics (e.g., mild to moderate processing difficulties, intermittent symbolic capacities) similar to a subgroup of children identified as making rapid progress over time and showing eventually more subtle problems (Type I Disorder in relating and communicating, Greenspan & Wieder, 1997, 1999). Neither is this chapter meant to be a detailed treatment of the various issues and approaches to developmental neuropsychological assessment currently in practice, for which there are a number of resources. (Baron, Fennell, & Voeller, 1995; Bernstein & Waber, 1990, Fennell & Bauer, 1997; Fletcher & Taylor, 1984; Gaddes, 1985; Hynd & Obrzut, 1981; Hynd & Willis, 1988; Obrzut & Hynd, 1991; Pennington, 1991; Reynolds & Fletcher-Janzen, 1997; Rourke, Bakker, Fisk, & Strang, 1983; Rourke, Fisk, & Strang, 1986; Spreen, Risser, & Edgell, 1995; Stefanatos & Black, 1997; Teeter & Semrud-Clikeman, 1997; Vanderploeg, 1994; Wilson, 1987, 1992). Rather, it will briefly highlight some issues distinctive to child neuropsychology and focus on an assessment approach that emphasizes especially the importance of seeking out ways to capture a child's inherent abilities so as to best promote a child's cognitive and emotional development.

A summary of when, generally, to seek a neuropsychological evaluation is contained in Chart 1.

A NEUROPSYCHOLOGICAL APPROACH TO EVALUATION: ISSUES DISTINCTIVE TO DEVELOPMENTAL NEUROPSYCHOLOGY

What is Neuropsychological Assessment?

Neuropsychological assessment is distinguished from other forms of assessment primarily by its attempt to understand a child's behavioral and psychological functioning in terms of brain-behavior relationships. In contrast to psychological assessment of a child's intellectual and personality functioning, a neuropsychological evaluation bases its exploration and interpretation of a broad range of functions—spanning reasoning, attention, language, memory, visual, sensory-perceptual,

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Chart 1.
When to Seek a Neuropsychological Evaluation

- When it is unclear whether or to what extent overt emotional, behavioral, or learning problems have a basis in CNS dysfunction.
- When greater specificity in a child's unique profile of strengths and weaknesses is sought for therapeutic, educational, or remedial planning.
- When a baseline understanding of the child's functioning is needed to monitor growth and progress or the effectiveness of therapeutic interventions (e.g., biomedical, social, remedial).
- When there is a complicated condition that gives rise to differing opinions and a clearer differential diagnosis is sought.
- When a more active brain process or neurological condition may be suspected and needs to be ruled out.

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motor, as well as affective and personality functioning—on a theory and model of the developing brain and on an understanding of brain-behavior relationships. A principle goal of a neuropsychological evaluation is to determine the extent to which a child's possible difficulties in, for example, thinking, attending, talking, listening, remembering, learning, or even in emotional lability or behavioral disturbances, may form a *pattern of impairment related to central nervous system (CNS) dysfunction*. When coupled with clinical understanding of psychological dynamics in child and family, neuropsychological assessment can also contribute to uncovering how neuropsychological dysfunction may become exacerbated by or implicated in psychological conflict (Black, 1995, 1997).

Neuropsychological interpretation of a child's functional difficulties rests on the integration of data obtained from performances on formal and informal tests, clinical observations, and history (including the child's developmental, medical, educational, social, and cultural history), with what is known about the pathophysiology, brain basis, and neuropsychological profiles of different neurologically based developmental conditions.

Although an understanding of brain development and brain-behavior relationships may set it apart, many of its assessment principles and procedures may, nevertheless, overlap with good psychological assessment practice. Thus, the guidelines proposed here are considered applicable to good practice in psychological assessment more generally. Neuropsychological assessment, as put forward here, rests fundamentally on an hypothesis-testing approach that incorporates principles of dynamic learning into its core assessment procedures, understands the multifactorial nature of complex tests and behavior, and is inherently comprehensive and integrative in its approach to understanding the whole child in the context of his environment.

Understanding Brain-Behavior Relationships, Brain Maturation, and Brain Plasticity

Child neuropsychology has emerged as a distinct area within the field of clinical neuropsychology largely as a consequence of the recognition that brain-behavior relationships in children differ in many ways from those established in adults. The developmental context of child neuropsychology requires that attention be paid to normal brain maturation and its correlation with the changing complex processes that develop over childhood, as well as to the changing environmental demands placed upon children as they grow.

It also requires an understanding of sensitive periods, brain plasticity, and the dynamic changes that may result from neural dysfunction and repair at various stages of development (Broman & Fletcher, 1999; Dawson & Fisher, 1994; Elman et al., 1998; Gunnar & Nelson, 1992; Johnson, 1997; Kolb, 1995; Spreen, Risser, & Edgell, 1995; Stiles, Bates, Thal, Trauner, & Reilly, 1998).

Recent Developments in Understanding Different Developmental and Learning Disorders

There has been an impressive refinement of theory and practice in child neuropsychology especially during the last 10 years, which has witnessed a wealth of research and cross-fertilization of information across disciplines during the 1990's "decade of the brain." Developments in understanding brain maturation and the dynamic relationship between brain development, behavior, and the environment have begun to be woven into its theoretical framework and assessment principles (Bernstein & Waber, 1990; Dawson & Fischer, 1994; Spreen et al., 1995; Taylor & Schatschneider, 1992). Technological advances in brain imaging techniques, such as volumetric and functional Magnetic Resonance Imaging [MRI], Position Emission Tomography [PET], Single Photon Emission Computer Tomography [SPECT], Brain Electrical Activity Mapping [BEAM], EEG Coherence Studies, Magnetic Source Imaging [MIS] and event-related brain potentials (ERP), have enabled documentation of neuroanatomical abnormalities and substrates of many different disorders and facilitated understanding of brain development and brain functioning even in very young infants and children (e.g., see Bell and Fox, 1994; Chugani, 1994; Dawson, 1994; Duffy, 1994; Gunnar & Nelson, 1992; Huttenlocher, 1994;

Molfese & Molfese, 1994; Thatcher, 1994). Refined quantitative and statistical techniques, informed by continuing growth in the neuropsychological understanding of different childhood conditions, have generated ways of capturing the heterogeneity inherent in different developmental and learning disorders through subtyping paradigms (Hooper & Willis, 1989, Rourke, 1985, 1991; van Santen, Black, Wilson, & Riscucci, 1994). Research into neurocognitive profiles associated with various neurological syndromes and psychiatric conditions has increased awareness of the possible overlap, co-mobidity, and continuum of conditions previously thought of as diverse, while enhancing conceptualization and differential diagnosis of distinct disorders.[ii]

Evidence through neuroimaging, autopsy, and neuropsychological research studies, has been providing ample testimony to the role that CNS dysfunction plays in developmental and learning disorders, and has begun to specify areas and systems of the brain that may be involved. Thus, for example, in contrast to early characterizations of autism and related disorders as forms of "psychotic withdrawal" attributed to problematic parenting, present day neuroscientific research has been disclosing possible involvement of different brain areas. These areas include, among others, medial temporal lobe abnormalities in cell density and size in the limbic system's hippocampus and amygdala (Bauman & Kemper, 1994; Kemper & Bauman, 1998); cerebellar and brainstem hypoplasias (Bauman & Kemper, 1994; Courchesne, 1989; Courchesne, Yeung-Courchesne, Press, Hesselink, & Jernigan, 1988; Courchesne et al., 1994a, 1994b; Courchesne, Yeung-Courchesne, Townsend, & Saitoh, 1994; Bailey et al.,1998); excess white matter in temporal and posterior parietal-occipital regions (Filipek, 1996; Filipek et al., 1992), and, generally, involvement of multiple brain

systems, with subcortical-cortical reciprocal influences (Dawson & Levy, 1989). From these studies and others, Waterhouse, Fein, and Modahl (1996), for example, have concluded that dysfunction in multiple overlapping neural mechanisms can explain certain observed behavioral dysfunctions in autism; in particular, problems in cross-modal sensory integration, impaired affective understanding, asociality, as well as problems in extended selective attention, fluid shifting of attention, effective working memory, ability to process complex stimuli, and other skills necessary for normal interaction, language acquisition, and play. (See also Zimmerman and Gordon, Chapter 27, "Neuromechanisms in Autism," this volume). *Neuropsychology's understanding of brain-behavior relationships grows as does its ability to identify the constellation of functional issues that fundamentally define a disorder with enhanced information about underlying neural mechanisms.*

Evidence for the neurogenic basis of reading and other types of learning disabilities has also been advancing and offsetting earlier misunderstandings of learning disabled children as "lazy," "stupid," or "lacking motivation." For example, dyslexia, understood as a specific reading disorder, has been related to the absence of normal asymmetry of the planum temporale, and to the presence of neuronal ectopias in the molecular layer of the left perisylvian cortex (Galaburda et al., 1989; Galaburda, 1991, 1993).[iii] This neural picture may help explain the functional difficulties in auditory and phonological processing experienced by many children with reading disabilities and provide a rationale for certain targeted remedial approaches. Developmental language disorders, for which there are different identified subtypes, have been shown to relate to many different areas of CNS involvement (Jernigan, Hesselink, Sowell, & Tallal, 1991). Studies of attention

deficit disorder give evidence for involvement of frontal-striatal circuitry (Casey et al., 1997; Castellanos, Giedd, & Eckberg, 1994; Castellanos et al., 1996; Filipek, 1997; Giedd & Castellanos, 1997; Heilman, Voeller, & Nadeau, 1991; Lou, Henriksen, & Bruhn, 1984; Lou, Henriksen, Bruhn, Borner, & Nielsen, 1989; Mirsky, 1996; Mirsky, Anthony, Duncan, Oherin, & Kellam, 1991; Mirsky, Fantie, & Tatman, 1995; Swanson & Castellanos, 1998; Zametkin, 1990) as well as cross-hemisphere fibers of the corpus callosum and smaller right frontal regions (Giedd et al., 1994; Hynd, Semrud-Clikeman, Lorys, Novey, & Eliopulus, 1990; Hynd et al., 1991a, 1991b; Semrud-Clikeman et al., 1994). *The implications of these studies for neuropsychological assessment are that behavioral measures can then be developed and used which tap into the functions known to relate to the different neural systems identified, thus contributing to more sensitive means for differential diagnosis of developmental and learning disorders.*

A Model of Brain-Behavior Relationships

A fundamental assumption in developmental neuropsychology, then, is that the overt behavioral difficulties involved in different developmental and learning disorders result from dysfunction of specific areas and systems of the brain. According to some models of cerebral function (Das & Varnhagen, 1986; Geshwind & Galaburda, 1987; Goldberg, 1995; Luria, 1973, 1980; Mesulam, 1985), the brain is considered to be a highly differentiated organ comprised of numerous systems or neural networks that are specialized to mediate a particular "domain" of behaviors while acting in a dynamic, integrated way. These neural systems subserve different roles in the acquisition, organization, and use of information. Anatomically distinguishable networks

have been identified that mediate particular aspects of behavior such as language expression and comprehension, spatial abilities, memory, attention, and emotional processing. For example, for right-handed individuals, an area in the frontal lobe of the left cerebral hemisphere is thought critical to processes for oral word production, and an area of the left posterior temporal lobe is thought critical to processes involved in language comprehension. Frontal or anterior cortical regions have been associated with goal-directed and regulatory behavior, as well as aspects of attention. Other aspects of attention seem to be mediated by diverse areas such as, for example, the brain stem, portions of the limbic system, basal ganglia, superior temporal and inferior parietal cortices, and cerebellum (Akshoomoff, Courchesne, & Townsend., 1997; Castellanos, Giedd, & Eckberg, 1994; Castellanos et al., 1996; Denckla, 1994, 1996; Denckla & Reiss, 1997; Furster, 1989; Heilman et al., 1991; Mirsky, 1996; Mirsky et al., 1991, 1995).

Different networks or systems are thought to be distributed over different neural axes that define the functional parameters of the CNS. These include the anterior-posterior, lateral (left hemisphere-right hemisphere), and cortical-subcortical axes. Complex fiber networks interconnect different regions within and between different axes. All behavior is assumed to be then a function of the dynamic interaction among interconnected systems and subsystems. Dysfunction in particular cortical areas is assumed to result in difficulties in domains of behavior thought to be mediated, directly or indirectly, by those areas or interconnected systems.

Child Developmental Disorders vs. Adult Acquired Disorders: The Role of Brain Plasticity

Developmental and learning disorders are considered to represent congenital and static CNS dysfunction as opposed to acquired and progressive conditions. Despite the specific brain systems being identified for various conditions, it is generally thought that children with developmental and learning disorders may not have outright "deficits" on neuropsychological testing such as can be found, for example, in focal brain lesions caused in adults by a stroke or tumor. Instead, with *developmental disabilities and learning disorders, a more diffuse* (involving multiple brain areas) *and sometimes subtle picture of CNS involvement is often present.* Neuropsychological dysfunction in children can be hidden from view because overlaid by other issues or compensated for in various ways.

This is especially the case given the plasticity of the brain. Brain plasticity refers to the ability of the immature nervous system to change or reorganize in response to trauma or experience. The concept arose out of observations that damage to the cortex early in life often resulted in far more limited impairment than when sustained later in development. One of the processes thought to mediate neural plasticity is that uncommitted or undercommitted areas of the brain that have an exuberance of synaptic connections and resources can subsume functions that would normally have been subserved by the damaged area (Huttenlocher, 1990, 1994). Thus, when there is overt damage to specific areas of the brain, alternative neural pathways can be stimulated and reorganization may occur so that affected functions may be taken over by other areas (Burnstine, Greenough, & Tees, 1984). This can result in "alternative pathways" or "atypical circuitry" (Goldman-Rakic, Isseroff, Schwartz, & Bugbee, 1983). Changes in the organization of a brain system may sometimes, however, go on to affect, in a dynamic way, yet other functions, and as a consequence compensating areas themselves may become less efficient. For example,

localized damage to the left inferior frontal cortex, which would impair speech production in adults, results in a brief period of disruption in children followed by substantial recovery (Aram & Eisele, 1992; Bates, 1999; Dennis, 1988; Stiles et al., 1998). This recovery of function is thought to be mediated, at least in part, by reorganization of language either intrahemispherically or in the contralateral hemisphere (Bates, Vicari, & Trauner, 1999; Rasmussen & Milner, 1977). Moreover, in some cases where there is reoganization of language to the right hemisphere, diminished right hemisphere functions, such as weakened visual-spatial skills, can result (Nass, Peterson, & Kork, 1989; Teuber & Rudel, 1962). Establishment of alternative pathways may also describe what is happening when strategies for reading used by reading disabled subjects are studied: For example, Frank Wood and his colleagues (Wood, Felton, Plowers, & Naylor, 1991), using a measure of cerebral blood flow detection, showed that during a task requiring processing of auditory verbal stimuli (e.g, words heard had to be analyzed as to the number of sounds in them), there was activation at Wernicke's area in the temporal region of the left hemisphere in normal subjects, but less activation in this area in reading disabled subjects and, instead, excessive activation in the area of the angular gyrus. This, it was interpreted, could imply either an altered connectivity with structurally displaced location of axons in dyslexics, or their use of a less efficient compensatory strategy because of disturbed connections.[iv] Once brain systems have fully matured, compromise by a lesion may not result in significant reorganization, and an individual may likely experience more permanent changes in affected skills.

Various brain regions become functional at different times in development and, until the region is functional, the effect of an early lesion may not be evident. The age at which a CNS disturbance occurs is thus also important, as is knowledge of brain maturation timetables as to when particular brain systems mature. The notion that it is "better to have your brain injuries early," referred to as the Kennard Principle after Margaret Kennard who described such effects in the motor system (Kennard, 1942), has expressed the resiliency of the young brain to compensate for early injuries. Since formulated, this principle has been expanded to include a more in-depth understanding that sometimes deficits can be delayed or reemerge or result in anomalous behavior later on, depending on timing and brain location (Kolb, 1995). If, for example, an insult (which can either be acquired or genetically targeted to unfold) is to a region that has not yet matured, one may see behavioral disturbances only then when the anatomic substrate becomes critical for some neuropsychological function. This is what is called "growing into a deficit." The phenomenon of "growing into a deficit" has been suggested, for example, as one of a number of possible explanations for the regression in functioning sometimes seen in cases of autistic spectrum disorders in children at around age 19 to 22 months.[v] It is at this age, it is reasoned, that the functions specific to the maturation of the limbic system's amygdala and hippocampus, considered to be affected in autistic individuals, become developmentally important. At around this age, the normal developing child develops representational memory, flexible accommodation schemes, and the ability to learn in novel situations, functions in part attributable to the maturing amygdala and hippocampus. Things might start to fall apart, it has been speculated, at a time when these brain areas, found to be too small with too densely packed cells and with reduced complexity of dendritic arbors in autistic subjects, are supposed to mature and

subserve age-appropriate functions (Bachelevier, 1994, 1997; Bauman, 1997; Kemper & Bauman, 1998; Overman, 1990). Similar factors may also determine late onset of other neurologic conditions that may have their origin much earlier in the perinatal period. For example, temporal lobe epilepsy may sometimes result from high forceps delivery, although seizures do not emerge until early adolescence.

Given continuing mylenation and brain maturation during childhood, and the positive effects on brain growth that can result from experiential learning and optimal conditions (Greenough & Black, 1992; Nelson, 1999), including appropriate and timely remediation, functional difficulties can also be compensated for and a child can "grow out of a deficit" as well. Thus, in children who have nonverbal learning disabilities (NLD), graphomotor functions may greatly improve in later childhood (Rourke, 1989). Visual-spatial and organizational difficulties may become ameliorated with hormonal changes and the onset of puberty (Bernstein, 1991; Stiles et al., 1998). In children with language and reading disorders, auditory processing, language comprehension, and reading inefficiencies may subside with directed remediation (Alexander, Anderson, Heilman, Voeller, & Torgeson, 1991; Baaker & Vinke, 1985; Bell, 1991b; Howard, 1986; Korkman & Peltomaa, 1993; Lindamood, & Lindamood, 1997; Lovett et al., 1994; Merzenich et al., 1996; Tallal, 1996.).

The absence of focal deficits and the phenomenon of neural plasticity all imply what Martha Denckla has called a "*pastel*" version of symptomatology in children (Denckla, 1979a). Child neuropsychological assessment of developmental conditions is thus different from assessment of adult conditions. This is reflected in some of its principles and procedures, which are aimed at assessing

sometimes subtle and "*relatively inefficient*" areas of functioning across a broad range of skill areas (Black, 1989; van Santen et al., 1994; Wilson, 1987) As will be seen, sometimes these inefficiencies reveal themselves in relatively weak rather than deficit scores; in compensatory efforts, successful or not; and in less than optimal coping strategies, which can increase emotional issues, processing time, lead to certain types of errors, or affect adequate functioning in other domains.

A Process-Oriented Approach to Child Neuropsychological Assessment

There are different approaches to child neuropsychological assessment. The one to be described here is not a fixed battery approach (e.g., Halstead-Reitan Battery) (Golden, 1980; Reitan & Wolfson, 1985; Russell, 1994), which uses a fixed number and grouping of tests, with interpretations made on the basis of quantitative analyses. A battery approach relies on data derived mainly from standardized tests, and uses algorithms, pattern analysis, and indices made up of scores from groups of tests, rather than individual subtests, in order to identify brain impairment, laterality of impairment, and empirical patterns typical of different diagnostic conditions. The approach to be described here is also not a clinical-inferential approach that makes use mainly of clinical experience and qualitative analyses without the use of any standardized tests.

Rather, the approach outlined here is a process-oriented, flexible approach that makes use of both quantitative and qualitative data, uses knowledge of brain-behavior relationships, information about performances of children with a variety of developmental and neurological disorders, and an understanding of the dynamic interplay between neural and behavioral systems and the environment to

guide its assessment and neuropsychological interpretations (see Bernstein & Waber, 1990; Wilson & Risucci, 1986; Wilson, 1992). A process-oriented approach (see Bauer, 1994; Kaplan, 1990; Luria, 1973, 1980; Wilson, 1986, 1987, 1992), rests on a few core features, which will be described in greater detail in what follows. Briefly sketched, they include the key principle that observing and reporting *the way in which a problem or task is solved* may be as useful and sometimes even more important for understanding neuropsychological functioning *than any actual score* achieved. Thus observations and considerations of *how* a performance is accomplished, *rather than merely what* a child scored, become critical (Wilson, 1992).[vi] A process approach will look to the processing requirements of different tasks, their input and output demands, and to the nature of the child's handicaps, and continually, in a reiterative hypothesis-testing manner, find increasingly "process-pure" ways to determine what is impacting on performance. This will also involve, for example, testing of limits, modifying standardized procedures, and including strategies for enhanced learning to get at what is holding a child back or what will facilitate a child's performance. As one child neuropsychologist, Barbara Wilson, has put it, "such an approach requires that the question be: 'What needs to be assessed?' rather than 'What test to use?'" If the question about the child can be specified, then an appropriate way of "measuring" it can be found, whether one uses a standardized test or improvised procedure (Wilson, 1987).

THE ASSESSMENT PROCESS

Neuropsychological Functions and Domains of Assessment

The list of neuropsychological functions listed in Chart 2 stems from areas known to be affected in developmental disabilities of various kinds as well as in neurological conditions. *They are skills that relate to different systems and subsystems in the brain with a neuropsychological evaluation seeking to find out whether consistent, known behavioral clusters or patterns of functioning within and between these different areas are conjointly affected.* This list gives examples of functions assessed; it is not exhaustive. The functions listed have been developed as a result of knowledge of brain-behavior relationships, empirical and subtype studies of specific disorders, and are built up and amended with ongoing research. (Also included in Chart 2 are more overarching domains, such as overall cognitive functioning, academic functioning, and personality functioning.)

Some examples of measures which can be used for assessing functioning in the different domains are contained in a chapter appendix. The measures chosen are restricted to young children ages 2 to 10.

Some Guiding Principles and Procedures of Child Neuropsychological Assessment

Some key principles and strategies that orient our approach to assessment include understanding the need for:
- Breadth of Assessment (range of functions assessed)
- Depth of Assessment (developmental history and view of the child over time and in different contexts)
- Formal and Informal Assessment Procedures
- Use of Standardized Tests: Advantages and Disadvantages
- Criteria for Choosing Appropriate Measures
- Task Analysis of Complex Behaviors

Chart 2. Neuropsychological Functions and Domains of Assessment

- **Organizational and Executive Functions and Attention**
  – Vigilance and selective attention
  – Mental tracking and cognitive flexibility
  – Organized systematic functioning (e.g., visual search; planning vs. acting impulsively; problem solving; cause-and-effect reasoning).
  – Initiating, sustaining, and shifting of attention; inhibiting distractions
  – Dynamic motor coordination and integration
  – Motor persistence and modulation
  – Alertness and arousal

- **Language-Related Functions**
  – Auditory processing (e.g., auditory discrimination, analysis, sound blending)
  – Phonological production and speech
  – Auditory cognitive functions
    – Language comprehension
    – Expressive language

- **Memory Functions**
  – Verbal memory
  – Visual memory
  – Memory and learning

- **Visual-Related Functions**
  – Visual-perceptual functions
  – Visual-spatial functions
  – Visual cognitive functions

- **Sensory Perceptual Functions**
  – Auditory, visual, tactile perception
  – Finger agnosia and stereognosis

- **Motor Functions**
  – Fine and gross motor coordination
  – Graphomotor functions
  – Praxis

- **Affect Sensitivity**
  – Visual, vocal, contextual affect processing
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- **Overall Cognitive Functioning**
  (e.g. performances on "intelligence" measures, including analysis of the impact that neuropsychological dysfunction and/or emotional issues may be having on resulting scores)

- **Academic Functioning**
  (e.g., performances on spelling, reading [word attack, word identification, reading comprehension], mathematics, and writing measures, including analysis of the impact that specific neuropsychological weaknesses and/or emotional issues may be having on resulting scores)

- **Social-Emotional/Personality Functioning**
  (e.g. performances on projective measures, standardized questionnaires, clinical observations)

- Testing of Limits and Modification of Test Procedures
- Reiterative Hypothesis-Testing Strategies
- Determining Cognitive Potential and Establishing a Neuropsychological Profile of Strengths and Weaknesses
- Neuropsychological Integration and Interpretation of the Data
- Diagnostic Formulation and Recommendations

The following sections attempt to review these critical components of the assessment process.

Breadth of an Assessment

An assessment should have sufficient "breadth;" that is, coverage of the range of functions targeted for evaluation, as outlined in Chart 2. A neuropsychological evaluation typically covers such a broad range of skills in order to assess for CNS integrity and to disclose *patterns of impairment* typical of a disability. Besides the fact that all neural axes and functional systems need to be explored in order to do this (e.g., the anterior-posterior axis; the lateral, left-right axis; the cortical-subcortical axis) (Bernstein & Waber, 1990; Luria, 1973), which necessitates completeness and balance in the range of functions looked at, breadth of assessment is necessary in developmental and learning conditions for a number of reasons:

First, a developmental disability is rarely identified by *one core deficit*, but, as mentioned, usually entails more *diffuse CNS involvement*, that is, involves more than one focal brain area. Breadth of assessment is necessary then to be able to discern such diffuse CNS dysfunction.

Second, the overt manifestation of a given disability may be very different in different children. This may reflect the etiological diversity of many developmental conditions

as well as the inherent variation across individuals, possibly due to the interweaving of genetics, environment, and maturation. For this reason, as well as because of the effects of plasticity as described earlier, neuropsychological assessment will often recognize the *heterogeneity* involved in different developmental and learning disorders. Research into the neuropsychological profiles of different subtypes of developmental disorders captures this heterogeneity. Subtypes, which are shorthand descriptions of the different possible neuropsychological profiles characteristic of a given disorder, have been proposed, for example, for reading disorders (Baaker, 1979, 1992; Denckla, 1979b; Mattis, French, & Rapin, 1975; Petrauskas & Rourke, 1979; Shaywitz et al., 1996), arithmetic disabilities (Keller & Sutton, 1991; Rourke, 1993), childhood language disorders (Aram & Nation, 1975; Black, 1989; Rapin & Allen, 1983; Rapin, Allen, & Dunn, 1992; van Santen et al., 1994; Wilson & Risucci, 1986), attention deficit disorders (Hynd et al., 1991b; Mirsky, 1996; Mirsky et al., 1991, 1995; Pennington, 1991), and pervasive developmental disorders (Klin, Volkmar, Sparow, Cicchetti, & Rourke, 1995). Each subtype of a developmental or learning disorder can be described in terms of its own characteristic *pattern of neuropsychological assets and deficits.*

Neuropsychological subtyping in developmental language disorders (DLD), for example, also makes clear that there is more affected in a language disorder than simply language-related functions. It is, in fact, the presence or absence of memory impairments, nonverbal visual-spatial and visual-cognitive impairments, or even affective processing deficits and emotional difficulties that can differentiate one subtype of DLD from another (Black, 1989; Rapin, 1996; van Santen et al., 1994; Wilson, 1986).

Thus, breadth of assessment is necessary for evaluating the distinctive patterns of impairment that characterize a disorder, and which may distinguish it from other disorders. A neuropsychological evaluation of a child with a DLD, in contrast to a language evaluation, would assess not merely expressive and receptive aspects of language functioning, but nonverbal cognitive, memory, organizational, attentional, perceptual, and motor functions. Important diagnostic information is thereby obtained, including greater insight into the child's nonverbal cognitive potential and information critical for identifying membership in a specific neuropsychological subtype group. A developmental language disorder otherwise hidden from view, or possibly confused with another disability, may then be identified (Black, 1997). Furthermore, since specific vulnerabilities and prognostic outcomes are also correlated with specific subtypes of DLD (Wilson & Risucci, 1988), such differential diagnosis, made real by the breadth of an assessment, also allows for long-term planning and remediation. Open channels and strengths, also disclosed because of the breadth of an assessment, can help generate specific compensatory and remedial recommendations for the individual child.

Thus, breadth of assessment is necessary because the goals of an evaluation include discerning *patterns of impairment* suggestive of a specific developmental or learning disorder, distinguishing one type of developmental disorder from another, and finding open channels and strengths for remediation.

Third, breadth of assessment is also necessary because most presenting problems, such as difficulties in listening, understanding, expressing oneself, and reading, are themselves inherently complex. The neuropsychologist uses a task analytic approach to understand higher cortical functions such as

these (Luria, 1973, 1980). Activities such as reading involve, from the neuropsychological perspective, a myriad of component skills. To understand why a complex skill may be deficient, one must be able to hone in on each of the component skills in order to find out what is contributing to the difficulty. Some of the component skills in reading, as an example, can include auditory processing skills (e.g., discrimination, analysis, and blending of sounds, and maintenance of sequences of sounds in memory—all a part of phonemic awareness), visual-perceptual discrimination of letters, association of letters with sounds, visual scanning, speed of processing, and comprehension of semantically and syntactically complex language. These correspond to multiple brain areas and systems, including cortical temporal, frontal, parietal, and occipital regions, as well as subcortical areas. There is a one-to-many relationship here of reading, as the index problem, to the many different component processes and possible neural substrates. There is also the possibility of there being a many-to-one relationship, where many different behaviors can be affected given one affected brain region.

The brain acts in an integrated way, linking up many highly differentiated systems and subsystems to eventuate in a higher cortical process or a complex behavior. A neuropsychological assessment will want to span the functions attributable to many different areas and systems to understand what is behind a deficient performance or a dysfunctional behavior. The intent of the assessment in evaluating for a developmental or learning disorder is to disclose the impaired component skills that lead to the complex skill breaking down. Breadth of assessment is necessary, then, because in neuropsychological evaluation one is engaged in differential understanding of complex presenting issues which may depend upon different and inter-related brain systems.

Depth of Assessment

Neuropsychological assessment necessarily has "depth" in the sense that it includes past, present, and future information in its attempts to neuropsychologically interpret the data. "Depth" reflects on the evaluation's fundamentally developmental and integrative orientation.

Depth means that it is inherently developmental, incorporating knowledge of brain development as well as developmental expectations across all functions—motor, language, cognitive. The child's brain continues to mature and to be vulnerable to different environmental influences and demands made upon it at different developmental stages and ages. Signs of impairment, as discussed earlier, may emerge, submerge, and re-emerge later on in the life cycle in different forms, not only in response to genetic unfolding, brain maturation, and plasticity but also in response to environmental stress or support. This opens up interpretative challenges; it also allows a future-oriented perspective to the evaluation, and opens up opportunities, as well, for making recommendations to intervene in the child-environment system.

Depth also includes knowledge of the child's personal history and developmental growth. The presence of risk factors such as prenatal, perinatal, and neonatal conditions, medical history, developmental milestones, as well as family and social-emotional factors, can provide a framework for raising hypotheses, in particular about possible etiology and other factors contributing to current problems.

The child's place within the family system and larger environmental context is important to know, especially in light of the impact that early manifestations of disabilities may have on interpersonal interactions which can, in turn, influence, exacerbate or mask neuropsychological underpinnings of a disability (Black, 1995, 1997). Thus, depth will also include obtaining information about the child as seen in different contexts over time, understanding how others (parents, caretakers, teachers, therapists) have perceived and currently perceive the child, and how the child behaves in different settings. Integrative understanding here includes thinking through what impact the demands and interpretations made by others, at home and at school, may have on the child's experience and behavior.

Incorporating information across time and context provides a framework for understanding factors that have contributed to, are sustaining, or alleviating for current problems.

Formal and Informal Assessment Procedures

Neuropsychological assessment procedures include both formal and informal methods that are intended to tap into the targeted skill areas, whether or not a normed test is available. Again, fundamental to a process-oriented approach is that one searches for ways of understanding that and why a particular function or cluster of functions is impaired: Once one knows what the diagnostic question is, once one knows what brain areas or correlated functions need to be explored, one can then find measures or devise ways of assessment, whether one uses a standardized test, improvised procedure, or informed observation. Neuropsychology has a long tradition of using both formal and informal procedures to assess behavioral and psychological functioning. It is indebted in this approach to the endeavors of Aleksandr Luria, a pioneer in the field, who documented and devised innumerable non-standardized ways of tapping into higher cortical functions in brain-damaged patients and, by doing so, contributed to the core fundamental understanding of brain-behavior relationships (Luria, 1973, 1980).

In current practice in the assessment of childhood developmental disorders, an understanding of what neuropsychological functions need to be explored and what consistent patterns of impairment are to be expected if a brain-based condition is present are continually being updated and extended through ongoing research. Formal, standardized, normed test measures do not necessarily keep apace with these developments, nor tap into the functions that need to be assessed at all ages. Moreover, which tests to choose and how well or how confounded they are in assessing any particular function may have to be analyzed each time with each individual child (see the following section, "Task Analysis").

The choice of measures then is guided by brain-behavior relationships and how well a given measure can tap into a targeted skill, whether the procedure for doing so is a normed test or not. For example, in assessing for possible weaknesses in cross-hemisphere or intra-hemisphere white fiber connections, which may be affected in neurodevelopmental conditions such as attentional deficit disorders (Hynd et al., 1991a) or nonverbal learning disabilities (Rourke, 1989) (as well as in frank neurological conditions such as agenesis of the corpus callosum), one could use formal measures that test, for example, the efficiency of bilateral integration using both hands in simultaneous placement of pegs as on the Purdue Pegboard Test; or one could use informal measures which look at the *quality* of bilateral integration as, for example, in dynamic praxis tests (e.g., flipping one's hands in a smooth alternating sequence), catching a ball, bi-manually manipulating objects, or crossing midline. Using both quantitative data and qualitative observations, moreover, can increase the evidence for and certainty of any conclusions drawn.

As another example, if one were looking to see whether a young child of 3 or 4 had

attention-related and executive function difficulties, one might have a hard time coming up with many standardized measures which would tap into such functions for this particular age group (see chapter appendix). Yet, assessing attention and executive functions would be a critical part of evaluating for whether a child was experiencing a brain-based developmental condition, and is especially important to assess in the preschool years because underlying frontal cortex matures especially rapidly in synaptic density and branching at that time (Chugani, 1994; Huttenlocher, 1979, 1997; Thatcher, 1997). Critical to know would be what is involved in attention and executive functions, especially for children of this age. Understanding the constellation of possible signs and behaviors associated with the underlying interconnected neural systems involved (e.g., frontal-striatal circuitry) would serve to guide the search for multiple pieces of evidence and help determine whether a consistent *pattern of performances* was present, implicating a neurogenic impairment. In this way, one could devise ways of looking as supplements to the few formal measures available.

Example of Using Both Formal and Informal Procedures to Assess Organizational and Executive Functions in the Preschool Child

The overarching principle to remember is that it is the targeted function or behavioral cluster to be assessed that guides the search for which measures to use, not just age-appropriate available tests. The assessment procedures chosen are guided by knowledge of brain-behavior relationships and the search for multiple pieces of evidence to rule in or rule out whether a function is impaired. The following will describe what is involved in assessing organizational and executive functions in the preschool-aged child in order to

exemplify how assessment can proceed using both formal and informal methods.

First, there needs to be an understanding of what is involved in the behavioral cluster of attentional, organizational, and executive functions. Briefly defined, these are skills concerned with the regulation and organization of behavior and thinking at all levels, automatic and reflective—from automatic regulation of smooth, modulated motor movements to more "executive" functions of being able to organize play or language, methodically problem-solve, use a plan of action to guide behavior or think in a cause-and-effect way (Furster, 1989). Involved, too, are working memory or mental tracking of different trains of thought or input, as well as flexible shifting and sustaining of attention. Problems in self-control, self-modulation, motor persistence, and "defective response inhibition" are also characteristic of children who have problems here (Barkley, 1997; Heilman et al., 1991; Lyon & Krasnegor, 1996). Such children are unable to automatically use an external cue, such as a verbal command, to regulate behavior so that, for example, a command *not* to respond to a certain thing or *not* to behave in a certain way will, instead, elicit that very response. Children who show difficulties here may also show noncompliant tendencies and appear self-directed, stubborn, have "strong personalities," or be outright oppositional. They may also show perseverative behaviors, obsessive preoccupations, or rigid adherence to routines. Emotional lability is also associated with difficulties in frontal lobe functioning, with problems in affect regulation and extended negative mood states.

Thus, in looking to assess whether attentional and executive functions were affected in a 3- or 4-year-old one could analyze performances, whether on tests or in any context, to see if a consistent pattern, including the above and related features, was present (see also Chart 2). In order to assess "defective response inhibition," for example, one could give a simple test of "competing programs," an informal procedure without norms that asks the child, for example, to put up one finger every time the examiner puts up two and put up two fingers every time the examiner puts up one. On this apparently simple test, a child who has problematic response inhibition (and is likely to appear impulsive) and shows difficulties with using a verbal rule to regulate behavior, will have a difficult time following the task at all, or may simply imitate what is visually presented rather than keep the complex verbal rule in mind. One can then observe whether such a child responds similarly to other verbal rules, whether in the testing situation or in real life. For example, given the command to pick up only one peg at a time on a pegboard task, such a child may consistently "forget" and pick up more than one peg, despite the finger dexterity to be able to do so; or told by his parents not to do something, he will consistently do that very thing, despite his ability to comprehend the message, and so appear noncompliant.

More generally, in assessing for organizational difficulties, one could look at *how* systematically and organized the child approached tasks and look at functioning at different levels and across different modalities—motor, visual, auditory. For example, motorically, one could informally look at how smooth, coordinated, or well-modulated a child's movements were. One could observe whether a child showed impulsive, jerky or tremulous movements; or difficulties sustaining a motor act.[vii] One could observe whether the child showed a lack of modulation in voice and motor control when focus and concentration were taxed. For example, one could observe how a child may scream out

responses under time pressure when asked to quickly name things around the room or jump haphazardly and bang into things when asked to stand on one foot. Formally, there are some tests or scales that could be used at this age range (e.g., individual tasks on the Miller Assessment for Preschoolers [MAP], PEET [age 3] PEER [age 4]; or McCarthy Motor Coordination Scale), but cut-off scores or domain scores are often all that are available rather than individual scores, and observations and interpretations of performances remain critical (also because more general motor coordination difficulties may be confounding the scores). (For a reference list of all standardized tests mentioned, also in what follows, see the chapter appendix.)

One could also make informal observations while the child was performing on formal tests: Motorically, one could look at how systematic and organized a child's approach was while putting blocks away or placing pegs in a pegboard (e.g., while performing on WPPSI-R Animal Pegs or the Bayley's Pegboard). Visually, one could look at how organized the child's visual search for a hidden or targeted figure was and thereby how successful the child was in search and cancellation tasks (e.g., on the ITPA Visual Closure Test or on NEPSY Visual Attention). Verbally, one could read a story and ask a child to relate back what was remembered and see whether the child could organize his thoughts into words in a way commensurate with his comprehension and memory (e.g., on McCarthy Verbal Memory II). On all these tests, one could get scores, too, but the observations and the quality of responses would be significant in themselves, especially for confirming the interpretation of organizational difficulties as affecting low scores achieved.

One could proceed in a similar way to higher levels of functioning and look at whether organizational problems were evident

in the child's play, problem-solving, and cognitive style. For example, one could observe how spontaneously the child categorizes, structures, or organizes his play, or sets up a coherent and elaborate sequence of activities in an age-appropriate way. Or, does a random quality infect the child's play with schemes appearing disorganized, repetitive, or with little elaboration? One could also ask about the child's thinking and problem solving. Does the child use an intended result to plan actions or incorporate known consequences into the way he behaves? Formal testing can use, for example WPPSI-R Mazes to tap into planning skills. But, informally, one can see planning skills in any problem-solving task, in the methodical stop-and-think approach, rather than trial-and-error procedures, when a child is asked to put shapes in a formboard, get an object out of reach, or figure out how an unfamiliar mechanical toy works. In everyday life, one can ask if the child understands punishments and rewards, cause and effect, and can use them to guide his behavior.

One can also observe how flexible and naturally methodical the child is and focus on whether his cognitive and personality style is also consistent with such a neurogenic picture. Does the child show a tendency to be either overly impulsive and distractible, or, at the other extreme, overly rigid and compulsive? Children with frontal lobe dysfunction can show both these extremes. It seems that the very problems that underlie organizational and attentional difficulties may also co-determine defensive style and personality. The child who is highly distractible and unable to plan and guide actions in accord with rules or anticipated consequences can show a propensity to be impulsive in dealing with emotionally laden issues and to use, for example, avoidance, denial, or blaming others. A child sensitive to experienced disorganization, and loss of attentional focus as

beyond his control (in an ego-dystonic way) may well opt for over-control and an obsessive and inflexible style.

One would want to answer all these questions, combining test performances and scores with observations and an understanding of the child's functioning in everyday life, in order to be able to determine whether a consistent pattern of difficulties was present, implicating executive and organizational dysfunction.

What applies to the use of formal and informal measures for assessing attentional and executive functions is also applicable when assessing other neuropsychological functions: Once one knows what brain areas or correlated functions need to be explored, one can then find measures or devise ways of assessment, whether one uses a standardized test, improvised procedure, or observations. Importantly, the use of both quantitative and qualitative data increases the evidence and likelihood that a clinical judgment is justified with regard to whether an area of functioning is truly impaired or not.

Standardized Tests: Advantages and Disadvantages

An important advantage of using formal, normed tests, however, is the ability to generate a *more precise picture of intra-individual differences* in the child, which can be crucial for disclosing patterns of relative inefficiencies and a characteristic neuropsychological profile known to be reflective of a disorder.

It is known that standardized tests are intended to provide a systematic and precise means of obtaining information about the child's functioning in different skill areas: Standardized administration and scoring procedures are designed to maximize reproducibility of performances at different times and places and across examiners. Tests, constructed with regard to reliability and validity

requirements, and normed on matched peers across diverse, but representative population parameters allow for performances to be reported in standard scores and percentile rankings. Thus a means is set up whereby a child can be reliably compared to others in his peer group, with a percentile ranking allowing one to know where in the normal distribution the child stands on a specific test. (For example, a ranking at the 65th percentile means that the child is performing in the average range, with 35% of all other children his age doing as well or better than him.) A standard score, such as a percentile ranking, allows, in other words, for one to appraise a child's performance with regard to other children and so determine whether, in relation to normally developing peers, a child's performance is adequate or not, strong or weak. (A performance in the borderline (by convention between the 9th and 2nd percentile) or deficit (less than the 2nd percentile) range is a weak performance absolutely. A score in the superior (from the 91st to 97th percentile) to very superior (the 98th percentile and above) range is a strong performance absolutely.)

More important, percentile scores allow one to compare the child's own performances in different areas of functioning with each other. It thus critically allows intra-individual comparisons to be made so that one can determine whether a score for a given child is weak relative to other performances of which he is capable. For example, a child may be of superior cognitive abilities, performing at the 95th percentile. For such a child, even a score in the average range on a particular measure (e.g., at the 50th percentile) may be considered "relatively inefficient" and index a critical weakness. Thus, performances on formal tests allow one to more precisely build up a profile of strengths and weaknesses for an individual child that reflect not only absolute levels of the child's standing in regard to

peers, but the child's different levels of functioning relative to each other, using his own capacities as the internal standard of comparison (see the following section, "Determining Cognitive Potential and Establishing a Neuropsychological Profile of Strengths and Weaknesses" for further discussion).[viii]

It is important, however, to keep in mind the disadvantages to the use of standardized tests. These include the lack of measures for assessing various critical neuropsychological functions for specific ages, as described above; or, the lack of specifically sensitive tests, with many tests requiring multiple functions to do them, or having multiple subparts to them, so that the meaning of scores is dubious without interpretation. Because of the multifactorial nature of so many tests, it becomes, in fact, important when reporting standardized scores to simultaneously clarify and interpret the meaning of those scores for a particular child—to include not merely the score, but its significance as a reliable descriptor for particular skills (see the following section, "Task Analysis of Complex Behaviors").

There is also a more general caveat about the use of standardized tests: No matter how standardized procedures are meant to be, a host of nonspecific variables that have to do with the particular situation, examiner, or child intervene and affect performances, most often in nonobvious and nondocumented ways. These nonspecific variables can influence scores to a great extent. For example, with very young children, the differential affects of the unfamiliar, stressful testing situation itself are not frequently enough understood nor incorporated into efforts to woo the child into performing in a way commensurate with what he can do. Even less frequently are the child's emotional reactions to challenging tests used to qualify and clarify low performances obtained, or prompt searches to find other ways of eliciting information.

There are also problems with regard to normative data. Some tests are being republished with changes and new norms (for example, the Stanford-Binet, 4th edition, WISC III, Bayley, Leiter). Care must be taken to understand differences in content and norms when children are retested and not to misinterpret lower scores on newly normed measures to mean a decrement in functioning. Norms for some tests may also cover too wide an age range (e.g., over one year) without regard to critical growth that may take place within that time frame, so that scores can be inflated for an older child in the age span and depressed for a younger child. The quality of the normative data must be evaluated: Too few numbers of subjects in a validation study and/or too large a range of performances may make scores for an individual child less reliable. Also, importantly, there is a real lack of normative data obtained on special populations with which comparisons can be made more directly. Because of this, information from a given test is less informative, diagnostically and predictively, and could be misleading if an individual's performance is not interpreted accurately, since the influence of handicapping conditions on test performances are unaccounted for in national norms.

Criteria for Choosing Appropriate Measures

The most desirable measure is one from which a standard score such as a percentile ranking can be derived, measures a circumscribed skill area in as pure a way as possible, and whose input and output demands are so defined that they that can be easily weighted in performance outcome. Also to consider are the reliability and validity of a test, especially its construct validity and correlation with other known measures, and the quality of the existing normative data. The most important

criterion for choosing a measure, however, is whether and how well it taps into the targeted neuropsychological function being explored.

Composite measures can be misleading, in particular composite IQ scores, but also broad "domain" scores, which may be even more confounded than individual subtests by the areas of neuropsychological dysfunction that one is striving to disclose. If using a composite test, one should be sought that has norms for individual subtests with a clear factorial make-up rather than one which reports only overarching scores on broad scales.

Measures used can be drawn from the entire repertoire of assessment instruments and procedures, whether these be psychological, cognitive, language, neurological, motor, or visual measures. It is the goal of detecting patterns reflecting involvement of different systems and subsystems of the brain that guides the choice of measures. It is perhaps erroneous to characterize an individual test as "neuropsychological" (a term usually reserved for measures having a history of use in neuropsychological research and evaluation); rather, it is tests or observations that are interpreted neuropsychologically.[ix]

Task Analysis of Complex Behaviors

A key principle of neuropsychological assessment is *task analysis of complex behaviors.* As mentioned, this involves analyzing or breaking down human activities, whether attending, comprehending, or reading, for example, and understanding the basic component skills that make them up. It also involves understanding the diverse and highly specialized areas of the brain as together, in a dynamic way, being responsible for such complex skills.

Even what looks to be an apparently simple motor coordination difficulty, exemplified by a child who shows a tendency to fall or to bang into things may have a number of brain areas at its base: For example, the cerebellum for muscle tone and coordination; the basal ganglia for the integration of sensory messages; subcortical-cortical loops for impulsivity and planning problems; the frontal lobe for kinetic, sequenced flow of the motor act; the motor strip for motor weakness; the parietal lobe for visual-spatial difficulties or for a kinesthetic-based dyspraxia; the occipital lobe for visual disturbances; and so on. Neuropsychological assessment will focus on examining other skills that would also be affected if the given area of the brain was responsible, and would thus attempt to isolate as best as possible, through task analysis of behaviors and reiterative hypothesis testing, what systems were involved.

Task analysis is also an integral part of interpreting a child's performance on different tests because of the multifactorial nature of so many tests. Although the most desirable measure is one that can tap into a particular neuropsychological function as purely as possible, most tests in the available repertoire of measures do not tap into one skill, but rather demand the use of multiple skills. Moreover, even when a measure is considered to primarily assess a particular function, when evaluating a child with suspected neuropsychological dysfunction, it may be that the child's areas of weakness—which may reflect skills required by a test but not considered essential or part of the test's primary factorial structure—are what impact adversely on performance. In other words, because of interference by the child's areas of neuropsychological dysfunction, the targeted skill that the test is purported to measure may not be what ends up getting measured, at least not solely.[x] This phenomenon makes it particularly important during a neuropsychological assessment of a child with a developmental or learning disorder to analyze a child's

performance on a given measure over and beyond any score achieved.

For example, it may be misleading to think that a test such as "Block Design" on the Wechsler scales assesses only visual-spatial abilities, or visual-motor coordination, which are the typical functions conventionally affixed to scores on this measure. Ideally, if all other systems were intact, it may primarily assess the functions it is known for, but executing the task requires a number of different component skills, and a number of different brain systems: For example, it could include visual-spatial apprehension of the gestalt, analysis of how the complex design is made up of individual blocks, ability to shift back and forth between analytic and synthetic reasoning skills, mental rotation of the blocks, planning and organizing the reconstruction of the design, fine motor agility to manipulate the blocks, visual-motor coordination to follow through with placing the blocks, sustained attention to the task, speed of performance, visual double-checking, and self-checking. If a child scores poorly on such a test, it becomes important to ask which of the possible component skills involved was making him fall down. Rather than visual-spatial ability (right hemisphere), it may be a child's faulty organizational skills, or weak analytic abilities (left hemisphere), or weak ability to quickly shift back and forth and use both analytic and synthetic strategies (weak inter-hemispheric fibers), or lack of differentiated finger agility to turn over the blocks, or the presence of a dysmetric or poor motoric aim so that the child is slowed down and feels too uncomfortable with the task to try his best—and, because a very sensitive child with esteem issues, he becomes self-directed and spaces out.

Many tests have such complex demands intrinsic to them, which need to be analyzed and uncovered during the evaluation. For example, if a child of almost 8 with a math disability does very poorly (5th percentile) on the Stanford-Binet, 4th edition, Quantitative subtest, one would think that the score needs no interpretation, but is simply indicative of the very disability that the child is known to have. However, analyzing the task demands and the child's performance reveals a number of problems. On this task, large dice with dots on them are used and the child is asked to match the number of dots, add the dots, and then to recognize a number pattern in them. At times, very lengthy verbal instructions are given to explain the switches in task demands. The task also uses pictures to support questions of addition, subtraction, measurement, and to query about mathematics-related language (i.e., spatial prepositions such as "between"). When this child's performance was analyzed, he was found to have considerable difficulties counting the dots on the dice because he would lose the 1:1 correspondence. He also had difficulty switching sets and, when instructions became wordy, tended to perseverate on an earlier task demand. And, he had difficulties processing the language of spatial concepts. Thus, a number of weaknesses appeared to interfere with his performance, including attention and executive function weaknesses (difficulty switching sets), language-related issues (comprehension), modulation issues (when trying to match the pace of counting with dots counted), and possibly visual scanning difficulties. The child also did not use any strategies to help himself on this task. He did not use a finger as an aid when visually scanning or counting; he did not verbally rehearse questions to help himself process task demand. In fact, when the test was re-administered in testing the limits, some of these strategies were provided along with more simplified language instructions. Under these circumstances, the child was able to do many of the items previ-

ously failed, with potential performance in the average range [40th percentile]. In this case, task analysis of the demands of the test and of the child's performance allowed one to discover a number of weaknesses that were all contributing to a poor score and, most likely, feeding into the child's school-related math disability. It also allowed one to isolate those areas that needed remedial attention in order to help the child do better.

Especially, then, when assessing a child with suspected neuropsychological dysfunction, it is important to ask not merely *what* a child scores but, importantly, *how* he achieved that score or performance. It is the *how* that reveals what component skills are making him fall down, or what avenues of compensation he may naturally bring to bear or can be taught to use.

Testing of Limits, Modifications of Test Procedures

Thus, neuropsychological assessment involves modifications of tests and standardized procedures in order to: (1) test hypotheses about dysfunctional areas impacting on the child's performances; (2) test strategies that may work to help the child; and (3) elicit the child's optimal performance potential.

Testing the limits is an accepted practice in psychological assessment. It entails relaxing standardized administration and scoring procedures, crediting items passed beyond the official ceiling cut-off, relaxing time constraints, and returning to missed items after a test is completed in order to explore weaknesses and provide compensatory strategies. Scores reported as a result of testing the limits can be reported as "potential" scores, and given in addition to scores based on standardized procedures. Such "potential" scores begin to show what a child is inherently capable of, were adjustments made to accommodate and compensate for his disability.

In neuropsychological assessment, where the explicit goals of the assessment include diagnostic disclosure of areas of neuropsychological dysfunction along with remedial recommendations to help a child function more optimally, testing of limits and modifications of procedures becomes an essential core component of the assessment process.

Impaired performances present opportunities then to explore what is holding a child back and what possible strategies can come to the child's aid to enable him to do better. Take, for example, a child who is suspected as having weak analytic and organizational skills on the Block Design task (e.g., possibly a child with a developmental language disorder in addition to attentional issues, but who has otherwise good spatial orientation). In testing the limits, the child can be shown how to explicitly analyze a design as made up of four blocks, and how to work methodically and piecemeal to reconstitute the design. Improved performance would indicate not only confirmation of the suspected weaknesses as negatively impacting on performance, but a chance for the child to try out for himself what strategies will work. Such modifications of procedures can engage the child in a learning process, in which he may be encouraged to see how, more generally, he might benefit from slowing down, analyzing things, and approaching things more methodically one step at a time, and that there are ways of getting around sensed weaknesses. In this way, testing may itself begin to be therapeutic.

As another example, take a child who does very poorly on a short-term visual memory task such as Bead Memory on the Stanford-Binet, 4th edition. On Bead Memory, the child is asked to reproduce a patterned sequence of differently colored and shaped beads shown briefly. The task also requires good mental tracking and executive function skills in that various aspects of the bead pres-

entation (e.g., color, shape, sequence) have to be remembered and held in working memory simultaneously. The child who does poorly here may have a difficult time keeping track of all these things at the same time. Once he may get the colors but miss out on the shape; the next time he may get the colors and shapes, but miss out on the sequence. A child with visual memory difficulties, and difficulties shifting between left and right hemisphere strategies, may also not spontaneously use any verbalizing, visualizing, or other strategies to help him remember. From other tests, it may be discovered that such a child does better on visual memory tasks when representational material is used, such as material that pulls for language mediation (e.g., as on the WRAML Pictorial Memory test where a scene, such as beach scene, is briefly shown and the child is then asked to recognize elements that have been added or changed); and that he has, more generally, better language than visual-related skills, better verbal memory than visual memory. For such a child, testing the limits on the Bead Memory task can include giving him several strategies which play on the strengths he is not spontaneously using. He can be told to help himself by verbally rehearsing the names of the colors and shapes under his breath; he can be encouraged to imagine a visual image, like a lamp, that the bead pattern may resemble; he can be told that there are three aspects of the beads that he has to remember. Through such strategies, which include verbalizing, visualizing, and a metacognitive strategy that allows him to grasp the demands of the task as a whole, his performance may improve. Remedial recommendations can then be directly informed by such explorations with the child.

Making adjustments to standardized procedures is important when evaluating children with various handicapping conditions. A child who cannot point to a picture because of lack of differentiated finger movements can be given a "magic wand" to use; a child who has a very slowed response time may be tested under relaxed timing constraints; a child who cannot process complex language spoken too quickly may be given simplified instructions spoken slowly and supplemented with gestures; a child who has poor methodical visual scanning and checking of options because of an attentional disorder can be aided by pointing out options for him and reminding him to carefully look at each one. The divergence from standardized procedures after a test is administered must be consciously undertaken and duly noted. But, the goal of obtaining information essential to understanding the child's inherent abilities and weaknesses and how best to promote his optimal development necessitates it.

Reiterative Hypothesis-Testing Strategies

Both convergent and divergent evidence is used to confirm hypotheses about which specific skills may be affected and, eventually, about what the differential diagnosis may be. An evaluation can itself be a reiterative hypothesis-raising and testing process throughout all its phases, taken in abstraction, from the initial interview and review of history, to the selection of measures, interpretation of performances, choice of new measures, until and through the final phase when all data across domains of inquiry and different contexts is integrated, and diagnosis and recommendations are reached.

This section will discuss some strategies for ruling in or ruling out when a skill area may be affected, given the multifactorial nature of tests, the complexity of behavior, and the need for task analysis. As mentioned, one chooses measures partly based on how "purely" they can assess a given function. One also does so according to how well they

may compliment additional measures so that the targeted skills contributing to the child's problems may be more systematically isolated and identified. Particular attention is paid throughout this process to understanding what the input and output demands of each test are, and how readily or not a given child may be able to respond to a set of implicit or explicit task expectations. How this hypothesis-testing process works can best be demonstrated by an example.

Hypothesis Testing While Exploring Visual Memory Skills: The Case of Harry

As an example, suppose the targeted skill to be explored is visual memory. We want to keep in mind whether a given measure assesses the targeted function reliably at the developmental age that we want, and what else is required beyond the targeted function that may also impact on performance. For young children, there are a number of visual memory measures available that make use of either representational (e.g., meaningful, familiar objects) or nonrepresentational materials (e.g., geometric figures, abstract designs). Representational materials can pull for language mediation, such as naming and verbal rehearsal strategies, and so can elicit left-hemisphere participation to enhance memory. Nonrepresentational material may pull more for visual-spatial cognition and right-hemisphere participation. Measures may also include a sequencing component, where the visual material to be remembered must be remembered in the order in which it was presented, which may require good organizational and related skills in addition to memory. One would thus want to select a number of measures that separate out these individual aspects involved so as to make clear what skill(s) are actually down if a child happens to do poorly. Visual-memory capacities are typically attributed to the medial

temporal lobe of the right hemisphere. Thus, one would also want to look for other indices that other functions, subserved by the same or interconnected brain areas, were affected or, on the contrary, intact. Furthermore, visual memory may itself be weak secondarily to or in conjunction with weaknesses in visual-related perceptual and visual-spatial skills.

As a case example, take a child of 8, Harry, who performs in the above average range overall on the Stanford-Binet, 4th edition (S-B) intelligence test (IQ=114, 81st percentile) but does relatively weakly, although still in the average range, on the S-B visual-memory tasks (e.g., S-B Bead Memory, 27th percentile; S-B Memory for Objects, 27th percentile). Does Harry have a visual memory impairment? On the basis of the scores, one could *hypothesize* a visual memory weakness, especially because of a striking discrepancy between these performances and his strongest scores on auditory cognitive measures, which are in the superior range (i.e., S-B Vocabulary, 92nd percentile), and in contrast to verbal-memory performances, which are also in the superior range (S-B Memory for Sentences, 92nd percentile; S-B Memory for Digits, 95th percentile). But, is it visual memory that is lowering Harry's performances? We know from an analysis of requirements on the two S-B visual-memory tasks that sequencing is part of task demand on both subtests. Additionally, on S-B Bead Memory, mental tracking and frustration tolerance (while awaiting the time delay before duplicating the visual bead pattern) are also involved. We wonder, then, if these aspects of task demand are contributing to Harry's low scores. We also know that verbal mediation can be used on both tasks and so wonder whether scores are modified up or down because of this.

Because review of Harry's errors does show sequencing problems, we cross-check

our queries regarding sequencing with how well or poorly Harry does on other attentional, organizational, and sequencing tasks. We find that he, in fact, shows rather pronounced difficulties in these functions. Behaviorally, Harry could appear very absorbed and concentrated, but he could also show at times attentional lapses, with distractibility to internal thoughts, and a sometimes disinhibited tendency to bound out of his chair or lie on the floor. On a test of sustained, vigilant attention, the CPT (Vigil), Harry does very poorly (<1st percentile). He also shows problematic shifting of attention (e.g., Underlining Tests, overall 13th percentile; Rapid Automatized Naming [RAN], 15th percentile to 50th percentile) with an observed tendency to become obsessively preoccupied with certain thoughts and a compulsive-like style at times when responding. For example, he would repeatedly bang the table in exactly the same way each time he gave an answer. He shows problems in planning and sequencing; for example, when asked to put numbers on a clock face, he accumulated them all on one side, and he still had not mastered, even at age 8, certain rote sequences, such as naming the months of the year. Thus, it appeared reasonable to consider, on the basis of these formal and informal measures, that the attentional and sequencing demands on the S-B visual memory tasks may have, in fact, been stressful for Harry and contributed to relatively low performances.

But, this is still not evidence enough to rule out or rule in a visual-memory impairment. More evidence is needed—convergent or divergent—from other test performances, informal observations, and what is known about Harry's functioning in every day life to draw any firm conclusions. Other visual-memory measures are therefore given. On the WRAML Visual Learning Test, where there are no sequencing demands, Harry's

performance is, in fact, deficient (2nd percentile). On this test, abstract visual designs distributed around a board are briefly shown and the child has to remember exactly where he saw each one, given four trials and opportunities to learn their exact placement. Here, even after repeated trials, Harry is unable to remember where on the board a particular abstract design was seen. He also becomes very distraught on this test because of the negative feedback built into it, with his participation dampened more and more as he is made aware of his errors and shown, per standardized administration, that the correct designs are elsewhere than he thought. Even though his score may be lower than ability because of this emotional reaction and consequent inability to profit from any repeated exposures, this deficient performance supports the hypothesis of a visual-memory impairment. Additional memory measures are given that make use of both representational and nonrepresentational materials.

Harry is found to do consistently better, although still relatively weakly compared to his vocabulary knowledge and verbal memory scores, whenever representational materials are used. When asked to remember familiar objects without any sequencing demands, such as details of a familiar scene like a picture of a grocery store on the WRAML Pictorial Memory test, Harry's enthusiasm and motivation for the task are high, and he is observed to actively rehearse the names of what he sees under his breath while viewing the pictures (37th percentile). It is now thought that Harry's weak, but still much better, performances on tests using representational material, including the ones from the S-B, are due to his using a left-hemisphere strategy, and his good verbal abilities, to compensate for what is considered, now with greater certainty, a visual-memory problem. On other visual-memory measures using

nonrepresentational material, performances are all found, in fact, to be very weak. When asked to reproduce complex abstract designs after a time delay, Harry gives back much detail, but in a very fragmented way, with poor recollection of the exact placement of the details and of their interrelationships (e.g., WRAML Design Memory, 5th percentile; REY Complex Figure Test, delayed recall, 3rd percentile). Although Harry also has some fine motor and graphomotor difficulties that impact on his performances here, observations about the quality of his performance support the interpretation of his low scores. The over-attention to details reproduced in a fragmented way is congruent with what is known about error style on drawings when there is right hemisphere involvement.

Harry's visual-perceptual skills are adequate (DTVP-2 Position in Space, 50th percentile), and cannot account for the degree of difficulty he shows. He does show relative weaknesses in visual-spatial organization (poor right/left orientation on another, weak WISC III Object Assembly, 9th percentile; weak Benton Judgment of Line Orientation, 13th percentile), which indicate that poor memory for visual-spatial material may itself be twinned to more overarching visual-spatial difficulties. Additional information from other contexts, especially school, emphasizes Harry's tendency to avoid looking at people, with his teachers complaining of "poor eye contact." On a test of facial memory, in fact, he also does very poorly (TOMAL Facial Memory, 2nd percentile). Other relevant features in his presentation and history include an overly pronounced sing-song quality to his voice, poor social relations, and awkward, sometimes inappropriate behavior with peers. On tests of affect sensitivity, Harry shows weak ability to discriminate emotions in people's faces, in their vocal intonation, and in different contexts. Many of these weaknesses

are consistent with dysfunction in related right-hemisphere brain systems.

In sum, in this case, one obtains multiple pieces of convergent evidence to support the hypothesis of visual-memory weakness, set in yet starker relief by the child's areas of strength, and possibly aggravated by the child's more general visual-spatial, organizational, and attentional weaknesses. At the same time, it raises the broader hypothesis that the constellation of problems that the child shows may point to a nonverbal learning disability (NLD) or, perhaps, Asperger's syndrome, which would be further explored through examining whether the child's profile of neuropsychological strengths and weaknesses was similar to the paradigmatic profile *pattern* of neuropsychological assets and deficits known to be associated with these disorders (Klin et al., 1995; Rourke, 1989).

Determining Cognitive Potential and a Neuropsychological Profile of Strengths and Weaknesses

The concept of "cognitive potential" is somewhat elusive and hard to define. Yet, it plays an important role in neuropsychological practice.

As mentioned, overall scores on standard IQ measures may be misleading in determining the actual or inherent ability level of the child. The very areas of neuropsychological dysfunction that we are trying to isolate and understand may be adversely impacting on overall scores so that they may not be reliable indices of the abilities they purportedly measure, but, rather, reflections of the ways in which the child's disability interferes with his optimal functioning. Yet, it is essential that an assessment be able to document what a child's cognitive level and inherent ability potential may be. This is important not merely to enlighten those in the child's environment for the purposes of education and

intervention, but because it is indispensable for determining the child's own areas of strength and weakness. Determining inherent cognitive ability in a child with a developmental or learning disorder is important for establishing an intra-individual comparison standard against which to judge the child's own performances.

Oftentimes, learning disability guidelines put forward by state education departments for placement and special education services refer to discrepancy formulae between a child's performances on academic measures and his IQ scores. Again, this can be quite misleading *because IQ scores may be reflective of the very same component skill inefficiencies that are bringing down academic performances* (see also Fletcher, 1992). Especially for children who are very bright, and who score in the average range in areas of weakness or at grade level on academic tests, this can prevent recognition of disabilities and appropriate intervention. Also, for children who are functioning at a lower cognitive level, a more sensitive means of determining when a performance indexes an impairment is desirable. Instead of overall IQ, then, for some children, another index or way of estimating cognitive ability level may be needed.

How does one determine what the intra-individual comparison standard should be, or how does one get at inherent cognitive ability? Unfortunately, there are no standard guidelines for doing so. In neuropsychology, both normative (derived from an appropriate population-normed measure) and individual (derived from the particular person being assessed) comparison standards are used (Lezak, 1995). When there is an acquired or traumatic brain condition, the intra-individual comparison standard is an estimate of premorbid (i.e., prior to the trauma) intellectual functioning. These estimates can include,

for example, a vocabulary score as a good "hold" test for original intellectual endowment, or any "best performance," whether that be the highest score or set of scores on testing, or scores derived from premorbid achievement (Lezak, 1995). In developmental conditions, the intra-individual comparison standard may be, likewise, an estimate derived, for example, from the child's best performance on one or more reliable, cognitively weighted tests or subtests that are thought to accurately represent the child's ability. The standard might also be some quantitative parameter computed from his mean performance across such a group of measures (van Santen et al., 1994), or a score extrapolated from testing the limits on one or a number of different core cognitive tests.

Once one establishes an intra-individual standard to use, there is still the question of determining when a score should be considered a weakness indicative of neuropsychological dysfunction. Because in developmental conditions one may find a "pastel" version of symptomatology, there may not be outright deficits (scores <1st percentile to 2nd percentile)—which would signal impairment based on absolute level derived from population norms. Rather, one frequently finds "relative inefficiencies." But, how do you know when a score is "relatively inefficient?" And, furthermore, when is such a score interpreted as representing an area of neuropsychological dysfunction? Although there are purely statistical criteria for determining when scores are "significantly discrepant" from each other (see Kaufman, 1976; Sattler, 1988), oftentimes these are applied to comparisons between subtests on composite measures and not to comparisons across measures (Chapman & Chapman, 1973, 1978). A rule of thumb derived from such statistical procedures, however, and often used clinically and in research, is that scores should be at least

1 to 1½ standard deviations from each other to signal a possible significant discrepancy. (Given the lack of equivalent reliability and validity of scores across measures, and given the fact that most measures are multifactorial and may be confounded by different functions, smaller and/or larger discrepancies may also be significant. Task analysis for deciding whether a given score adequately represents a targeted neuropsychological function is, of course, presupposed in making any of these score comparisons.) Nevertheless, even then one hasn't arrived at a neuropsychologically meaningful discrepancy. The clinical judgmental process for deciding on whether a score is a "relative inefficiency" and represents an area of neuropsychological dysfunction includes looking at a number of factors simultaneously: How discrepant a score is from the intra-individual comparison standard, how discrepant a score is from the absolute standard reflected in age-expected norms; and, importantly, whether the performance in question is an expected weakness given a known neuropsychological profile pattern for a given disability (Black, 1989; van Santen et al., 1994). A comparison of a child's individual profile of strengths and weaknesses with ideal, paradigmatic patterns reflective of a known disorder, or with a constellation of inefficiencies known to reflect brain dysfunction, is integrally a part of judging whether a given score or cluster of scores represents a neuropsychologically meaningful weakness.

Such an approach can help uncover hidden disabilities or establish in greater relief a child's profile of strengths and weaknesses. For example, in the previous case of Harry, his scores on some memory tests, which were in the average range, would not be considered inherently weak were it not for the comparison to his own cognitive abilities; and they were yet more strikingly set off when his very superior vocabulary score and verbal memory scores were used as the standard of comparison. The severity of Harry's deficits was, in fact, clear because of the enormous discrepancy between scores, especially those derived from more extended assessment to test hypotheses. And, they were seen as neuropsychologically meaningful because they formed part of a consistent pattern of weaknesses reflective of a known neuropsychological disorder. But, in many cases of developmental and learning disorders, problems are often more subtle or hidden: Many children perform in the low-average or average ranges, or perform fairly uniformly across many measures including on standard intelligence measures, even though some of these performances may reflect areas of considerable neuropsychological dysfunction. If their inherent cognitive potential is never sought out, if they are given only a limited battery of tests, and their scores on these are taken at face value rather than analyzed and interpreted, misdiagnosis and misunderstanding may easily result.

Searching for Cognitive Potential and Establishing a Neuropsychological Profile of Strength and Weaknesses: The case of Debbie

The case of Debbie, age 5, exemplifies the importance of searching for cognitive potential during an evaluation. Debbie was thought of as very "low functioning," possibly retarded, by her parents and teachers, and possibly on the pervasive developmental disorder spectrum. (Her older brother of 9 had been diagnosed with autism many years before.) At age 5, Debbie was not yet talking in coherent or intelligible sentences, was prone to rigid, over-controlling patterns of behavior, and showed "autistic features," such as flapping her hands and social withdrawal. Imperative in the assessment of

Debbie was the search for her open channels and strengths and how to facilitate them. Once optimal potential was elicited, a profile of strengths and weaknesses could be established. In the assessment process, the uncovering and addressing of Debbie's emotional coping strategies, along with modification of standardized procedures, helped reveal those strengths.

On the Stanford-Binet, 4th edition, administered and scored in a standardized way, Debbie performed in the borderline range (overall composite score 77, 8th percentile). Attentional issues, self-protective distractibility, refusals, and massive language difficulties all inhibited, however, her test-taking ability. When scoring and administration criteria were relaxed in testing the limits, performance potential across both verbal and nonverbal tasks was in the average range [composite 93, 33rd percentile]. (Brackets [ ] are used to denote "potential" scores obtained by testing the limits.) Differences and gains were most apparent in nonverbal and memory domains. It was here that attentional issues and inability to cue into complicated verbal instructions clearly inhibited her ability to show what she was truly capable of. For example, she refused to continue a test which moved from using a simple formboard to using blocks with design patterns (S-B Pattern Analysis): It was the *shift* in task demand, inherent to the subtest, that made her balk and refuse to go on despite all forms of encouragement. Readministration in another session of just the patterned blocks, saw her performance jump from a borderline level (8th percentile) to a solidly average level [65th percentile]. In fact, her score could have been superior [92nd percentile], were her attentional issues and lack of persistence, seen in the considerable intra-test scatter present, not interfering even on this administration. When Debbie was given

nonverbal rather than standardized overly complex verbal instructions on a visual analogical reasoning task, she also performed well, with her score moving from borderline (8th percentile) to the above average range (S-B Matrices [81st percentile]). Thus, Debbie's visual-cognitive reasoning abilities, given testing of limits, were estimated to be at least above average rather than borderline, as standardized administration had yielded.

Because of an understanding of what was holding her back as well as glimpses into her visual-reasoning strengths, another nonverbal cognitive measure was administered, the Leiter, in order to provide confirmation of the hypothesis of above average nonverbal abilities. On the Leiter, no verbal demands are made at all: There are no verbal instructions, and no verbal responses are needed. Nor are there any internal shifts in task demands or expectations. Furthermore, a certain routine is set up where materials are presented and can be removed in a rhythmic, consistent manner. This was concordant with Debbie's own self-comforting strategies and need for routine and redundancy—a need which possibly had its roots in her language deficiencies and inability to feel secure in knowing what was expected of her, and not, as some had suspected, as part of an "autistic" need for sameness. Debbie easily caught on to task demand on the Leiter and did appear, in fact, comforted by the rhythm of the routine of its standardized administration. Her ability to concentrate and actively participate notably improved, her affect was more positive, and her interpersonal demeanor much more friendly, cooperative, and interactive. Debbie scored solidly above average on the Leiter, even using standardized procedures (IQ=113, 80th percentile; mental age = 5.9 years).

Once the circumstances under which Debbie could excel became clear, other performances could be elicited that tapped more

capably into her abilities. One such area was on imitative tasks, such as visual-cognitive, motor praxis measures: For example, when asked to imitate a series of complicated body or hand movements, or when asked to gesture her way through her understanding of the use of objects (e.g., ITPA Manual Expression, 92nd percentile; KABC Hand Movements, 99th percentile). With inherent cognitive potential revealed, the severity of Debbie's weaknesses on language-related tasks became that much more striking, both receptively and expressively. Debbie's neuropsychological profile of strengths and weaknesses exemplified a very severe developmental language disorder, most likely of the phonological syntactic type, with clear strengths in most visual-related areas.

In the final interpretation, Debbie's lack of verbal skills masked easy access by others to her cognitive strengths. Furthermore, some of her unusual features, worrisome to the family and others, could have stemmed in part from her use of her excellent visual cognitive and imitative skills to emulate behaviors of her older autistic brother and to "fit in" to a family system which had been belabored and depressed by both children's needs. Once strengths were disclosed, the parents could renew their investment in their daughter, seen on her own individual trajectory. The search for cognitive potential allowed one to more accurately disclose Debbie's profile of strengths and weaknesses, aided in differential diagnosis, and significantly informed intervention to foster the child's developmental growth.

Integration and Interpretation of the Data

The above principles and procedures have been described in abstraction from what usually takes place as an integrated and dynamic process during the evaluation. In the final analysis, all data are interpreted as to their meaningfulness in an ongoing, hypothesis-testing, deliberative procedure which culminates in (1) identifying the child's neurocognitive profile as fitting a particular diagnostic condition; (2) summarizing the various contributions to the child's general adaptation as well as difficulties; and (3) elaborating upon recommendations for intervention. Throughout the evaluation, an active integration and weighing of information is done on the backdrop of what is known about brain-behavior relationships, brain maturation in typical and atypical populations, different childhood neurological, neuropsychiatric, and developmental conditions, and general expectations for development of language, motor, and cognitive functions in childhood.

The data of the evaluation that needs to be integrated and interpreted encompasses:

- The background history of the child, which includes developmental, medical, school, family, and cultural history.
- The compendium of qualitative and quantitative data resulting from administering formal and informal assessment measures, with attention given to observations of the child during all phases of the assessment process, especially to the child's errors, problem-solving approaches, compensatory strategies, and reactions under pressure.
- An understanding of the child's personality, social relations, and coping strategies, also as seen by significant others and in interactions with others during the evaluation.
- An understanding of the different demands, stresses, and supports provided the child in different contexts, at home and at school.

Integration of data is, in other words, across the breadth and the depth of the evaluation.

Review of background history lays the foundation for raising initial hypotheses related to diagnostic questions. It sets the framework for questions about the possible etiological roots of the child's problems, about the child's developmental course and rate of progress, and about the history of stress and support that may also be part of the dynamic interplay of factors contributing to the child's issues. Understanding prenatal, perinatal, and neonatal risk factors, for example, can begin to reveal whether there were early events which could have predisposed the child to constitutional vulnerabilities. For example, maternal condition during pregnancy (e.g. nutrition and stress, presence of medical conditions such as toxemia, gestational diabetes, need for medications, or use of drugs), and difficulties during and immediately following delivery (e.g., difficult labor, presence of distress signs such as meconium, low apgars) may have neurodevelopmental sequelae. A history of similar types of problems as the child's in the immediate and extended family can raise questions about genetic predisposition and the maturational unfolding of related difficulties. It can also raise questions about how other affected family members have dealt with problems and therefore what attitudes they consciously or unconsciously bring to bear toward the child. Medical history may reveal problems that are known to have repercussions associated with neuropsychological dysfunction (e.g., metabolic or hormonal problems, a history of severe otitis media, exposure to lead or other toxins). Early infancy difficulties such as problems establishing a routine sleep-wake pattern, early colic or fussiness, or feeding problems may signal neuropsychological vulnerabilities that continue in different forms later on. For example, problems in early feeding may be a result of difficulties in the smooth sequencing of suck and swallow patterns which can reappear as more general organizational and sequencing difficulties later. Whether the child has met normal developmental milestones provides information about which systems may be affected and about early experiences of the child and family with the child's atypical development. Educational history is, of course, important for understanding how the child has met various demands placed upon him outside the home, about specific academic successes and failures, and about his social interactions with peers.

Information about the child's personality is obtained from the assessment process as well as from parents and other significant people in the child's life. This can be done on hand of standardized questionnaires, observations of interactions with parents, and possibly with peers in a classroom setting, as well as by formal, projective personality assessment and analysis of the interactive dynamics set up between child and evaluator. Personality measures, such as drawings (e.g., House-Tree-Person, Kinetic Family Drawing), the Rorschach, and story-telling projective measures (e.g., the CAT or TAT) can be important vehicles for disclosing emotional difficulties that may be present, including anxieties, depressive affect, aggressive ideation, difficulties in self-esteem regulation, experience of heightened vulnerability and loss of self-control, and the lack of a coherent sense of self. The child's subjective view of himself and others can be interpreted from responses on projectives, especially when combined with other information from history, observations, and testing. The child's ability to solve social problems, to understand the motives, feelings, and intentions of others, and to reach conclusions about appropriate behavior can be interpreted, for example, from the child's stories, or from other instruments (e.g., Test of Problem Solving

[TOPS]); or from explicit tasks set up to explore the child's understanding of other minds (Baron-Cohen, 1991; Happe, 1994). Projectives are an important vehicle for helping to distinguish neurogenic and psychogenic conditions. The first principle for such a differential is whether a consistent pattern of neuropsychological impairment is present, indicating a neurogenic condition. Projectives, however, can serve to further distinguish between those emotional difficulties that may be sequelae to and consistent with neuropsychological dysfunction from those whose intensity and character set them apart as primary concerns in their own right, and feeding into the child's difficulties. For example, a child may respond in a very tangential and hard-to-follow manner in stories told to ambiguous pictures on the TAT—a measure known to elicit depressive and aggressive themes and the child's attitudes and defensive coping style in face of them. The tendency to become verbally incoherent or sidetracked would have very different psychological import depending on whether evidence was also found that the child showed a language disorder with organizational difficulties affecting language formulation. A child who shows breakdowns in reality testing because of lack of conformity of his percepts with those conventionally seen by children his age on the Rorschach will be viewed very differently if he has visual-perceptual and visual-memory difficulties than if not.

Importantly, the final interpretation of the data should include an understanding of the child's particular coping style and personal ways, adaptive or not, of accommodating to various neuropsychological skill inefficiencies. In many cases of developmental and learning disorders, there is a strong concomitance with emotional and behavioral difficulties (Beitchman, 1985; Beitchman, Cohen, Konstantareas, & Tannock, 1996; Beitchman,

Nair, Clegg, Ferguson, & Patel, 1986; Black, 1989; Cantwell & Baker, 1991; Rourke, 1989). Neuropsychological dysfunction can itself masquerade as an emotional or behavioral problem and be hidden from view, or it can feed into and be inextricably interwoven with psychological conflict. The experience of inefficiencies and discrepancies in abilities are inevitably given meaning and explanation by the child, taken up into his sense of self, and played out in fantasy and behavior. This often takes place, moreover, alongside and in response to interpretations made by significant others in the child's environment about those behaviors, whether at home or at school. This can set up a powerful framework of interpretation and misinterpretation, by both the child and others, which may feed into and perpetuate the child's emotional difficulties and hinder understanding and redressing of his core problems. The task of a comprehensive neuropsychological evaluation then also includes "unbuilding" to find the disability in the child and its possible exacerbation or implication in psychological conflict also within the child-world system.

For this reason, information about the child's behavior in contexts other than the testing situation, and the attitudes, supports, or stresses on the child that come from the broader environment also form a critical part of the data to be integrated and evaluated.

Diagnostic Formulation and Recommendations

The final diagnostic formulation made on the basis of all the data should include whether there is a developmental or learning disorder and its specific characterization. If another neurological syndrome or condition is uncovered, this would be specified in terms of whether there was evidence for a static vs. an active process, diffuse vs. circumscribed deficits, long-term vs. acute condition. A

summary statement of the child's current cognitive level and an estimate of inherent cognitive potential, however elusive, should be made along with specification of the major areas of strength and weakness found. Included, too, should be the nature of any emotional difficulties or complex interweaving of neurocognitive and emotional factors found. The final summary should describe, importantly, the child's key strengths and open channels that serve adaptation now and can enhance development in the future.

Recommendations resulting from the neuropsychological evaluation address those aspects of the child's functioning and the child-world system (including family and school) that may be hindering the child's optimal adaptation, while actively supporting those aspects that can be counted on to further promote it (see Bernstein & Waber, 1990). Recommendations can be remedial, therapeutic, and sometimes prophylactic given a forward trajectory into the child-world system of expectations. Recommendations are offered as suggestions for consideration and can pertain to:

- *A supportive educational placement for the child,* with description of the specific setting, structure, number of children, and teaching style most conducive to the child's development (e.g., ratio of teachers to children; small group learning, hands-on experiences, minimal distractions and background noise, visual supplements in the classroom, access to computers, augmentative communication, aided language stimulation). The child's neuropsychological profile of skills and general cognitive level of performance play an important role in delineating the child's learning style and needs, and the specific classroom characteristics that will best match them.
- *Type and frequency of specific therapeutic services* (e.g., occupational therapy,

physical therapy, language therapy, psychotherapy, reading remediation).
- *The need for other specialized evaluations* (e.g., medical, genetic, neurological, opthalmological, audiological, language, motor) or psychiatric consideration of psychopharmacological intervention (e.g., to address motor tics, anxieties, attentional deficits, impulsivity, hyperactivity).
- *Specific remedial suggestions that address the child's areas of neuropsychological dysfunction.* This is an area that should be elaborated upon extensively, in light of the detailed understanding of the child's neuropsychological profile gained from the evaluation, and on the basis of strategies tried out to enhance performances during testing of limits. Even seemingly small suggestions may be of significant benefit to the child: For example, having a child with visual search problems use a finger to help scan pictures or text, or suggesting that visual materials in school be presented in large, uncluttered formats so that the child does not disorganize and become distracted; or suggesting that a child who has serious organizational difficulties use her love of color and coloring to sustain her focus on a project and more actively process and encode the material. Remediation, generally, can be targeted at either the weaknesses directly or at strategies to help the child compensate. For example, a child found to have inefficient auditory-processing difficulties, with problems in sound discrimination and sound sequencing (e.g., problems in phonemic awareness), may profit from direct remediation of weaknesses through a program such as the Lindamood Phonemic Sequencing (LiPS) Program (Lindamood & Lindamood, 1998; also see Lindamood & Lindamood, Chapter 23, this volume, for further discussion).

This is a program which ties articulatory processes to expanding phonemic awareness, and may reinforce improvement in auditory processing through the oral-motor feedback also provided and the consequent activation of interconnecting fiber networks in the brain (Heilman, Voller, & Alexander, 1996). A child who has spelling problems because of difficulties in phonemic awareness may be encouraged to use possible strengths, such as good visual memory, and focus on encoding and recalling the "look" of a word. A child who has verbal-memory and language-comprehension difficulties, but good visual-related skills and a rich imagination, may be taught to capitalize on his strengths to compensate for weaknesses: He can be encouraged to rely on visualizing strategies to enhance verbal recall (i.e. "seeing" the numbers or message), and to similarly use strong visualizing and imaginative skills to enhance language comprehension (e.g., see Nanci Bell's program of Visualizing and Verbalizing for Language Comprehension and Thinking (V/V) (Bell, 1991a; Bell, Chapter 25, this volume). Such a child would also profit, more generally, from visual prompts and hands-on experiences in the classroom to supplement language communication and direction. Children who have problems in visualizing, and in weak integration skills (because of, perhaps, weak inter- and intra-hemispheric connections as with, for example, white matter disease or NLD), may also profit from direct remedial work on visualizing skills through such a program as V/V as well. Young children who have multiple challenges, with, for example, severe language disorders affecting both expressive and receptive communication, and possibly severe motor praxis difficulties too, may profit from augmentative communication strategies and "aided language stimulation" to open up their interest in and ability to process information in the world around them (see Goosens, Crain, & Elder, 1994).

• *Specific suggestions for psychotherapeutic intervention with the child and/or family*. These are informed by knowledge of the child's neuropsychological profile as well as the possible interweaving of neuropsychological dysfunction with the child's emotional and behavioral issues. As an example, psychotherapy may be recommended for a child, Nick, who appears depressed, has social problems, seems uninterested in making friends, and retreats into an overactive and isolative fantasy life. Found on evaluation to have a nonverbal learning disability, Nick also showed associated problems in affect perception and inability to readily take the perspective of another or have insight into another's feelings and intents. A highly verbal child, when telling stories on projectives, Nick ended up elaborately relating tales about his internal fantasy world, which appeared peopled by mechanical-like figures who fragmented, transformed into different shapes, and went on different death-defying adventures. Recommended for such a child could be a psychotherapeutic approach that would also be remedial since here the child's neurocognitive issues are certainly impacting on his interactional problems and his feelings of fragmentation, lifelessness, depression, and need for transformation. Other specific recommenda–tions might then entail inclusion in a small, psychotherapeutic social-skills group with other children, where specific training in understanding and using facial

expressions, gestures, posture, and prosody to express specific feelings and intentions could be combined with role playing and dramatic enactment of appropriate behavior in different social situations. Another possibility could include having the child write down the stories that preoccupy and isolate him from others, and have others in the group or family add to them and act them out with him. Individual psychotherapy could address more directly, through talk or through play, the child's self-concept, understanding of self in relationship to others, and problems in esteem regulation, while helping him to develop more self-satisfying and competent ways of fulfilling his social needs. In other words, individualized psychotherapeutic recommendations could be developed for a child that would address important aspects of the child's neuropsychological profile as these are related to emotional difficulties.

Recommendations could also be generated for work within the family, in particular for addressing possible misreadings and long-term misunderstandings that the parent(s) or other members of the family may have made about the child's issues. The medium for intervention with the child can then become work within the family and/or school system to support more realistic understanding of the child's strengths and weaknesses, to promote more effective coping and compensating strategies, and to address ways of either modifying demands placed on the child or helping the child meet future cognitive, academic, and social expectations.

SUGGESTED FORMAT FOR A NEUROPSYCHOLOGICAL EVALUATION

A comprehensive neuropsychological evaluation, as described here, which integrates understanding of the child's emotional functioning and behavior in different contexts, can take the following general format:

Background History and Previous Evaluations

Before the initial session, background information about the child is collected and reviewed in order to guide inquiries during the initial session with the parents and raise hypotheses about the child's functioning during the evaluation.

The parents are asked to complete a comprehensive developmental history questionnaire, which covers questions about the pregnancy, and the child's developmental, medical, school, family, and social history. Also included are questions about the family's concerns, the child's assets and weaknesses, other caretakers responsible for the child, and life events that may have critically impacted on the child or family. These questions will be taken up again in the context of meeting(s) with the parents.

The parents are asked to distribute school questionnaires to the child's teachers and/or therapists and have them returned directly. These questionnaires elicit information that can begin to set in relief how the child is seen in contexts other than the home. Questions asked pertain to the teacher's or therapist's views of any social, emotional, or academic problems the child has, how the child is different from other children in the class, the child's strengths and weaknesses in learning and in coping, the structure and setting of the classroom, strategies that have been found to

work well for the child, and other types of helpful information.

Copies of any relevant previous evaluations, such as neurological, audiological, language, psychological, or motor evaluations, as well as relevant educational and school records are also requested. In addition, if there are particular concerns about the child's emotional functioning or attention-related issues, standardized questionnaires (such as the Achenbach Child Behavior Checklist, Conners, or McCarney Scales) are sent to both parents as well as teachers, to see whether perceptions of the child vary between people and in different contexts.

Clinical Interview with Parents

The clinical interview with the parents is held, without the child present, in order to complete questions about background history and to more fully understand the parents' concerns and viewpoints about the child. The clinical interview with the parents is used, importantly, to begin to understand what kinds of interpretations and possible misinterpretations each of the parents may have attributed to the child's behavior, as well as to understand family and marital dynamics. Some clinically revealing questions ask, for example, about parental fantasies and hopes before the child was born, parental "theories" about what is wrong with the child, what the parents worst fears for the child are, and how each of them sees the child as like or unlike the other parent. These types of questions also can elicit some of the deeper fantasies and fears as well as possible projections and defenses that may be orienting, even if not consciously, for each of the parent's interactions with the child. They start to bring into focus, as well, what the child may be experiencing and responding to in the family. The initial contact with the parents also allows an alliance to be built up with them based on

fuller knowledge of their own concerns and struggles. This alliance is important for later findings and discussions and for intervening into the system on behalf of the child and family's well-being.

Observations of Interactions

Especially for young children, ages 1 to 6, assessment of the child begins with observation of the family during a free-play session in the office, where each of the parents are encouraged to interact and play with the child as usual. For very young children, or children with separation issues, parent(s) may remain with the child during the course of the evaluation, with observations of interactions continuing.

An observational visit to the school may also be useful, especially if a disparity in viewpoints between family and school has been noted or if, for example, many of the child's behavioral issues occur in the school setting. Such a visit can also illustrate how the child behaves when other than family demands or supports are placed upon him, and how the child interacts with other children and other adults. For older children with learning problems, a visit to the school can be very illuminating about the structure of the classroom, teaching style, curriculum content, and academic expectations. It can also be very useful for understanding what further possibilities exist for incorporating later on specific remedial recommendations.

Assessment Sessions with Child

A series of more formal neuropsychological assessment sessions are then scheduled. The number and length of such sessions depend on the age and constraints of the child, the complexity of the case, the hypotheses raised, and what is needed to answer them. Very young children cannot be expected to go through testing that is longer than about 1 to

$1^1/_2$ hours. Older children can sometimes be scheduled for 3 hours or more or even for a whole-day session with breaks. The therapeutic needs of the child, which can include helping a child accommodate to the assessment process, as well as the assessment goal of finding strategies to elicit optimal performance, can lengthen the evaluation and number of sessions. The number of hours involved in an assessment can range anywhere from 3 to 15 or more.

Discussion of Findings

Findings are discussed with the parents usually over one or two sessions. If more follow-through and explanation are needed, additional sessions are scheduled, since the parents' processing of the evaluation's findings and recommendations are critical to the evaluation's effectiveness. It is during these feedback sessions that the child's behaviors may begin to be seen in a new light and that long-standing family dynamics may begin to be addressed. It is also a time for jointly considering how and where to intervene into the system, at home or at school. The parents may be encouraged to think through situations at home that exemplify some of the areas where neuropsychological dysfunction has fed, for example, into resistant, frustrating, or oppositional behavior or, on the other hand, into withdrawal and seclusion by the child. Specific ideas can then be generated together as to how the family may begin to address the child's issues at home. Fears and fantasies and other viewpoints of the parents, discussed during the initial interview, can be raised again and worked through in light of the evaluation. Pragmatic reassurances and steps that can be taken to follow through on enabling recommendations to move forward, especially with regard to school and different therapies, are also discussed. At the end of the first findings discussion, the parents are

given a full written report which fully documents all of the child's performances and interpretations made.

Findings may also be discussed with the older school-aged child. Although discussion must be aimed at a level, complexity, and amount that the child is able to process, the child can be given a broad understanding of areas of strength and weakness, and of special talents. Especially, when specific component skills have been identified as interfering with certain academic subjects or functioning in everyday life, some insight into these, and strategies to use to manage problems, may start the remedial process off. Children with learning disorders, who may have the not so secret fear that they are stupid or crazy, may especially benefit from an emphasis on inherent cognitive strengths, with reminders of tests taken and successful strategies used. This approach can be a good dose of much needed esteem-enhancing support. Importantly, a discussion of findings with the child may begin to help circumscribe the weaknesses that may have started to spill over, because unknown and unchecked, into other areas of the child's life.

SUMMARY

In sum, developmental neuropsychological evaluation bases its exploration and interpretation of a broad range of neurocognitive functions on an understanding of brain maturation, brain-behavior relationships, and the dynamic interplay between neural systems, behavior, and the environment. The approach proposed for neuropsychological evaluation of developmental and learning disorders is a process-oriented, hypothesis-testing approach that incorporates principles of dynamic learning into its core assessment procedures, attempts to elicit the child's optimal performance potential, understands that

the multifactorial nature of tests and the complexity of behavior requires analysis of performance, and is inherently comprehensive and integrative in its attempts to understand the child in the context of his experiences and the world around him. ∎

Notes

[i]Terminological clarification of "neurocognitive" and "cognitive" might be helpful: The term "neurocognitive" in neuropsychology refers to the broad, supraordinate domain that forms the focus of its study and encompasses all functions related to cortical and subcortical structures. The term "cognitive" may be used synonymously with "neurocognitive;" or "cognitive" may also refer, in a more delimited way, to reasoning, thinking, or problem-solving skills, whether mediated verbally or nonverbally. Although perhaps not truly separate from other functions, such as language, visual, or memory functions, because building upon them and mediated by them, "cognitive" functioning may, nevertheless be separable from functioning in any one particular domain while still not being equivalent to the broad supraordinate "neurocognitive" domain. Different neuropsychological constructs may be used to denote components of a child's more cognitively weighted abilities; for example, one may focus on a child's "auditory-cognitive" skills or "visual-cognitive" skills, or imaginative, integrative, or abstract reasoning capacities. In all these cases, weight is given to the more conceptual and complex requirements of the child's functioning when denoting an ability as "cognitive." "Cognitive" in this latter sense is perhaps more congruent with the general understanding of the term "cognitive" and its use in other disciplines, such as developmental psychology. In this chapter, "cognitive" is used in this latter, more commonly understood sense and the term "neurocognitive" is reserved for the more over-arching term.

[ii]For example, there is now documented overlap of cases of Tourette's syndrome, ADHD and obsessive-compulsive disorder (OCD), sometimes characterized within the notion of a broad "basal ganglia syndrome" as well as by "Pandas." (Palumbo, Maughan, & Kurlan, 1997; Swedo, Leonard, & Kiessling, 1994,; Swedo et al., 1998). Although ADHD is comorbid with a number of disorders, it can and should be reliably distinguished from other conditions, such as anxiety and conduct disorders.

As another example, Rourke (1989, 1995) identified the syndrome of nonverbal learning disabilities (NLD)(a term first coined by Mykelbust,1975). Children with NLD have arithmetic disabilities and show a particular neuropsychological profile pattern: They evidence neuropsychological weaknesses in visual-perceptual, psychomotor, tactile-perceptual, visual-spatial, and organizational skills; have difficulties in concept formation, adapting to novel information, and have social-emotional problems; and they show strengths in psycholinguistic abilities and rote verbal memory. This characteristic neuropsychological profile of NLD is thought by Rourke to be related to disturbances of the white matter of the brain. It has now been shown that there are numerous neurological and neurodevelopmental conditions in which the NLD pattern is exemplified, including early hyprocephalus (Fletcher, Francis, Thompson, & Brookshire, 1992); Asperger's syndrome (Klin, Volkmar, Sparrow, Cicchetti, & Rourke, 1995); Williams Syndrome (Bellugi, Sabo, & Vaid, 1988), de Lange syndrome (Stefanatos & Musikoff, 1994); callosal agensis (Casey, Del Datto, & Rourke, 1990); Turner's syndrome (Ross, Stefanatos, Roeltgen, Kushner & Cutler, 1995); congenital hypothyroidism (Rovet, 1993); and traumatic brain injury (Fletcher & Levin, 1988).

[iii]Dyslexics show larger right plana and so symmetrical plana rather than normal asymmetry of left plana greater than right. Neuronal ectopias are brain cells that are inappropriately placed and form disorganized circuits in the molecular layers of a brain region. The ectopias identified are most likely attributable to faulty pruning of neurons during the last trimester of prenatal brain development, whether this be due to genetic or environmental causes.

Difficulties when required to rapidly process visual information, also possibly involved in reading, have been related to a magnocellular defect in the lateral geniculate nucleus of the thalamus (responsible for processing fast, low contrast information, motion perception, and stabilization of images during eye movements) (Livingston, Rosen, Drislane, & Galaburda, 1991; Galaburda & Livingston, 1993).

[iv]More recently, Simos, Brier, Apouridakis, & Papanico-Laou (1999) have shown, using the spatial and temporal analysis possible with MEG, that dyslexic subjects will switch from a left hemisphere strategy when distinguising voiced or unvoiced consonants ('e.g., 'b' vs 'd' or 'p' vs 'k') to a right hemisphere strategy. Normal subjects maintain a left hemisphere strategy over time.

[v]Early regression among PDD children may also be a result of subclinical epileptiform activity, or possibly some auto-immune process that may be environmentally triggered, or due to some as yet unidentified process (see Stefanatos, Grover, & Geller, 1995; Stefanatos, Kolros, Rabinovitch, & Stone, 1998; Tuchman & Rapin, 1997; Chez, Buchanan, Field-Chez, Loeffel, & Hammer, 1998; Connolly et al.,1997, 1999; Swedo, Leonard, & Kiessling, 1994; Swedo et al., 1998; Warren, Odell, Meciulis, Burger, & Warren, 1996; Warren et al., 1997; Zimmerman, Potter, Stakkestao, & Frye, 1995; Zimmerman, 1999).

[vi]As Barbara Wilson (1992) says "…it is as important to understand how a child arrived at a given score as it is to know the score itself. Ten children who obtain the same test scores may have arrived at them in ten different ways. It is most important to have some understanding of what those ways are." She has said this in a myriad of ways and its wisdom infuses her approach to assessment and teaching.

[vii]Difficulties sustaining a motor act are known as "motor impersistence" and involves such things as not being able to maintain standing on one foot or sustaining quick repetitive finger movements. Norms are available for children 5-10 years on the PANESS, developed by Martha Denckla (1974, 1985) (see also Gardner, 1979, pp.100-109), but not for younger chil-dren, although general age expectations are known for younger children (see, for example, Bayley motor scale; McCarthy, leg coordination subtest; Carolina Curriculum). Motor impersistence has been correlated with attentional disorders (Heilman et al., 1991) and considered reflective of behaviors that may serve as signs of neostriatum involvement, or of prefrontal-subcortical circuitry (Denckla & Reiss, 1997; Giedd, 1996; Giedd et al., 1994).

[viii]For these inter-test comparisons to be meaningful, all tests involved must have adequate levels of reliability because otherwise spurious individual differences can easily occur.

[ix]There may be claims that a test is "neuropsychological" only because of its history of being used, or being similar to other tests that have been used, for assessing specific neuropsychological functions in children and adults with different acquired and congenital neurological conditions (e.g., the NEPSY is composed of such types of tests). But, it is the interpretation of a test performance rather than the test itself that characterizes the assessment as a neuropsychological assessment.

[x]That such skills are not recognized in any of the factor loadings for a test may be due to the absence of special populations in test validation and norming studies.

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Appendix

STANDARDIZED MEASURES FOR CHILDREN AGES 2 THROUGH 10

This list is a sampling of standardized tests available for children ages 2 through 10 years. Measures are listed with regard to the age range of available norms and according to the primary function or domain that a test is purported to measure. Given the multifactorial nature of tests, however, what a test actually measures needs to be determined, as described in this chapter, by careful analysis of the demands of each test, its input and output demands, and by understanding *how* a given child achieves or fails to achieve a score; that is, through analysis of the child's performance, through modification of procedures, reiterative hypothesis testing, and integration and understanding of other data, including observations and informal assessment procedures.

There is considerable overlap and even redundancy between measures listed in each domain. The decision as to which test(s) to choose depends on the hypotheses raised about a given child, task analysis of the test, the test's reliability, validity, and normative data, and other criteria.

Overall Cognitive Functioning

Some tests may contain a separate "cognitive domain;" some may have different cognitive indices reflecting verbal and nonverbal domains; some may be primarily nonverbal. Composite measures (e.g., Stanford-Binet, WISC) may be made up of individually normed subtests that tap heavily into, for example, language, motor, and memory functions, which can be used independently to give an indication of the child's functioning in these areas. Table A-1 lists tests available for testing overall cognitive functioning.

Table A-1. Tests of Overall Cognitive Functioning

Test	Age Range of Norms (in years)
Bayley Scales of Infant Development	0 to 4 (48 mo.)
Columbia Mental Maturity Scale (CMMS)	3.6 to 7.11
Differential Ability Scales (DAS)	2.6 to 17.11
Hiskey-Nebraska Test of Learning Aptitude (H-N)	3.0 to 16.0
Kaufman Assessment Battery for Children (K-ABC)	2.6 to 12.6
Leiter (Arthur adaptation)	3.0 to 7.11
Leiter-R	2.0 to 20.11
McCarthy Scales of Children's Abilities	2.6 to 8.7
Miller Assessment for Preschoolers (MAP)	2.9 to 5.2
Mullen Scales of Early Learning	0 to 5.8 (68 mo.)
Pictorial Test of Intelligence (PTI)	3 to 8
Ravens Colored Progressive Matrices	5.6 to 11.6
Stanford-Binet, revised 4th edition. (S-B)	2.6 to adult
Test of Nonverbal Intelligence (TONI-2)	5 to adult
Wechsler Intelligence Scale for Children (WISC-III)	6.0 to 16.11
Wechsler Preschool & Primary Scale of Intelligence (WPPSI-R)	3.0 to 7.3

Attention, Organization, and Executive Functions

This group taps into a seemingly disparate set of functions that include, for example, working memory or mental tracking, flexible shifting of attention, sustained attention, organizational and sequencing skills as these affect planning, motor movements, visual search, problem solving, reasoning, language formulation, and other functions. (See chapter for description of what an evaluation of these functions may mean for a preschool-aged child.) Table A-2 lists tests available for testing attention, organization, and executive functions. Tables A-3 through A-9 list tests available for testing other functions.

Table A-2. Tests of Attention, Organization, and Executive Functions

Test	Age Range of Norms (in years)
Computerized Performance Test (CPT) (e.g., Conners', IVA, TOVA, Vigil,)	6.0 to adult
ITPA Visual Closure Test	2.4 to 10.3
K-ABC Hand Movements	2.6 to 12.6
Matching Familiar Figures Test	5 to 12
NEPSY Visual Attention, Statue	3.0 to 5.0
NEPSY Tower, Auditory Attention, Visual Attention	5.0 to 12.11
PANESS (Denckla)	5.0 to 10.0
Purdue Pegboard (bilateral coordination)	2.6 to 16
Rapid Automatized Naming (RAN) (Denckla)	5 to 13

Rey-Osterrieth Complex Figure Test	5 to adult
Trail Making Test (Halstead-Reitan) (A vs. B)	8 to 15
Underlining Tests	5 to 15
Verbal Fluency Tests:	
California Verbal Learning Test (CAVLT-2)	6.6 to 17
CELF-R Word Associations	5.0 to 16.11
McCarthy Verbal Fluency	2.6 to 9
NEPSY Verbal Fluency	3.0 to 12.11
Controlled Oral Word Association: FAS, Categories	6 to 13
Wisconsin Card Sorting Test	6 to adult
WISC-III Symbol Search, Coding, Mazes	6.0 to 16.11
WPPSI-R Mazes, Animal Pegs	3.0 to 7.3

Table A-3. Tests of Auditory Processing and Language-Related Functions

Test	Age Range of Norms (in years)
Auditory Processing	
Comprehensive Test of Phonological Processing (CTOPP)	5.0 to 24.11
GFW Auditory Discrimination	3.8 to 65
GFW Sound Symbol Tests	3.9 to 18.11
Lindamood Auditory Conceptualization Test (LAC)	5 to 18
NEPSY Phonological Processing	3.0 to 12.11
The Phonological Awareness Test	5 to 9
Wepman Auditory Discrimination	5 to 8
WRAML Sound Symbol	5.0 to 17.11
Language-Related Functions	
Phonological production and speech articulation:	
(buccalingual tests, oromotor exam, articulation screening)	
Goldman-Fristoe Test of Articulation	2.0 to 16
MAP Tongue Movements	2.9 to 5.2
NEPSY Oromotor Sequences	3.0 to 12.11
Auditory cognitive functions, receptive language emphasis:	
CELF/Preschool, receptive language tests	3.0 to 6.11
CELF-R or CELF-III, receptive language tests	5.0 to 16.11
DAS Verbal Comprehension	2.6 to 5.11
DAS Similarities, Word Definitions	6.0 to 17.11
ITPA Auditory Reception, Auditory Association	2.4 to 10.3
K-ABC Riddles	2.6 to 12.6
McCarthy Opposite Analogies, Verbal Memory II	2.6 to 8.7
Menyuk Syntactic Comprehension	5 to 12
NEPSY Comprehension of Instructions	3.0 to 12.11
Peabody Picture Vocabulary Test (PPVT-R)	1.9 to 18
PEER Complex Sentences	4 to 6
Receptive One Word Picture Vocabulary Test (ROWPVT)	2.11 to 11
Reynell Developmental Language Scales, receptive tests	1 to 7

S-B Comprehension, Vocabulary	2.6 to adult
Test of Auditory Comprehension of Language-revised (TACL-R)	3.9 to 11
Test of Language Competence (TLC)	5.0 to 18.11
Token Test	3 to 10
WISC-III Comprehension, Similarities, Vocabulary	6.0 to 16.11
WPPSI-R Comprehension, Similarities, Vocabulary	3.0 to 7
Zimmerman Preschool Language Scale	1 to 7

Expressive language emphasis
(includes tests of fluency and word retrieval):

Boston Naming Test	5.0 to 13
California Auditory Verbal Learning Test (CAVLT-2)	6.6 to 17
CELF Preschool, expressive language tests	3.0 to 6.11
CELF-R or CELF-III, expressive language tests	5.0 to 16.11
DAS Naming Vocabulary	2.6 to 8.11
DAS Word Definitions	6.0 to 17.11
Expressive One Word Picture Vocabulary Test (EOWPVT)	2.11 to 11
ITPA Auditory Association, Grammatic Closure	2.4 to 10.3
McCarthy Verbal Memory II, Verbal Fluency	2.6 to 8.7
NEPSY Verbal Fluency	3.0 to 12.11
Rapid Automatized Naming (RAN)	5 to 13
S-B Absurdities, Vocabulary, Comprehension	2.6 to adult
Test of Language Competence (TLC)	5.0 to 18.11
Test of Word Finding (TWF)	6.6 to 12.11
WISC-III Vocabulary, Similarities, Comprehension	6.0 to 16.11
WPPSI-R Vocabulary, Similarities, Comprehension	3.0 to 7

Table 4. Tests of Memory Functions

Test	Age Range of Norms (in years)
Overall:	
Test of Memory and Learning (TOMAL)	5.0 to 19.11
Wide Range Assessment of Memory and Learning (WRAML)	5.0 to 17.11
Verbal memory:	
(for word retrieval, see also Language Functions, expressive emphasis)	
CALVT-2	6.6 to 17
McCarthy Numerical Memory (digits), McCarthy Auditory Memory I (words) & II (story)	2.6 to 8.7
NEPSY Narrative Memory	3.0 to 12.11
NEPSY List Learning	7.0 to 12.11
S-B Digits, Sentence Memory	2.6 to adult
TOMAL, verbal memory subtests	5.0 to 19.11
Token Test IV	3 to 10
WRAML, verbal memory and verbal learning subtests	5.0 to 17.11

Visual memory:

Benton Visual Retention Test	7 to 13
DAS Recall of Designs	6.0 to 17.11
Hiskey-Nebraska Visual Attention Span	3.0 to 15
ITPA Visual Sequential Memory	2.4 to 10.3
NEPSY Memory for Faces	5.0 to 12.11
PTI Immediate Recall	3 to 8
Rey-Osterrieth Complex Figure Test	5 to adult
S-B Bead Memory	2.6 to adult
S-B Memory for Objects	5.0 to adult
TOMAL, nonverbal memory subtests	5.0 to 19.11
WRAML, visual memory and visual learning subtests	5 to 17.11

Table A-5. Tests of Visual-Related Functions

Test	Age Range of Norms (in years)
Visual-Related Functions	
Visual-perceptual/discrimination:	
Embedded Figures Test	6 to 13
Hiskey-Nebraska Picture Identification	3.0 to 16.0
PTI Form Discrimination	2.6 to 9
Test of Visual-Perceptual Skills (non-motor) (TVPS)	4.0 to 12.11
Visual-spatial processing, constructional and reasoning skills:	
Benton Judgment of Line Orientation	7 to 14
DAS Block Building	2.6 to 4.11
DAS Pattern Construction	3.0 to 17.11
Hooper Visual Organization Test	5 to 13
Jordan Left-Right Reversal Test	5.0 to 12.6
McCarthy Block Building, Puzzles	2.6 to 8.7
McCarthy Right-Left Orientation	5.0 to 8.7
NEPSY Route Finding, Arrows	5.0 to 12.11
Reversals Frequency Test	5.0 to 15.9
Right-Left Orientation Test (Benton & Spreen)	8 to 15
S-B Pattern Analysis	2.6 to adult
WISC-III Object Assembly, Block Design	6.0 to 16.11
WPPSI-R Object Assembly, Block Design	3.0 to 7
WRAVMA Visual-Spatial Matching	3.0 to 17.11
Visual-cognitive reasoning skills:	
Benton Test of Facial Recognition	6 to 14
DAS Picture Similarities	2.6 to 7.11
DAS Matrices	6.0 to 17.11
ITPA Visual Reception, Visual Association, Manual Expression	2.4 to 10.3
Leiter	2 to 20.11
PTI Similarities	3 to 8

Ravens Coloured Progressive Matrices	5.6 to 11.6
Ravens Standard Progressive Matrices	6.6 to 16.6
S-B Matrices	5.0 to adult
Test of Problem Solving (TOPS)	6 to 11
TONI-2	5.0 to adult
WPPSI-R Picture Completion	3.0 to 7
WISC-III Picture Arrangement	6.0 to 16.11

Table A-6. Tests of Sensory-Perceptual Functions

Test	Age Range of Norms (in years)
Benton Finger Localization	6 to 12
Benton Tactile Form Perception	8 to 14
MAP Stereognosis, Finger Localization	2.9 to 5.2
NEPSY Finger Discrimination	5.0 to 12.11
PEER Graphesthesia, Stereognosis	4 to 6
PEET, Intersensory Integration	3 to 4
Tactual Performance Test (Reitan)	5 to 13
Tests for Sensory-Perceptual Disturbances (Reitan-Klove) (e.g., sensory imperception (tactile, visual, auditory), finger-tip number writing, tactile finger recognition)	5 to 14

Table A-7. Tests of Motor Functions

Test	Age Range of Norms (in years)
Overall (laterality, hand grasp, motor tone, muscle strength, motor coordination, fine motor):	
Purdue Pegboard	2-1/2 to 16
Graphomotor and visual-motor:	
Beery VMI	4.0 to 17.11
Bender Gestalt Test	5.0 to 10.11
DAS Copying	3.6 to 7.11
McCarthy Drawings, Geometric Design	2.6 to 9
NEPSY Visuomotor Precision	3.0 to 12.11
WPPSI-R Geometric Design	3.0 to 7
Wide Range Assessment of Visual Motor Abilities (WRAVMA)	3.0 to 17.11
Motor coordination, motor impersistence, and praxis:	
Bayley, Motor Scale	0 to 4 (48 mo.)
ITPA Manual Expression	2.4 to 10.3
McCarthy Imitation, Leg Coordination, Arm Coordination	2.6 to 8.7
MAP Imitation of Postures, Hand-to-Nose, Romberg, Foundations, Coordination	2.9 to 5.2

Mullen, Motor Scale	0 to 5.8 (68 mo.)
NEPSY Imitating Hand Positions, Oromotor Sequences	3.0 to 12.11
NEPSY Fingertip Tapping, Manual Motor Sequences	5.0 to 12.11
PANESS (Denckla)	5.0 to 10
PEER, Gross Motor	4 to 6
PEET, Gross Motor	3 to 4
Sensory Integration and Praxis Tests	4.0 to 8.11

Table A-8. Tests of Achievement

Test	Age Range of Norms (in years)
DAS Early Number Concepts, Matching Letter-Like Forms (pre-academic)	2.6 to 7.11
DAS Basic Number Skills, Spelling, Word Reading	6.0 to 17.11
Gray Oral Reading Test -3 (GORT-3)	7.0 to 16.11
Wide Range Achievement Test 3 (WRAT-3)	5.0 to adult
Woodcock Reading Mastery Tests	5 to adult
Wechsler Individual Achievement Test (WIAT)	5 to 19
KeyMath Revised	K to grade 9 (5 to 14 yrs.)
PEER, Preacademic Learning	4 to 6
Test of Written Language (TOWL)	7.6 to 17.11
Test of Written Spelling (TWS)	5.5 to 15

Table A-9. Tests of Personality Functioning

Test	Age Range of Norms (in years)
Projective Techniques:	Preschool to adult
Children's Apperception Test (CAT, CAT-S)	
House-Tree-Person	
Kinetic Family Drawings	
Rorschach	
Sentence Completion	
Thematic Apperception Test (TAT)	
Standardized Questionnaires	
Child Behavior Checklist (CBCL), Parent and Teacher forms	2 to 18
Personality Inventory for Children (PIC)	3 to 16
Conners' Rating Scales-Revised (CRS-R), Parent and Teacher forms	3 to 17
McCarney Attention Deficit Disorders Evaluation Scale (ADDES)	4 to 20
Parenting Stress Index	
Vineland Adaptive Behavior Scales	0 to 18.11

TEST REFERENCES

References for most of the tests mentioned in the appendix follow. Some tests may not be available through regular publishing companies. Descriptions and norms may be obtained in articles or book chapters or sometimes in unpublished manuscripts. For an overview of measures and norms available for children, refer to O. Spreen & E. Strauss (1998). **A Compendium of neuropsychological tests** (2nd ed.). New York: Oxford University Press.

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