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EDUCATIONAL AND PSYCHOLOGICAL ASSESSMENT OF EXCEPTIONAL CHILDREN

Theories, Strategies, and Applications

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CHAPTER 11

Neuropsychological Assessment of Exceptional Children

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OUTLINE

Clinical neuropsychology is a field of study that attempts to relate what is known about the functioning of the brain to what is understood about human behavior. More specifically, to define the role of the nervous system in thought and action, neuropsychologists study empirically the behavioral phenomena associated with neural changes induced by injury, disease, or dysfunction (Adams, 1973; Lyon, 1985a).

Within the past decade, clinical neuropsychological studies of children have been increasingly called upon to make relevant and informed contributions to the assessment and treatment of acquired (i.e., cerebral trauma) and putative (i.e., learning disabilities) neurologically based developmental disorders. This increase in the application of neuropsychological principles to the understanding and remediation of developmental disorders can be attributed to several factors. First, advances in the basic neurosciences have provided new technologies for investigating the means by which the brain develops and processes information, and the differences between individuals with respect to information processing.

Second, there has been a marked increase in the survival rates for youngsters who have received traumatic brain injuries. In addition, improvements in neonatal intensive-care practices have decreased the mortality rates of infants who are born with significantly low birth weight (<1500 grams) (Hynd & Obrzut, 1986). However, children recovering from such conditions frequently display persistent learning and behavior difficulties associated with their neurological history. As such, assessment practices that are based upon knowledge of brain development (and maldevelopment) and behavior, are useful for documenting the nature of the disorder, monitoring the recovery and/or development of cognitive, linguistic, perceptual, and motor skills, and delineating treatment options.

Finally, there is a growing awareness that some relatively subtle learning and behavioral difficulties frequently seen in school settings (i.e., dyslexia, attention deficit-hyperactive disorder) are referrable to intrinsic neurological differences in brain structures or functions that are responsible for linguistic processing, alertness, motor activity, and arousal levels (Duane, 1986; Rourke, Fisk, & Strang, 1986). Because a greater number of children are identified each year as manifesting neurodevelopmental learning and behavior disorders, one can expect that the need for specialists with expertise in neuropsychological assessment will also increase in the future.

With this information as background, the primary purpose of this chapter is to acquaint the reader with (1) the major purposes and measurement properties of neuropsychological assessment practices; (2) the different types of neuropsychological models and assessment batteries employed with exceptional children and their usefulness in contributing to remediation programs; and, (3) some recent advances in the application of neurodiagnostic technology to the understanding of developmental disorders.

There is a significant volume and complexity of literature and topics associated with neuropsychological assessment of exceptional children, so our review is necessarily selective rather than exhaustive. Readers are encouraged to peruse recent papers and texts by Boll (1981); Lyon, Moats and Flynn (in press); Obrzut and Hynd (1986); Rourke, Fisk, and Strang (1986); and, Tramontana and Hooper (in press), for comprehensive coverage of the concepts presented.

PURPOSES AND MEASUREMENT PROPERTIES

One's purpose for conducting neuropsychological assessment obviously influences the means by which brain-behavior relationships are measured and assessment results interpreted. As Boll (1981) has pointed out, the primary initial purpose or goal of neuropsychology is to describe brain-behavior relationships in a reliable and valid manner. Boll also stated that the ultimate, but yet to be realized, purpose is "... the development of remediation and rehabilitation procedures based upon the empirically validated understanding of the behavioral consequences specific to the condition in question in each patient" (p. 582). It is clear, however, that the majority of neuropsychological measures and allied procedures have been designed to infer brain function from behavior rather than to be used in formulating treatment programs. This issue will be addressed throughout the chapter.

In the main, prominent neuropsychological assessment batteries and diagnostic procedures have been developed and refined over the past fifty years to (1) describe the impact of brain damage or dysfunction on a range of human abilities, (2) reliably differentiate individuals who present with brain damage and dysfunction from those who do not, and (3) discern the specific behavioral effects of different types of neuropathology (e.g., tumor vs. stroke vs. head injury) (Lyon, Moats, & Flynn, in press).

It is frequently reported in the neuropsychology literature that these clinical outcomes are realized most effectively when (1) the assessment procedures consist of objective, standardized, and quantitative measures of an individual's structure of neuropsychological ability (Alfano & Finlayson, 1987; Reitan, 1966; Reitan & Wolfson, 1985; Rourke. 1981; Rourke, Fisk, & Strang, 1986); (2) the assessment procedures include measures that are psychometrically scaled to measure abilities on a continuous scale rather than an interval scale (Golden, Hammeke, & Purische, 1978); (3) the assessment tasks and measures are valid and reliable reflections of cerebral dysfunction, and are not confounded by the effects of age and education (Finlayson, Johnson, & Reitan, 1977); and (4) the assessment tasks sample a broad range of abilities to include measures of general intellectual ability, the ability to retain verbal and nonverbal information, motor and psychomotor abilities, sensory-perceptual functions, receptive and expressive language skills, attentional skills, analytical reasoning and concept-formation, and personality, behavioral, and emotional status (Alfano & Finlayson, 1986; Reitan & Wolfson, 1985).

A number of studies have shown that neuropsychological assessment batteries and allied procedures that have been developed according to these principles are valid for the purpose of identifying the presence of brain damage or dysfunction in both adults (Boll, 1981; Golden, Hammeke, and Purische, 1978; Reitan & Davison, 1974) and children (Hynd & Obrzut, 1986; Rourke, 1981; Rourke, Fisk, & Strang, 1986; Teeter, 1986). Further, there are data that indicate that widely used neuropsychological batteries (e.g., Halstead-Reitan, Luria-Nebraska) are capable of describing the nature of the neural insult (e.g., type of lesion, site of lesion, etc.), particularly when those batteries are applied to adult clinical populations and interpreted by skilled clinicians. There is also some evidence, albeit limited in scope, that the information derived from adult neuropsychological assessment batteries can be useful in constructing some remediation and rehabilitation programs, (Diller & Gordon, 1981a, 1981b; Diller & Weinberg, 1977; Finlayson, Gowland, & Basmajian, 1986; Luria, 1966b; Luria & Tzetkova, 1968; Rao & Bieliauskas, 1983).

NEUROPSYCHOLOGICAL MODELS AND ASSESSMENT BATTERIES

In general, neuropsychological models of developmental disorders conceptualize a child's learning strengths and weaknesses as manifestations of efficient or inefficient brain regions and/or systems (Gaddes, 1980; Hartlage & Telzrow, 1983; Obrzut & Hynd, 1986; Rourke, Bakker, Fisk, & Strang, 1983). A variety of standard neuropsychological batteries as well as selected neuropsychological assessment procedures have been employed to elucidate such patterns of strengths and weaknesses. Selected batteries will be discussed in the following section. Emphasis is placed on elucidating the general properties and clinical contributions made by each battery, with respect to their diagnostic validity and ability to forge linkages to treatment. Space limitations preclude comprehensive descriptions of the tasks and tests employed in the batteries. For such details, readers are referred to Boll (1981); Golden, Hammeke, and Purische (1978); Reitan and Davison (1974); Rourke (1981); and Teeter (1986).

THE HALSTEAD-REITAN NEUROPSYCHOLOGICAL TEST BATTERIES

(Reitan, R.M., 1979, Reitan Neuropsychology Laboratory)

The Halstead-Reitan assessment procedures (Boll, 1981; Hartlage & Tarnopol, 1977; Teeter, 1986) are a mainstay of clinical neuropsychological practice with children. The Halstead-Reitan tests have been reported to be sensitive to brain dysfunction in a number of developmental disorders, including asthma (Dunleavy & Baade, 1980), autism (Dawson, 1983), Gilles de la Tourette's Syndrome (Bornstein, King, & Carroll, 1983), and epilepsy (Herman, 1982). An abundance of data shows that the Halstead-Reitan batteries are valid for the differential diagnosis of brain damage in children (Boll & Reitan, 1970; Reed, Reitan, & Klove, 1965). Further, the batteries have been found useful for the neuropsychological classification of minimal brain dysfunction in young children ages five to eight years (Reitan & Boll, 1973) and learning disabilities in older children (Reitan, 1980; Selz & Reitan, 1979).

The tests and clinical-interpretation methods within the Halstead-Reitan Battery for adults have now been extended downward for children between the ages of five and eight years (Reitan, 1979) and ages nine to fourteen years (Reitan & Davison, 1974). Hartlage and Tarnopol (1977) have reported that the tasks, designed by Ward Halstead and expanded and revised by Reitan, now form the best and most comprehensive neuropsychological batteries available. In the main, the development and use of the Halstead-Reitan tasks are predicated on the belief that neuropsychological batteries must include procedures that are sensitive to the full range of human adaptive abilities that are subserved by the brain and that are predictably impaired when brain systems are deficient.

A critical element in all phases of the neuropsychological examination, from test selection to clinical interpretation, is the use of several inferential methods. These methods include (1) comparing an individual's performance on the tasks with the performance of an appropriate comparison sample, criterion group, or an absolute standard of expectation, (2) evaluating variations in performance within and between components of a task (e.g., comparing verbal and performance IQ's), (3) identifying pathognomonic signs that are highly predictive of brain impairment (e.g., aphasia), and (4) comparing the functional efficiency of the two sides of the body. Excellent discussions of these interpretive methods can be found in Boll (1981), Reitan and Davison (1974), and Rourke (1981).

In 1980, Reitan initiated formal attempts to explicitly relate neuropsychological assessment data to treatment, through the development of a program titled Reitan Evaluation of Hemispheric Abilities and Brain Improvement Training (REHABIT). According to Reitan (1979, 1980), the efficacy of REHABIT for remediation is dependent upon (1) a comprehensive neuropsychological evaluation (by use of the Halstead-Reitan procedures), which clearly identifies areas of brain-related strengths and weaknesses, and (2) a determination from the assessment data as to whether the particular neuropsychological deficits reflect specific neural-cognitive deficiencies or generalized cognitive problems affecting several functional systems.

According to Reitan (1980), direct linkages between assessment and treatment are forged by the training concepts inherent in the REHABIT model. For example, REHABIT proposes that the general area of neuropsychological deficit be directly treated by use of alternate forms of neuropsychological tests as training items. According to Alfano and Finlayson (1987), such an approach seems reasonable, because challenging the areas measured by neuropsychological tasks could provide direct stimulation of the wide range of neural functions that they assess. (Serious readers are referred to Mann, 1979; and Mann & Sabatino, 1985, for alternate points of view.)

Following this general form of deficit training, remediation in five specific areas (tracts) uses previously developed educational materials and tasks. The tracts include (1) Tract A, materials for the development of expressive and receptive language and verbal skills; (2) Tract B, materials to develop abstract language functions, to include verbal reasoning, verbal concept-formation, and verbal organization; (3) Tract C, materials designed to enhance general reasoning capabilities; (4) Tract D, materials for developing abstract, visual-spatial and temporal-sequential concepts; and (5) Tract E, materials designed to promote understanding of basic visual-spatial and manipulation skills. Thus, Tracts A and B are generally linked to left-hemisphere functions, Tracts D and E to right-hemisphere functions, and Tract C to general logical analysis and reasoning functions subserved by all functional systems.

Data to support the REHABIT rehabilitation and remediation concepts are difficult to find (Lyon, Moats, & Flynn, in press). Reitan (1979, 1980) does report a few case studies but the information provided in them can not be construed as empirical validation for the REHABIT model. In fact, reviews of similar neuropsychological process remediation models (Lyon & Moats, in press; Mann, 1979) have indicated that such practices suffer from a lack of both construct and ecological validity, particularly in their application to children who display academic achievement deficits but do not demonstrate brain injury. In the absence of empirical validation for the REHABIT model, the clinician is ultimately responsible for judging whether the time spent in assessment and training activities is in the best interests of the child.

Rourke's Neuropsychological Assessment and Treatment Model

Rourke and his colleagues (Rourke, Bakker, Fisk, & Strang, 1983; Rourke, Fisk, & Strang, 1986) have argued convincingly that the aims, content, and style of neuropsychological assessments are improved significantly when a comprehensive battery of neuropsychological tasks is administered to children and the data interpreted according to several frames of reference (level of performance, pathognomonic signs, differential (pattern) score approach, comparisons of performance on two sides of the body, pre- and post-lesion comparisons). Rourke's (1975) orientation to assessment practices and the relationship between assessment data and treatment, is influenced significantly by Reitan's concepts of neuropsychological measurement and modes of clinical interpretation (see previous discussion and Rourke, 1981).

Rourke, Fisk, and Strang (1986) propose that linkages between assessment and remediation are best formed when a developmental, neuropsychological model is employed. Within the context of such a model, specific information related to the child's neuropsychological ability-structure is collected and interpreted in relation to (1) the immediate demands in the environment (e.g., school and social demands). (2) hypothesized long-range demands (e.g., occupational and social functioning), (3) specific short- and long-term behavioral outcomes that best characterize the child with respect to developmental status, information-processing strengths and weaknesses, and neuropsychological status, (4) based on the above information. an ideal remediation program for the child, and (5) the development of a realistic remediation program, taking into account the child's characteristics and the actual availability of remedial sources for family, school, and child. Rourke's developmental, neuropsychological remediation/rehabilitation model appears to have potential for linking assessment data to treatment, because it stresses a comprehensive analysis of the systematic interactions between the child's variables and environmental factors, and the pragmatics of clinical-service delivery (Lyon, Moats, & Flynn, in press).

THE LURIA-NEBRASKA NEUROPSYCHOLOGICAL TEST BATTERIES

(Golden, C. J., 1987, Western Psychological Services)

A. R. Luria's (1973, 1980) seminal conceptualization of the human brain as composed of functional systems, has led to the development of standardized, neuropsychological assessment batteries for use with both adults and children. The first attempt to organize Luria's clinical assessment methods into a formal test battery was carried out by Anne-Lise Christensen (Teeter, 1986). Charles Golden and his colleagues further refined Luria's procedures into standardized batteries for adults (Golden, Hammeke, & Purische, 1980) and children (Plaisted, Gustavson, Wilkening, & Golden, 1983).

The Luria-Nebraska Neuropsychological Battery for Children (Plaisted, Gustavson, Wilkening, & Golden, 1983) consists of eleven scales, which assess motor skills, acoustico-motor organization, cutaneous and kinesthetic functions, visual functions, receptive language, expressive language, reading, writing, arithmetic, memory, and intellectual processes. The battery has been found to be sensitive to detecting demonstrable neuroencephalopathy in children (Teeter, 1986). Several recent studies have also shown that the battery can discriminate between learning-disabled children and normally-achieving students (Geary & Gilger, 1984; Noland, Hammeke, & Barkley, 1983).

To date, there have been no formal attempts to relate assessment data obtained from the Luria-Nebraska to structured remediation programs for children. However, Luria's (1973) concepts of brain-behavior relationships can be clinically useful if applied to intervention practices in an informed manner. This conclusion may be a reasonable one for at least two reasons. First, Luria's model incorporates concepts related to both brain systems and their development. As such, a dynamic theoretical basis exists from which predictions about outcome and potential for remediation can be made. Second, Luria's model argues that disturbances in complex cognitive functions can be related to a wide variety of brain-related deficiencies. For example, failure to learn to write could be attributable to deficits in any of several brain systems. Thus, different children who display written-language deficits might not each respond equally well to the same remediation procedure.

One additional point is in order. Luria (1963, 1973, 1980) advocated the use of dynamic, nonstandardized assessment methods that could vary across patients, according to the nature of the clinical question. He supported the use of these procedures with substantial data from clinical case studies. Further, Luria (1963, 1980) presented a rationale for the application of assessment procedures directly to the treatment and rehabilitation process, and reported case-history data to substantiate his point of view. It is possible that attempts to standardize Luria's dynamic assessment methods could reduce their power in relating assessment findings to treatment-program planning. The reader should keep in mind that this possibility remains an open question.

THE KAUFMAN ASSESSMENT BATTERY FOR CHILDREN (K-ABC)

(Kaufman, A. S., & Kaufman, N., 1983, American Guidance Service)

Another standardized assessment tool that relies on neuropsychological constructs is the Kaufman Assessment Battery for Children, K-ABC (Kaufman & Kaufman, 1983). Emphasizing a dual-processing model of cognition, the K-ABC Test purports to measure simultaneous and successive information-processing strengths and weaknesses in children up to age twelve years. In addition to the Simultaneous and Successive Scales, a third Achievement Test Cluster is used to measure acquired knowledge and verbal learning ability. The test-user is then encouraged to formulate hypotheses regarding remediation of academic deficiencies; these hypotheses should emphasize the subject's preferred processing mode. Unique to the K-ABC remediation framework (Gunnison, 1984) is the specificity of these recommendations to academic domains—reading, arithmetic reasoning, and written language—and the well-elaborated models of intervention, which attempt to code both the learner's behavior and the tasks' demands along the simultaneous/sequential dichotomy.

Unfortunately, the usefulness of the K-ABC even for descriptive and classification purposes has not been uniformly accepted (Lyon, Moats, & Flynn, in press). For example, Sternberg (1984a) argued that the test lacks construct validity, a problem that might be related to the author's misrepresentation or misreading of the evidence supporting a simultaneous-successive processing dichotomy. Further, in equating processing style with scores on selected tasks, the test fails to assess constructs that pertain to dynamic problem-solving. Selecting and conducting remediation on the basis of K-ABC results would thereby be a questionable practice.

Empirical support for remediation based on the K-ABC, as for other neuropsychological approaches reviewed in this chapter, is sparse. Although Gunnison and her colleagues (research in press, cited in Gunnison, 1984) have shown that children taught with methods described as simultaneous or sequential in emphasis can make meaningful gains in reading, both the assumptions underlying the aptitude-treatment linkages and the data base supporting those assumptions are weak (Ayres & Cooley, 1986). The logical-intuitive classification of children's responses and teaching strategies appears to have most value in its provision of a conceptual framework for diagnostic teaching. The concept of dual processing modes might simply encourage the clinician to behave in a flexible manner when alternative representations of concepts are needed by the learner.

Alternative Approaches

A number of researchers and clinicians attempt to assess children's neuropsychological characteristics with tasks that are not standardized in battery form (Lyon, Moats, & Flynn, in press). Generally, the tasks are selected according to their relevance to a particular theoretical model or a research question. Because the tasks included in selected assessment batteries lack a common standardization sample from which scores are derived, control groups matched on relevant variables are generally assessed along with the clinical group of interest.

In the main, studies employing this type of assessment approach are conducted for the purpose of establishing a classification scheme for children who are included in heterogeneous clinical populations (i.e., children with learning disabilities). Children are classified into different subtypes on the basis of their performances on the selected neuropsychological tasks. Once a solution is obtained, it must be internally and externally validated. To achieve internal validation, the examiner ensures that the identified subtypes are reliable, replicable, and robust enough to include most members of the clinical population of interest. To examine external validity, the examiner determines whether the classification is useful for descriptive, predictive, and clinical practice. One specific way to address external validity is to determine whether the subtypes' responses to treatment differ from one another (Lyon & Risucci, in press).

To date, a number of research programs have reported preliminary data that suggest that subtypes do respond differently to varying forms of remediation. Although all of the published investigations have been carried out with learning-disabled readers (dyslexics), the studies differ with respect to theoretical orientation, assessment tasks used to form subtypes, and classification methodology. For example, to identify subtypes, Lyon and his colleagues (Lyon, 1983; Lyon, 1985a, 1985b; Lyon, Stewart, & Freedman, 1982; Lyon & Watson, 1981) have applied empirical, multivariate, quantitative clustering methods to information-processing–task scores obtained by large samples of learning-disabled readers. External validity studies have then involved attempts to teach the disabled learners and to determine the interactions of teaching methods with various subtypes.

In contrast, Bakker (1983) has classified dyslexics into two major subtypes according to clinical criteria, the most important of which is left-ear/right-ear asymmetries in dichotic-listening tasks. External validation consisted of hemisphere-specific stimulation via presentation of words to right and left visual fields, and identification of whether subtypes responded differently to both site of presentation and type of stimulus used.

Flynn and her associates (Flynn, 1987) have concentrated on clinically identifying dyslexic subtypes on the basis of their reading and spelling error patterns. She has presented compelling pilot data showing that children with particular patterns respond well to specific methods of reading instruction.

Space limitations preclude a more comprehensive discussion of these types of alternative, neuropsychological assessment procedures. Interested readers are referred to Lyon, Moats, and Flynn (in press) and Stoddart and Knights (1986) for in-depth reviews.

ADVANCES IN NEURODIAGNOSTIC TECHNOLOGY AND THEIR APPLICATIONS

Recent advances in neuroimaging techniques, such as Computed Tomography (CT), Brain Electrical Activity Mapping (BEAM), and Magnetic Resonance Imaging (MRI), raise the possibility of construct validity being provided for the neuropsychological assessment of children. Each of these three neurodiagnostic procedures has the potential of providing unique information valuable to the early identification and ongoing study of exceptional children. Each in turn has limitations that require careful consideration of methodological design. In this section, the potential benefits and current limitations of each will be briefly discussed in relation to the neuropsychological assessment of exceptional children, particularly those with dyslexia. Duane (1986) has provided a more extensive review of these neurodiagnostic tools and should be consulted for greater detail.

Computed Tomography

When this procedure is used, a special x-ray scanner and a computer produce a cross-sectional computed tomogram, called a CT scan, which provides a visualization of brain anatomy. Cerebral asymmetries, particularly in the widths of the two cerebral hemispheres, have been noted in CT studies of the general population; the left, posterior hemisphere is generally wider than the right, in right-handed individuals (Galaburda, LeMay, Kemper, & Geschwind, 1978; LeMay, 1976).

Because of the hypothesized relationship between left-handedness and dyslexia, computed tomography has been of interest in the study of dyslexia. However, because radiation is involved, CT scans are not indicated in the routine examination of dyslexic children. Therefore, few such studies have been conducted. Of the extant studies (Haslam, Dalby, Johns, & Rademaker, 1981; Hier, LeMay, Rosenberger, & Perlo, 1978; Leisman & Ashkenazi, 1980; Rosenberger & Hier, 1980), only Haslam and colleagues (1981) studied children exclusively and controlled for left- and right-handedness. CT scans of twenty-six right-handed, dyslexic males, nine to thirteen years of age, and eight normal-reading matched controls revealed no correlation of reversed asymmetry with dyslexia, history of language delay, or verbal IQ, although there was a higher incidence of hemispheric symmetry in dyslexics. The Leisman and Ashkenazi CT study of eight dyslexic children (C.A. 7-10.9) did find reversed symmetry in two children, and equal left and right parietooccipital regions in the remaining six; however, there was no mention of subject handedness. Thus, CT scans of dyslexic children have to date produced inconclusive data.

Computerized Electroencephalograms (EEG) and Evoked Potentials (EP)

In the past two decades, the possibility of neurophysiological studies through the computerization of EEG and EP data has emerged. The most recent generation of computer programs displays colored maps of the averaged electrical activity at selected cortical sites. The colors correspond to the amplitude of a particular brain-wave frequency at each electrode site; thus, areas of relative activation and quiescence can be visualized. An advantage of this technique is that children can be studied while they are performing cognitive tasks designed to elucidate neuropsychological profiles.

This approach has yielded enough early evidence of dyslexic neurophysiology, that Duffy, Denckla, Bartels, and Sandini (1980) concluded that quantitative neurophysiology may do for learning disabilities what the clinical EEG did for the diagnosis of epilepsy. To date, a number of studies have differentiated dyslexic children from normal achievers on the basis of their brain-wave patterns while resting and while performing cognitive tasks (Ahn, Baird, Trepeptin, & Kaye, 1980; Duffy, Denckla, Bartels, & Sandini, 1980; Hanley & Sklar, 1976; Naour, 1982).

Computerized EEG's and EP's have also been used to provide evidence that dyslexic children represent a heterogeneous population with distinct subtypes (see Lyon, Moats, & Flynn, in press). The second author's laboratory has used the Boder (1971, 1973) typology in its study of dyslexic children. Boder proposed three dyslexic subtypes: dysphonetic, dyseidetic, and mixed dysphonetic-dyseidetic, each characterized by a distinctive reading-spelling pattern. Dyslexics in the dysphonetic group have "difficulty interpreting written symbols with their sounds" (Boder & Jarrico, 1982, p. 6, 7). However, they have no major difficulty with visual gestalt function. Difficulty with the "memory of letters and whole-word configurations, or gestalts" (p. 7), characterize the dyseidetic group. The phonetic skills are intact in this group. Members of the mixed dysphonetic and dyseidetic subtype have problems in both grapheme-phoneme correspondence and the visual recall of words.

Analysis of ongoing EEG activity during performances of reading, spelling, and spatial-numerical tasks provide partially replicated evidence for a distinctly different, left-hemisphere, brain-wave activation pattern in one subtype of exceptional children (Flynn & Deering, 1987; Lyon, Moats, & Flynn, in press). Other subtyping projects using BEAM have classified children according to language characteristics; these projects have again found distinct differences in brain neurophysiology displayed during performances of cognitive tasks (Duffy & McAnulty, 1985).

Magnetic Resonance Imaging (MRI)

MRI images, generated by radio-frequency pulses within a magnetic field, are visually similar to CT scans, but yield superior resolution. Additionally, MRI procedures do not require x-irradiation and therefore would be preferred in pediatric studies. Disadvantages of MRI procedures include cost and the closeness of the chamber, which youngsters might find frightening. It is anticipated that newer systems will correct the latter constraint.

Combined Neuroimaging Studies

To date, no study has combined all three neuroimaging techniques in the examination of dyslexic children. Certainly, as Duane (1986) pointed out, such a study would provide some important complementary information regarding the neuroanatomical and neurophysiological substrates of dyslexia, and more importantly, of dyslexic subtypes. However, completion of such a study, and the replication necessary for validation of results, involves considerable logistical problems. The most formidable of these is the formation of homogeneous, distinct subtypes of dyslexic children; such a grouping would have to take into account such factors as handedness, activity level and attention, sex, age, socioeconomic and educational opportunities, intelligence, language profile, and type of reading disability. Because of the number and complexity of these subtyping variables and the usual attrition of at least one-third of the sample in most neurophysiology studies (Flynn & Deering, 1987; Duffy & McAnulty, 1985), such a study would need to be extraordinarily large to result in a sample size sufficient for statistical analysis. Duffy and McAnulty, for example, examined over 100 children in order to obtain a final sample of 44 children in a recent study using BEAM technology.

In addition to issues surrounding subject selection and subtyping, various constraints associated with each of the neuroimaging techniques must be addressed. Of these, the radiation used in CT scans is most problematic in the design of an integrated study. The possibility of linking brain-behavior mechanisms in dyslexia and other developmental disorders via investigations of cerebral anatomical structure, interhemispheric and lower-brain-stem activity, and ongoing cortical activity during the performance of cognitive tasks such as reading, clearly warrants the effort needed to complete such a study.

SUMMARY AND CONCLUSIONS

Neuropsychological assessment may contribute some useful clinical information to an understanding of the learning and behavioral difficulties observed in exceptional children. These clinical contributions most likely will have an impact on the diagnosis and description of neuropathology in pediatric populations. This will be particularly true as additional advances are made in the development and application of neuroimaging procedures.

Unfortunately, the clinical utility and validity of clinical neuropsychological assessment procedures in the design of remediation programs for exceptional children remain sparse (Lyon & Moats, in press). This limitation appears to exist for several reasons. First, a large portion of the assessment tasks that comprise the most widely used, standardized neuropsychological batteries for children, are downward extensions of batteries initially developed and validated on adult clinical populations. This is particularly true of the Halstead Neuropsychological Test Battery for Children (Reitan & Davison, 1974), the Reitan-Indiana Neuropsychological Test Battery (Reitan, 1969), and the Standardized Luria-Nebraska Battery for Children-Revised (Plaisted, Gustavson, Wilkening, & Golden, 1983). Likewise, the type of stimuli (task content) used in tasks to assess specific brain-behavior relationships are downward extensions of stimulus items presented to adults.

These test-development practices could seriously compromise a battery's power in predicting which treatment methods are most efficacious for particular children because (1) the tasks employed and their content are primarily based on models of adult brain function and dysfunction that occur following a period of normal development, (2) many tasks are designed to assess the effects of focal neuropathology typically seen in adults (e.g., tumors, cerebral vascular accidents, penetrating head wounds) rather than the generalized neural disorders usually observed in children (e.g., closed head injury, anoxia, epilepsy, perinatal trauma, etc.), and, (3) the neuropsychological tasks' content might have minimal relationship to the ecological demands that the child is facing in home and school environments. For example, even though many widely used children's batteries contain tasks assessing reading, mathematics, and writing skills, such tasks rarely possess adequate content validity. Consider that the Wide Range Achievement Test, a staple of many children's neuropsychological batteries and procedures, assesses only the oral reading of single words, mathematics calculation, and spelling, and thus leaves abilities in reading comprehension, math reasoning, and written language open to question.

A second issue, related to the previous points, is that some neuropsychological assessment procedures employed with children use tasks that yield static measures of competence in neuropsychological ability structures. The data obtained from such measures reflect only a child's past and current declarative knowledge of perceptual, linguistic, cognitive, psychomotor, and academic skills, not how they use or do not use such abilities in their daily lives (Brown & Campione, 1986; Lyon, 1987; Lyon & Moats, in press; Lyon, Moats, & Flynn, in press). A notable exception is the Category Test, known for its sensitivity to abstract concept formation, mental efficiency, and the ability to assess new learning (Boll, 1981).

Third, there is increasing concern that tasks making up neuropsychological assessment batteries for children primarily assess general cognitive ability, not distinct neuropsychological processes (Hynd & Obrzut, 1986; Seidenberg, Giordani, Berent, & Boll, 1983; Tramontana, Klee, & Boyd, 1984). If this possibility is true, administering time-consuming batteries beyond administration of a WISC-R can net redundant information. Further, the consistent finding that the WISC-R is not particularly useful for the development of instructional or remediation programs (Ysseldyke & Algozzine, 1982; Ysseldyke & Mirkin, 1982) does not bode favorably for the use of redundant neuropsychological batteries for the same purpose.

Fourth, issues related to development and brain maturation might obscure any possible benefits that accrue from the administration of standard neuropsychological batteries to children for the purpose of treatment-program design. For instance, Hynd and Obrzut (1986) reported that a number of neuropsychological tasks are simply not age appropriate and that no neuropsychological test battery has established adequate cross-sectioned norms. Further, these authors concluded that without such norms, "it becomes nearly impossible to provide any accurate appraisal of the possible impairment of developing abilities" (p. 10).

Finally, as Lyon and Toomey (1985) have stressed, describing brain-behavior relationships through the application of assessment procedures does not insure successful remediation of brain-based deficiencies. For example, neuropsychological assessment can help to clarify the physiological correlates of dyslexia, but altering the underlying neuropathology or identifying alternate intact processing routes might not be possible.