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Gamble, Constance Maria

FUNCTIONS UNDERLYING PERFORMANCE OF LEARNING DISABLED CHILDREN IN INTELLIGENCE AND NEUROPSYCHOLOGICAL TESTS

The University of Arizona
Ph.D. 1987

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FUNCTIONS UNDERLYING PERFORMANCE OF LEARNING

DISABLED CHILDREN IN INTELLIGENCE AND

NEUROPSYCHOLOGICAL TESTS

by

Constance Maria Gamble

A Dissertation Submitted to the Faculty of the
DIVISION OF SPECIAL EDUCATION AND REHABILITATION

In Partial Fulfillment of the Requirements
For the Degree of

DOCTOR OF PHILOSOPHY

In the Graduate College

THE UNIVERSITY OF ARIZONA

1987

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Acknowledgments

I would like to extend my gratitude to Dr. Inez Tucker; without her commitment to my success in graduate school this undertaking would never have been accomplished. Her exceptional dedication towards her students, and her expertise and integrity in the areas of counseling and counselor supervision, psychological measurement and its application, as well as her skills as an instructor mark her as a true professional and a role model to follow in the years to come.

I would also like to extend my thanks to Dr. Shitala Mishra for his dedication to my progress in graduate school. His skills and instruction in the areas of teaching, research and statistical theory have contributed much to my professional growth, and he is an excellent role model to follow in the years to come.

Special thanks go to Dr. Amos Sales, Dr. Bob Johnson, Dr. Robert Calmes, and Dr. John Obrzut for their support and guidance. Special thanks are extended to Dr. James Chalfant for his assistance in the completion of my program.

It was also a privilege for me to have completed my cognate in clinical neuropsychology under the instruction
of Dr. Ralph Reitan. I appreciate his erudition which stimulated a continued interest in this area.

I would also like to express my gratitude towards Dr. William Tsushima of The Straub Clinic, Honolulu, Hawaii for providing me with the data necessary to complete this project. His time and generosity are greatly appreciated.

Without the commitment and support of Dr. Kent Kloepping and the entire staff of Disabled Student Services, this undertaking might never have been completed. Special thanks to Dr. Kay Lesh for her support and encouragement during the last two years.

I would like to thank Ms. Lorie Blumenthal for her assistance in the editing and typing of this manuscript, and for her availability and patience in seeing it through to completion.
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Abstract

This study was designed to determine the factorial validity of specific components of the Reitan-Indiana Neuropsychological Battery with a learning disabled population. Scores of 42 children, 38 males, 4 females, ages 6.2 to 8.8 years were compiled on specific tests of the Reitan-Indiana. Principal component factoring of the original correlation matrix was followed by principal factoring, using a 4 factor solution; varimax rotation with six iterations produced the desired reduction of the correlation matrix; four factors emerged for the learning disabled population, which accounted for 53% of the variance: verbal intelligence, psychomotor speed, achievement, and memory. The factor structure that emerged was not consistent with the surface factors of the battery as conceptualized by its author suggesting that this battery may lack construct validity when used with a learning disabled population.
Chapter 1

Introduction

In 1968, the National Advisory Committee on the Handicapped of the U.S. Office of Education drafted a definition of learning disabilities which was adopted by the 91st Congress for the Learning Disabilities Act of 1969. With only slight changes in wording, this definition was included in the Education for All Handicapped Children Act of 1975. One of the biggest controversies concerning learning disabilities was their precise definition, a source of confusion due to the widely heterogeneous nature of learning disabilities (Hallahan and Cruickshank, 1973; Johnson and Mykelbust, 1967). The definition of 1975 remains the most widely accepted. It reads, "'Specific learning disability' means a disorder in one or more of the basic psychological processes involved in understanding or using language, spoken or written, which may manifest itself in an imperfect ability to listen, think, speak, read, write, spell, or to do mathematical calculations. The term does not include children who have learning problems which are primarily the result of visual, hearing, or motor handicaps, of mental retardation, or of
environmental, cultural, or economic disadvantages" 
(Section 5 (b) of P.L. 94-142).

In January, 1981, a similar definition was incorporated for the purpose of including learning disabilities among the list of severe disabilities eligible for vocational rehabilitation services. Learning disabilities were defined for the purposes of vocational rehabilitation as any disorder involved in perceiving, understanding, or using speech or the written word. The disabilities could cause problems in listening, speaking, writing, spelling, or mathematics (RSA-PI 81081; July 27, 1981).

It is evident upon reading these widely held definitions that learning disabilities reflect a variety of psychological correlations of neurological dysfunction. A difficulty that can present itself clinically is the precise definition: the psychoeducational definition and the neurological definition present a host of contradictions as to the specific criteria needed for classification learning disabled (Hartlage, 1982; Benton, 1973). The psychoeducational approach examines deviations from expected means in a variety of academic tasks despite normal intelligence (Johnson and Mykelbust, 1967). The neurological model examines psychological correlates of neurological dysfunction primarily manifested as perceptual deficits (Rourke, 1985; Benton, 1973; Gazzaniga, 1973; Cruickshank and Dolphin, 1951; Orton, 1925; Hinshelwood,
Historically, learning disabilities assessment follows a neurological model. Early attempts at diagnosis of learning disability tended to focus on deviations in performance on particular psychological correlates of neurological dysfunction: for example, visual memory (Benton, 1963) or visual-spatial perception (Bender, 1939).

In recent years, credence has been given to the neurological model of learning disabilities in educational settings (Hartlage, 1982). This is associated with a need to better understand the precise nature of the disorder, as a reading disability may reflect deficits in visual-spatial perception or auditory perception (Johnson and Mykelbust, 1967). These psychological correlates reflect underlying neurological dysfunctions (Reitan and Boll, 1973; Chalfant and Scheffelin, 1969).

The diagnosis of learning disabilities is a highly specialized and difficult task, dependent upon the instruments used and the degree to which they are sensitive to the individual's deficits (Hartlage, 1982). Due to the diversity of learning disabilities, comprehensive neuropsychological assessment batteries were needed to substantiate the variety of neurological dysfunctions observed in a learning disabled population. Among the first to meet this need was Ralph Reitan, who devised the
Halstead-Reitan Battery for Older Children and the Reitan-Indiana for 6 to 8 year olds, based on the test design of the adult battery. Both measure a host of neuropsychological functions: intelligence, auditory sequencing and memory, tactile sensitivity and discrimination, motor speed, strength and coordination, and visual memory and sequencing (Reitan and Wolfson, 1985). The changes in the older children's version (HRBOC) involved simplification of the category test, the trail-making test, and the speech-sounds perception test, as well as re-established norms on tests of motor speed and strength (Hartlage, 1982). Reitan has been cited for developing the most comprehensive batteries for children to date (Hartlage, 1982; Hallahan and Cruickshank, 1973; Reitan and Boll, 1973).

Controversy still exists as to the sensitivity of the widely used Reitan instruments in the assessment of learning disabilities. Concerns primarily center around the underlying methodological issues that would affect the ability to accurately detect and identify the nature of the client's learning disabilities (Hevern, 1980).

There is a need for accurate assessment and identification of an individual's learning disability as the consequent test interpretation has great impact upon the testee's educational planning, remediation, and vocational planning and rehabilitation (Reitan and Wolfson, 1985).
It is the purpose of this study to determine factorial validity of specific components of the Reitan-Indiana Neuropsychological Battery, and to determine the functions underlying performances of learning disabled children.

Statement of the Problem

Over the last decade the Reitan batteries have become widely accepted as a means of detecting learning disabilities in school-aged children (Hartlage, 1982; Hallahan and Cruickshank, 1973). Issues of concern have been raised critiquing the underlying methodology used in developing this instrument (Lezak, 1983; Hevern, 1980; Heaton, Beade, and Johnson, 1978). Major concerns center around the lack of norming with learning disabled children (Hevern, 1980; Hallahan and Cruickshank, 1973) and the failure to illicit specific patterns of performance (Hevern, 1980), as well as a general dearth of research into the precise nature of the underlying functions that may be detected by neuropsychological assessment (Lezak, 1983; Hevern, 1980; Hallahan and Cruickshank, 1973; DeHirsch, 1952). Hallahan and Cruickshank (1973) suggest that due to the heterogeneity of cerebral dysfunctions, the full extent of the individual's learning disabilities may not be reflected by neuropsychological examination.

The problem is that the Reitan batteries for older and younger children may lack factorial validity when used with learning disabled populations. In addition, a review of the literature indicates a lack of research into the
functions underlying the factor structure of these batteries when used with learning disabled populations.

Significance of the Problem

In the United States, neuropsychology grew out of the behavioral model of psychology and therefore early attempts at developing neuropsychological instruments reflected basic statistical application and design (Fletcher, Rice, and Roy, 1978; Reitan, 1955, 1958, 1959). In contrast, the work of the Russian, Alexander Luria, reflects another approach: examination of brain-behavior relationships is based primarily on clinical inference and extensive investigation into individual case studies (i.e., literally "mapping the brain"). Lezak (1983) suggests that these two extremes represent a continuum of neuropsychological tests in which the ideal model would consist of both qualitative and quantitative aspects. Actuarial or quantitative data that could discriminate between group differences would give a strong indication of an individual's performance relative to a group. On the other hand, the clinical model is based on the examiner's clinical insight otherwise not incorporated if the examiner relied solely on strict statistical inference (Meehl, 1954). Lezak (1983) describes this latter method as a psychological and social vacuum, in which examinee characteristics crucial to test performance are ignored by the examiner. Lezak (1983) also states that due to the uniqueness of neuropsychological
testing, it is doubtful that the ideal battery could ever be devised. Although standardized procedures are at the base of any reliable assessment tool, there still is not enough knowledge of neuropsychological functions to be able to enshrine any battery within a full-scale standardization (Lezak, 1983).

The Halstead-Reitan Neuropsychological Battery and the Reitan-Indiana Battery reflect the weaknesses inherent in neuropsychological assessment instruments: the dearth of a full understanding of neurological functions (Hallahan and Cruickshank, 1973), the lack of proper standardization (Hallahan and Cruickshank, 1973; Hartlage, 1982), and the failure to accurately identify specific defects (Hevern, 1980). Considering the heterogeneity and diversity of learning disabilities (Rourke, 1975, 1985; Hevern, 1980; Hallahan and Cruickshank, 1973), the difficulty of accurate assessment and identification of specific deficits with a single battery is apparent. Although classification of learning disabled, brain damaged, and normal controls has been accomplished with the Halstead-Reitan Battery for Older Children (Selz and Reitan, 1979b). discrimination was based on a sign approach and not on any underlying pattern or performance on specific traits (Hevern, 1980).

Considering Hartlage's statement regarding the need for more sophisticated knowledge in the clinical interpretation of the battery, particularly in regards to
underlying functions in the performance of the learning disabled student, there is a need for further research to specify more fully the underlying subdimensions in a learning disabled performance profile. This would aid in specifying the nature of the learning disability and lead to a more accurate and assessment and appraisal of the individual. Identification of latent factors would significantly aid in the overall use of this instrument in the detection of learning disabilities, and the overall interpretation would then have greater accuracy in specifying the nature of the underlying dysfunctions.

The significance of the problem is that the Halstead-Reitan Battery for Older Children and the Reitan-Indiana may not fully reflect the variety of neurological dysfunctions that exist in this widely heterogeneous population, and an overall interpretation of a learning disabled client's profile may be inaccurate, having great impact on the individual's educational planning and remediation.

Definition of Terms

Alexia: Inability to perceive the written word (DeHirsch, 1952).

Congenital aphasia: Inability to perceive and understand the spoken and printed word, associated with delayed speech and disorder grammar and syntax, due to no discernible pathological cause (Bender, 1959).

Expressive aphasia: Inability to retrieve words (anomia)
and organize them logically and syntactically due to impaction on the brain's language centers by a pathological process (Johnson and Mykelbust, 1967).

**Receptive aphasia**: Inability to comprehend spoken language due to impaction of the brain's language centers by a pathological process (Johnson and Mykelbust, 1967).

**Auditory perception**: Ability to perceive and understand language and accurately identify environmental sounds (Johnson and Mykelbust, 1967).

**Congenital word blindness**: Inability to perceive the written word without any obvious pathological cause (Claiborne, 1906).

**Constructional dyspraxia**: Inability to recognize shapes and forms and to reproduce their images (Reitan and Wolfson, 1985).

**Developmental lag/disability**: Any of the observed developmental milestones (i.e., speech, walking, crawling, and cognitive development), that appears significantly beyond the usual age depending on sex, race, and other factors (Johnson and Mykelbust, 1967).

**Dyslexia**: Difficulty in perceiving the written word (DeHirsch, 1952).

**Factor**: Any underlying construct that can contribute to the variance of certain combinations of variables, being the principal loading factor (Kim and Mueller, 1978).

"g": The general factor of intelligence; Spearman's
mental energy, the more complicated mental activities containing the highest amount of "g" (Spearman, 1923). A general, analytic, global factor which is shared by more complicated mental activities (Kaufman, 1975).

Learning disability: "Any disorder in a psychological process involved in perceiving, understanding, or using speech or the written word. The disability can cause problems in listening, speaking, writing, spelling or mathematics" (RSA-PI 81-82; July 27, 1981).

Minimal brain damage (dysfunction): Described as slight brain damage or dysfunction, either of external or of an inherited cause. It manifests itself in a variety of psychological correlates of neurological function (Benton, 1973). It has now been replaced by the more modern term, specific learning disability.

Orthogonal factors: Factors that are not correlated with each other; factors obtained through orthogonal rotation (Kim and Mueller, 1978).

Pathognomonic indicators: Neurological or neuropsychological signs that are strictly identified with pathological processes (Reitan and Wolfson, 1985).

SES: "Socio-economic status", i.e., the extent to which a performance on a test item is contingent upon cultural advantages that would include increased income, higher education, and preference for specific ethnic groups (Anastasi, 1982).
Strephosymbolia: From the Greek for "twisted symbol": Orton's (1928) description of the condition he believed caused reading and speech disturbances, due to lack of cerebral asymmetry.

Visual-spatial perception: The ability to perceive the environment and the printed/written word with accuracy and without distortion (Getman and Kephart, 1956).

Varimax: A method of orthogonal rotation which simplifies the factor structure by maximizing the variance of a column of the pattern matrix (Kim and Mueller, 1978).
Chapter 2

Review of the Related Literature

The purpose of this chapter is to present a review of the related literature examining two content areas: an examination of the neuropsychology of learning disabilities, and an exploration of current research needs in the neuropsychological assessment of learning disabilities, concentrating on the Halstead-Reitan Battery, and its children's versions, including the Reitan-Indiana derivative.

Introduction

The concept of learning disabilities, specific learning disabilities, or the more defunct term, minimal brain dysfunction, has a long history in which controversy still exists regarding appropriate etiologies and classifications. Strother (1973) and Benton (1973) summarized the difficulty, stating that a diagnosis of minimal brain dysfunction was based on a behavioral concept of possible neurological implications. This behavior manifested itself in a host of difficulties observed at home and in the classroom: distractibility, hyperactivity, reading and arithmetic difficulties, handwriting difficulty, difficulty with expressive speech, poor motor coordination, attentional
and memory deficits, auditory perceptual problems, visual perceptual problems, and receptive language difficulties (Benton, 1973). Compounding matters is the fact that until the last decade, learning disabilities were seen as "univocal" in origin (Rourke, 1985). Many experts advocated a single etiology whether of a mnestic, linguistic, attentional, or perceptual deficit origin. Confusion as to the appropriate definition, the possible etiology, and manifestations of learning disabilities even led many educators to deny their existence, citing the "disability" as the result of poor teaching (Rourke, 1985). In fact, the controversy over the labeling of children as "minimally brain damaged" or possessing a "minimal brain dysfunction", or being specifically "dyslexic" or "language impaired" indicates conceptual confusion over the etiology. Most importantly, and reflected in federal legislation (PL 94-142), is that the disorders are a manifestation of dysfunctions in the psychological processes involved in learning without any overt evidence of exogenous cause. The advent of PL 94-142 in 1975 identifying the need to evaluate children who exhibited learning disorders and provide them with appropriate remediation generated an expansion of research and clinical efforts to further understand this complex problem (Obrzut and Hynd, 1986). The current view is that learning disabilities reflect underlying anomalies of "neurodevelopment" of the brain,
either of genetic or unknown etiologies (Duffy, Denkla, Bartels, and Sandini, 1980; Galaburda and Kemper, 1979; Drake, 1968). This distinction has separated the classification of children who have learning disabilities from those determined to have suffered brain damage. The concept of neurodevelopment syndromes has lead experts to determine that higher cortical areas important in learning are functionally disrupted, resulting in a variety of processing deficits in the two cerebral hemispheres.

The last decade has seen remarkable advances, using neurological research findings and neuropsychological assessment batteries in the understanding of the etiology of learning disabilities, as well as more precise identification of learning disabilities and their behavioral and psychometric manifestations.

Construct validity is the crucial psychometric property that specifies that the underlying test construct or paradigm is valid and that variables of the test actually measure what they are purported to measure (Anastasi, 1982). Thus, an interpretation of a test possessing construct validity for a given population would be deemed an accurate and valid profile upon which to make judgments regarding intelligence, aptitude, or a given number of psychological traits (Anastasi, 1982).

This chapter will review underlying methodological concerns that would impact highly on construct validity
of the test: reliability, norming samples, methodology, and contamination from outside variables that were poorly controlled and could impede performance on these neuropsychological tests: socio-economic status, sexual differences, developmental variation, age, and educational achievement (Hevern, 1980).

The Neuropsychological Model of Learning Disabilities

The recognition of learning disabilities has its origins in the research of behavioral disorders observed in victims of cerebral-vascular disorders causing cerebral thrombosis and cerebral hemorrhage otherwise commonly referred to as "stroke". Nearly 150 years ago anatomical research of the brains of stroke victims who had exhibited language and speech disorders lead researchers such as Paul-Pierre Broca, Karl Wernicke, Hughlings Jackson, and Sigmund Freud to recognize that behavioral manifestations of language disorders could be localized to specific regions of the brain (Thompson, 1966). These men also developed some very intriguing and original ideas of the neurodevelopment of language, which is surprisingly akin to the neurodevelopmental model of specific language disability (Hallahan and Cruickshank, 1973).

Jackson (1958) developed the concept of the breakdown of language in the aphasic individual by determining it to be a functional regression of a highly organized apparatus reverting to an earlier state of functional development.
Aphasia reproduces a state which existed in the course of the normal process in learning spoken language.

Looking at the developmental aspects of language, Freud (1953) determined that language dysfunctions as exhibited by people who had aphasia were also representative of dysfunctions that reflected earlier, innate developmental factors.

The overall importance of the research of Broca, Wernicke, Jackson, and Freud was the association of behavioral abnormalities in speech and language in individuals with definite cerebral damage. Thus, a person who exhibited the classic symptoms of motor aphasia could be highly suspected of having a lesion in "Broca's area". This correlation between behavior and underlying cerebral pathology is the basis of all neuropsychological tests (Lezak, 1983) and later will have strong implications for the diagnosis and remediation of learning disabilities with neuropsychological instrumentation (Reitan and Boll, 1973).

Hinshelwood (1895) saw a relationship between the behavioral aspects of aphasia in a group of Scottish school children who exhibited reading difficulties that mimicked the phenomenon of alexia in aphasic patients. Hinshelwood coined the term "word blindness" to account for this apparent discrepancy in otherwise normal children. Examining the impairment of reading ability in the absence of any apparent physiological basis, Morgan (1896) and Kerr (1897)
used the phrase "congenital word blindness", suggesting that a developmental or neurological dysfunction of unknown etiology was the basis of the disorder. Claiborne (1906) and Town (1911) conceptualized "congenital aphasia", describing a developmental word and tone deafness similar to the syndrome observed in receptive aphasia.

As studies of pathology in adult cases led to conceptualization of language processes delegated to specific parts of the brain, studies of cerebral pathology in children aided greatly in understanding of localization of brain functions in children, particularly in the understanding of the neurodevelopmental process of language and language skills.

The World War I encephalitis epidemic in Europe that followed the panendemic influenza outbreak allowed researchers to observe effects in children on perceptual and cognitive abilities with overt evidence of brain damage. Hohman (1922) and Ebaugh (1923) observed delayed reading ability, acquisition of speech and language, and delayed motor development in these children which suggested a disruption of the developmental processes observed in the acquisition of these skills. Strauss and Werner (1938) began to see what they termed "developmental disabilities" in speech, language and motor skills as having an unknown etiology, or being due to direct trauma or a pathological process such as toxicity or an infectious process. Having
been influenced by the work of Head (1926) and Goldstein (1936) on the effects on behavior and intelligence in head trauma victims of World War I. Strauss and Werner (1940), in their initial work on mental retardation, determined two classifications of "developmental disabilities" endogenous, i.e., of unknown etiology, or possibly inherited, familial factors; and exogenous, i.e., as a result of overt, direct pathology. Strauss and Werner (1940) initiated the concept of diagnosing possible brain damage of unknown origin based on behavioral traits. According to Hallahan and Cruickshank (1973), Werner's and Strauss' greatest contribution to the field of learning disabilities was their recognition of primary perceptual-motor difficulties without any obvious cause, and recognition of the psychological manifestation of what they termed "hyperactivity".

Cruickshank and Dolphin (1951) and Kephart and Strauss (1950) also conceived of the idea of children of otherwise normal intelligence, with no history of "exogenous" cerebral insult, who exhibited aspects of developmental disability. DeHirsch (1952) attempted to hypothesize a cause for this phenomenon, stating that some primary integrative flaw in the processing of visual perception in the brain would account for difficulties in reading and writing. Getman and Kephart (1956) began to isolate the primary deficiencies in reading and writing observed in school children as
results of underlying deficits in visual perception and processing, and auditory deficits as well. Barsch (1967) expanded upon Getman and Kephart's ideas, and based on the concept of homeostasis, in which integration of one's perceptions of the physical environment and its dimensions is crucial to orientation in space, right/left discrimination, perception of depth, accuracy and speed in motor skills, hypothesized that poor proprioception in space was the link between the auditory and visual processing problems observed in these children and the perceptual-motor difficulties also seen. Hallahan and Cruickshank (1973) noted that it was ironic that the focus in the conceptualization of minimal brain dysfunction was the trend toward viewing the disorder(s) as perceptual-motor difficulties, and that surprisingly little research had been done in the area of speech and language, a highly critical developmental milestone. Orton (1928) observed a high degree of stuttering in children with reading difficulties, which he attributed to a flaw in cerebral dominance, since many of his subjects were left handed or ambidexterous. He felt that the central deficit existed in hemispheric organization, in which failure to establish laterality resulted in a disruption of the functions of speech, reading and writing. He used the term "strephosymbolia" (from the Greek for "twisted symbols") to define the condition he observed in children who demonstrated difficulty in oral language, written
language, and who were unable to read efficiently and recognize letters and words. Orton did not attract the following of Werner and Strauss, but he was among the first to recognize learning disabilities and among the first to attempt to formulate an underlying, unified theory to explain the host of difficulties seen in these exceptional children in the classroom setting.

Orton's concept of cerebral organization and its link to handedness has never been actually substantiated (Obrzut and Boliek, 1986) but he intuitively grasped the idea of failure to establish dominance for language with resultant impaction of hemispheric processing of language. In the 1980's, this concept is now more widely held than it has been in earlier years (Galaburda and Eidelberg, 1982; Duffy, Denckla, Bartels, and Sandini, 1980; Duffy, Denckla, Bartels, Sandini, and Kiessling, 1980). Despite Orton's early research into the theory of an underlying anomaly in cerebral lateralization of language as a possible source of reading and speech difficulties, his ideas were largely ignored. The "univocal" approach to an understanding of learning disabilities persisted well into the 1970's. The main difficulty has been the psycho-educational approach, which merely examines discrepancy between level of performance, i.e., intelligence test results versus results in achievement tests (Hartlage, 1982).
Johnson and Mykelbust (1967), using their clinically observed cases, theorized a multivariate etiology of learning disabilities manifested in a variety of ways, such as Gerstman's syndrome, dyscalculia, dyslexia, and auditory dyslexia. Recent advances in neurological research have given greater credence to a neurological etiology of learning disabilities with a manifestation of various clinical types (Rourke, 1985, 1975; Barkely, 1983; Gaddes, 1980; Benton, 1973; Gazzaniga, 1973). Astute clinical observation, neurological advances, and more sophisticated application of statistical tools such as cluster analysis and Q-type analysis (Adams, 1985) of groups of learning disabled children have yielded much data as to various types of learning disabilities and much hypothesizing as to the possible underlying etiology. Developments in neurological findings have led researchers to better conceptualize the cerebral etiology behind learning disabilities, and have abetted in the classification of learning disabilities with assessment instruments known to be sensitive to brain damage, the Weschler Intelligence Scale for Children being a case in point (Sattler, 1974; Rourke, Young and Flewelling, 1974; Reed, Reitan and Klove, 1965).

The most important findings in relationship to the understanding of lateralization of specific skills to either hemispheres have been the results into investigations
of intellectual functioning in patients who had undergone cerebral commissurotomies.

The concept of cerebral asymmetry, or specialization of cognitive tasks to certain areas of the brain, was substantiated by Sperry (1970; 1968) in his work with epileptic patients who had undergone commissurotomy to relieve intractable epilepsy. Although specialization of the left hemisphere to linguistic tasks was established and visual-spatial tasks to the right hemisphere was established, the lack of connection between the two brains led to a breakdown in the integration of information leaving severe, and permanent perceptual deficits in memory, word recognition, and recognition of auditory stimuli. Lateralization of language skills, and processing between the two hemispheres has been demonstrated by dichotic listening tasks. Dichotic listening tasks have aided in establishing the process of the lateralization of speech and language to the left hemisphere, and demonstrates hemispheric integration of language, as the right hemisphere processes certain aspects of semantic and pragmatic structures of speech (Heeschen and Jurgens, 1978; Springer and Gazzaniga, 1975; Satz, Bakker, Teunissen, Goebel and Van der Vlugt, 1975; Porter and Berline, 1975; Kimura, 1968).

Dichotic listening tasks are useful in demonstrating anomalies in cerebral processing in learning disabled
children. Obrzut (1979) demonstrated abnormalities in processing of linguistic and spatial information in a group of clinically determined alexic and dysphonetic readers with dichotic listening tasks. Dichotic listening with bisensory recall (i.e., with presentation of visual stimulus) was exhibited by these groups indicating a basic difficulty in processing linguistic (left hemisphere) and spatial (right hemisphere) information. Obrzut (1979) suggests that this is compatible with previous findings that encoding of visual and auditory stimuli in a configuration of multiple elements is difficult for learning disabled children (Senf and Feundl, 1971; Senf and Feshback, 1970; Senf, 1969), and that difficulty exists with simultaneous apprehension of bisensory information (Rudel and Teuber, 1971). Obrzut, Obrzut, Bryden and Bartels (1985) using dichotic listening tasks, demonstrated a failure to lateralize language in either hemisphere, and also demonstrated with the LD group more inadequacy than normal controls in sequential processing of receptive language, a left hemisphere task; this also implies failure of lateralization of language tasks to the left hemisphere.

The concept of failure of lateralization of language to the left hemisphere, with resultant discordance in integrative linguistic tasks that require right hemisphere participation, is a strong current postulate regarding
the underlying cause of some learning disabilities (Kershner, Henninger, and Cooke, 1984; Swanson and Mullen, 1983). Obrzut, Hynd, Obrzut and Pirrozo (1981) have suggested that a difficulty in sustaining and dividing attention between the two hemispheres may be the most significant manifestation of cerebral asymmetry. Kershner, Henninger, and Cooke (1984) postulated that learning disabled children spend inordinate amounts of time in encoding tasks, due to lack of hemispheric specialization. Cermak (1983), Swanson and Mullen (1983) and Shankweiler, Liberman, Fowler and Fisher (1979) have suggested that lack of hemispheric specialization impacts most strongly on long term memory storage of tasks of a linguistic or non-verbal nature. Further evidence of cerebral asymmetry has been demonstrated by cerebral axial tomography. Asymmetry has been demonstrated in brains of individuals clinically diagnosed as "dyslexic" (Thompson, Ross and Horwitz, 1980; Hier, LeMay, Rosenberger and Perlo, 1978). In both studies there existed in the subjects a reversal of the usual posterior hemispheric asymmetry found in normal individuals. However, a more recent study (Denckla, LeMay and Chapman, 1986) failed to demonstrate a significant difference from normal controls.

Equivocal findings can be expected if a group of learning disabled individuals are examined; this is due to
the heterogeneity of the population. All studies are sample dependent upon the population involved (Adams, 1985). If subtypes exist, then a particular study that gives negative results with an hypothetical inquiry, while one gives positive results, may be due to the selection of groups. It also must be remembered that positive test results in an investigation of underlying cerebral anomalies in the etiology of learning disabilities are to be taken seriously even if parallel studies yield negative results. Because heterogeneity exists, it must be remembered that any methodological design to determine underlying causes of learning disabilities are sample dependent: if negative results occur in one case, this is not to be taken to refute the notion of an underlying neurological cause (Rourke, 1985). In fact, in the investigation of learning disabilities subtypes, the concept of sample dependency of the methodological design is considered a cause of equivocal findings, because it is hypothesized that a variety of subtypes exist (Obrzut, 1979; Camp and Delacourt, 1977; Boder, 1971, 1970; Ingram, Mason and Blackburn, 1970).

More recently, studies of erratic eye movements among clinically diagnosed dyslexics have substantiated the idea of poor laterality and perhaps poor visual processing (Pavlidis, 1986). A study of this sort can be considered heuristic (Adams, 1985) as little documentation has
occurred regarding this fact.

One of the strongest clinical implications of an obvious base for neurological dysfunction is the finding of cerebral malformations in dyslexics' brains (Geschwind, 1982). Galaburda and Kemper (1979) reported cytoarchitechttonic abnormalities discovered in an autopsy of a dyslexic's brain.

In summary, there is an abundance of documentation to demonstrate neurological anomalies as a basis for learning disabilities. However, the clinical research methods used, e.g., dichotic listening, cerebral axial tomography, and autopsy are not within the reach of an ordinary researcher or educator. Much documentation of learning disabilities subtypes comes not from clinical observation (Benton and Pearl, 1978; Boder 1970) but from statistical analysis. A difficulty with statistical analysis of learning disabilities subtypes is that the results are affected by the heterogeneity of the population, i.e., sample dependency, and the fact that the psychometric instrument or variable in question functioning as a classification device may not possess construct validity and the so-called classification traits may not be valid.

Examining the current models of learning disabilities subtypes, several statistically based studies have yielded similar results. Marshall and Newcombe (1973) proposed a subdivision of impaired readers into visual, surface, and deep dyslexia based on analysis of error types.
Bakker (1979) distinguished between two groups of impaired readers, those having left hemisphere processing difficulties (slow but accurate: type P) and those with right hemisphere processing difficulties (fast but sloppy: type L), using analysis of error types. Mattis, French and Rapin (1975) derived three subtypes from an aposteriori inspection and cross-validation of their data. They determined a primary linguistic group, an articulo-graphomotor type, and a visual-perceptual type. Similar results were substantiated by cluster analysis of learning disabled populations (Watson, Goldgar and Ryschon, 1983; Satz and Morris, 1981; Lyon and Watson, 1981). Decker (1982) and Dekcer and DeFries (1981) used principal component factor scores to classify learning disabled children into a spatial/reasoning deficit pattern, a coding speed/reading disorder, and a reading impaired group without accompanying disorders. Denckla (1977) found similar groups to those of Mattis, et al., and determined a fourth group of reading disabled children as possessing a dysphonemic sequencing disorder. Doehring and Hoshko (1977) using Q-type factor analysis (i.e., examining factor loadings among subjects rather than variables) determined three types of learning disabled subjects: (a) associative, (s) sequential, and (o) those possessing an oral reading disability.

An important subgrouping has been the WISC-R "ACID" pattern (low scores in arithmetic, coding, information,
and digit span) found in profiles of learning disabled children. This suggests subtypes of learning disabled children who will exhibit problems in reading, spelling, and arithmetic (Ackerman, Dykman and Peters, 1977). Joschko and Rourke (1985) state that this pattern may represent two groups: one with immediate auditory-verbal memory sequencing problems, and a group comprised of those with primary visual-imagery disabilities. The authors also state that this pattern may not be representative of all learning disabled children, despite the fact that the ACID pattern is one of the strongest means of identification of learning disabilities (Rourke, 1981; Dykman, Ackerman and Oglesby, 1980; Petrauskas and Rourke, 1979; Ackerman, Dykman and Peters, 1976; Swartz, 1974). Petrauskas and Rourke (1979) urge more investigation into this WISC-R pattern since the populations involved may not have reflected the heterogeneity of learning disabilities. This exemplifies one of the difficulties in statistical analysis of learning disabilities subtypes: sample dependency of instrumentation. Statistical means of isolating traits may reflect the population in question. However, classification of learning disabilities and the accurate identification of the deficit can be a realistic goal if construct validity of a test can be measured (Fisk, Finnell and Rourke, 1985). If the variable in the test design measures accurately what it purports to measure,
then poor performance on a particular test or item may reflect disability in the dimension the test measures.

With the advent of a neurological conceptualization of learning disabilities as a neurodevelopmental problem, it is only logical that neuropsychological instrumentation would be used (Obrzut and Hynd, 1986). Unfortunately, there exists a dearth of research into the validity of the assessment tools, particularly the Reitan batteries, despite their frequent use (Hartlage, 1982; Hevern, 1980). This lack of research may be due to the assumption that neuropsychological instrumentation, particularly the Halstead-Reitan Battery, has factor validity owing to its high predictive hit rate in determining cerebral pathology in highly pathogonomic groups (Lezak, 1983). A strong issue emerges at this point: does the Reitan-Indiana Battery have construct validity for a learning disabled population? Because construct validity would aid in accurate diagnosis of the learning disabilities, and now that learning disabled subtypes have been determined to exist, a truly valid instrument would aid in classification of these subtypes, providing that sample dependency is taken into consideration.

The following section will focus on the specific needs regarding neuropsychological assessment of learning disabilities, and will focus on the methodology of the Reitan batteries that would impact upon the construct
validity of these batteries. Discussion of methodological concerns of the adult battery will be addressed, since the underlying construct paradigm of the battery, the biological theory of human intelligence of Halstead, (1947) was generalized to the children's batteries (Hevern, 1980).

Methodological and Research Issues in the Neuropsychological Assessment of Learning Disabilities

Historically, attempts to find psychological correlates of neurological dysfunction, i.e., brain-behavior relationships were pioneered in this country by Arthur Benton, Marianne Frostig, Lauretta Bender, and Ralph Reitan (Hallahan and Cruickshank, 1973). Benton, highly influenced by the work of Werner and Strauss, attempted to establish developmental standards for visual perception and memory to determine accuracy in the diagnosis of dyslexia. In 1963, his efforts produced the Benton Visual Retention Test, following a memory for designs format. Frostig developed a similar task, the Marianne Frostig Developmental Test of Visual Perception (1961). This differs from the Benton Test in that in addition to assessing memory, it incorporates measures of eye-hand coordination and figure-ground perception. These two popular tests emphasize the trend in the field of learning disabilities to view them as a visual perceptual deficit rather than as an auditory or linguistic deficit (Hallahan and Cruickshank,
Another measurement which reinforced this trend was the work of Lauretta Bender who in 1938 devised the Bender Gestalt, one of the stronger means for detecting visual-motor perceptual difficulties. The Bender Gestalt has since been critiqued for diagnosing learning disabilities: a criticism that can be generated to the trend reinforced by Benton and Frostig (Hallahan and Cruickshank, 1973). Reitan's comprehensive neuropsychological batteries have been cited as overcoming the limits of measuring a single criteria and for examining a wide range of neurological functions including auditory memory, cognitive flexibility and abstract thinking, sensory-perceptual functions, constructional dyspraxia, visual perceptual problems, and aphasia. A strength of the adult battery, the Halstead-Reitan Neuropsychological Battery, is that brain-damaged and normal controls can be distinguished. The author has attempted to incorporate developmental variations in performance of certain tasks, with standardized scores for specific age groups (Filskov and Goldstein, 1974; Klove and Matthews, 1974; Reitan, 1974, 1968; Reitan and Boll, 1974; Wheeler, Burke and Reitan, 1963; Wheeler and Reitan, 1963).

The use of neuropsychological batteries in the diagnosis and classification of learning disabilities would be a logical application to a clinical condition in which there is strong documentation of underlying
neurological anomalies. During the past decade there has been a continual and widely growing trend to incorporate neuropsychological assessment procedures in the evaluation of children with learning disabilities (Hynd and Obrzut, 1986; Gaddes, 1980). These instruments are deemed useful because neuropsychological investigation aids in the differential diagnosis of learning disabilities subtypes, and in the individual diagnosis of learning disabilities, and are excellent aids in planning appropriate clinical remedial intervention (Snow and Hynd, 1985). Currently, the Halstead-Reitan Battery for Older Children and the Reitan-Indiana Battery, developed from his adult battery, and the more recent Luria-Nebraska Neuropsychological Battery-Children's Revision (Golden, 1981) are the most employed. The Reitan batteries are the ones most used in learning disabilities assessment (Hartlage, 1982) but significantly little research has been generated at examining the effectiveness, accuracy and appropriateness in learning disabilities classification and diagnosis (Obrzut and Hynd, 1986; Hartlage, 1982; Hevern, 1980; Amante, 1980; Hallahan and Cruickshank, 1973). This is in surprising contrast to the Luria-Nebraska Battery, which has had several studies directed towards its diagnostic accuracy with learning disabled children (Teeter, Boliek, Obrzut, and Malsch, 1986); its construct validity with learning disabled children (Snow and Hynd,
1985) and its overall diagnostic accuracy (Carr, Sweet and Rossini, 1986; Gilger and Geary, 1985) as a discrimi-
nator of brain damaged from normal controls. Considering
the wide use of the Reitan batteries and the lack of
clinical research into the validity of these instruments
with learning disabled children, there appears to be a
need to substantiate its effectiveness as a diagnostic
tool in learning disabilities diagnoses, and its overall
construct validity. Adams (1985) states that one of
the most important factors in using a test for the
identification of learning disabilities would be its
construct validity. The variable (or test item in question)
should show a direct relationship to specific types of
brain damage, known paths of neurodevelopment, and to
demonstrate consistent reliability and validity in the
widest psychometric sense. The Reitan batteries for
children are modifications of the adult battery and during
the last 15 years, only some 50 critical studies of the
adult batteries have emerged. These studies focus on the
batteries' diagnostic accuracy, its norming procedures,
its reliability, and rarely, its construct validity.

Parsons and Prigatano (1978) addressed the need for
methodological accuracy in clinical neuropsychology. Five
critical variables were isolated that could contaminate
diagnosis and predictive accuracy: age, education, sex,
socio-economic status (SES) and examiner characteristics.
In regards to the variable, age, recent studies have confirmed effect of age differences in test performance. These involve slowing on motor tasks (Finlayson and Reitan, 1976) and loss of ability to distinguish or predict psychiatric or organic impairment in the elderly (Finlayson, 1977; Prigatano and Parsons, 1976). Goldstein and Shelly (1975) urged development of normative data for elderly patients so that no false positive indications of brain damage would occur.

Parsons and Prigatano (1978), looking at effects of education, noted that in all studies of the Halstead-Reitan reviewed by Heaton et al., (1978) including studies of Reitan's earlier methodological basis, the studies did not take into consideration the individual's educational level. Significant correlations between education and test battery performance were found by Prigatano and Parsons (1976); Finlayson, Johnson and Reitan, 1977; and Lin and Rennick (1974), the latter using a strictly epileptic sample. The latter also determined a high correlation between verbal IQ and the category test, supposedly a measure of non-verbal intelligence.

Barnes and Lucas (1974) discovered that discrimination between brain damaged and psychiatric populations disappeared when age and IQ were employed as covariance in an analysis of covariance. Conversely, Holland and Wadsworth (1976) were able to distinguish between brain damaged and
psychiatrically impaired when IQ was statistically controlled. Hevern (1980) cites that the two main general methodological concerns that must be remembered is that a high intellectual/educational level could yield a false negative in determination of brain damage, while conversely, low education level and perhaps average to low intelligence could yield a false positive. Hevern urges that weighing of education and IQ in the confirmation of refutation of an hypothesis involving brain damage of which battery is to be used.

Another critical area to be examined is the effect of examiner characteristics, another highly significant variable (Anastasi, 1982). Hartlage (1982) cites as one of the battery's inherent weaknesses, both for children and adults, is the need for highly specific training from the developer of the test, Dr. Ralph Reitan. Reitan's two year instruction at the University of Washington and later at the University of Arizona, in addition to a year of post-doctoral work at his personal laboratory, would only then qualify the person to make a sound or accurate judgment. Lezak (1983) cites the inherent flaws in a battery that is too long for both examiner and client, and requires a need for highly specific clinical training in the administration. The length of the battery, and the resultant fatigue plus the high chance of inept administration, would contaminate the validity of the performance
to a high degree.

If basic flaws in the methodology of this battery have been determined, and concerns regarding its validity arise, then concerns regarding its construct validity or its subtest factorial validity may be addressed. If items in the test reflect item bias (e.g., SES, education, intelligence, sex, and examiner attributes), then concerns regarding the subdimensions of the battery's items arise. As a psychometric instrument, Reitan (1955) developed his hierarchial model or human intelligence and brain-behavior relationships on an underlying psychological construct or paradigm, Halstead's biological theory of human intelligence (Reitan, 1955).

Factor analysis is the most significant statistical tool to use in determining a test's construct validity (Anastasi, 1982; Lyman, 1978). A review of the literature suggests a dearth of such studies with the Reitan batteries, for both adults and children.

Although the Category test, for example, is said to represent non-verbal intelligence abstraction formation and cognitive flexibility (Reitan and Wolfson, 1985) Lin and Rennick (1974) and Matarazzo, Wiens, Matarazzo and Goldstein (1974) determined a high correlation with verbal intelligence, Lansdell and Donnelly (1977) determined a low sharing with verbal intelligence but a high sharing with visual-motor tasks, hereby raising questions as to its
sensitivity to abstraction formation, presumed to be a function of the frontal lobes. Klonoff (1971) and Crockett, Klonoff and Bjerring (1968) determined factorial validity for normal children, but urged repeated validation studies. With older populations, Swiercinsky (1979) isolated eight factors from among 36 variables which accounted for 68% of the total variance and suggested that "this neuropsychological battery... may not be allowing provisions for independent assessment of specific areas as receptive speech, expressive speech, auditory processing, memory functions, concentration, and symbolic or abstract information processing" (Swiercinsky, 1979, p. 240). In other words, the battery(s) may not be sensitive to a host of neurological variables and may not actually measure what it purports to measure as the studies by Lansdell and Donnelly (1977) and Lin and Rennick (1974) indicate.

Reitan and Boll (1973) first investigated the use of the child modification of the adult battery, The Halstead-Reitan Neuropsychological Battery for Older Children (HRBOC) and the battery for 6 to 8 year olds, the Reitan-Indiana Neuropsychological Battery, in the detection of minimal brain dysfunction (MBD). Reitan and Boll attempted to determine neuropsychological correlates of a learning disabled profile, attempting to determine whether "MBD" groups resembled and performed similarly to normal controls
or to brain damaged controls. Results determined that "MBD" groups resembled normal controls in sensory-motor areas, and resembled brain damaged in measurements of attention, abstraction, and non-verbal intelligence, as well as reflecting deficits in verbal language as evidenced by the Aphasia screening test and the verbal portion of the WISC. However, no specific pattern was seen among the learning disabled group, and no determination of cut-off scores occurred; "MBD" performance was placed in the borderline range.

Selz and Reitan (1979) determined predictive accuracy, using the Halstead-Reitan Battery for Older Children, for "MBD" by discriminant function analysis; rather than use one specific factor or group of factors, a sign approach was used, classifying individuals with level of performance (IQ) or right/left differentiation, intra-individual comparison, and pathogonomic signs, with learning disabled less deviant in right/left differentiation and pathogonomic indicators. However, performance of a borderline nature, if illicit by any one or combination of the signs aided in classifying an individual as being learning disabled; there is still no evidence to show the exact nature of the deficit(s) (Hevern, 1980). The authors advise "extreme caution in the application of any actuarial procedure to individual diagnosis and remediation, considering the unique characteristics of individual
cases" (Selz and Reitan, 1979b, p. 263). This displays need for strong clinical skill in the battery's interpretation, a direct confrontation of the fact that psychometric criteria such as norming, reliability and validity are one of the battery's strengths in its diagnostic use as opposed to other neuropsychological measures (Reitan and Wolfson, 1985; Lezak, 1983).

Sexual differences were noted particularly in the use of the battery with children, particularly in motor strength, suggesting that females would be misdiagnosed as developmentally delayed based on norms that were contaminated with high male performance (Hevern, 1980).

Socio-economic status is a strong factor in test bias (Anastasi, 1982). Parsons and Prigatano (1978), noting the relationship between SES and intelligence, suggested that the impact of occupational background in adults and the SES in child subjects on test performance should be investigated. Hevern (1980) cites the lack of data in this area and concludes that further research is needed to look at the effect of SES on test performance.

Considering the heterogeneity of the learning disabled population, further research efforts would be needed to specify more fully the nature of the underlying functions other than the surface traits the battery represents (Hevern, 1980). In addition, it is crucial to generalize concerns regarding the adult battery to the
children's modification, the HRBOC, and the Reitan-Indiana, since the battery for adults and older children is identical, with only modifications in scoring (Hartlage, 1982). Certain components of the Reitan-Indiana are identical with that of the adult battery, again with modifications in administration and scoring (Hartlage, 1982).

A summary of the review of the literature indicates strong evidence of a neurological basis for learning disabilities, currently conceptualized as a result of underlying anomalies in the neurodevelopment of the child (Obrzut and Hynd, 1986). Learning disabilities are recognized as heterogeneous in nature, and neurological research and applied statistical analysis has yielded information as to a variety of subtypes. It is logical that neurospychological instrumentation be applied to individual diagnosis and to identification of learning disabilities subtypes. However, one of the most important factors in learning disabilities assessment is the construct validity of these neuropsychological instruments, but the review of the literature reveals a dearth of research into this area. It is the purpose of this study to add to the literature and hopefully generate ideas for current research needs in the neuropsychological assessment of learning disabilities with the Reitan instrumentation.
Chapter 3

The Study

This section will provide a description of the sample population, the instrumentation applied and the data collection (procedure). The research questions and the hypotheses will be addressed; following will ensue a discussion of the statistical analysis that was applied, followed by an analysis of the data in the following chapter as well as a discussion of the assumptions and limitations of the study.

Descriptions of Subjects

The subjects of this study consisted of a group of 42 children, consisting of 4 females and 38 males. Age range is from 6 years, 2 months to 8 years, 8 months. Mean age is 7.6. All are from middle income homes, and all are public school attendees primarily from the city of Honolulu or nearby areas of the island of Hawaii. Ethnic composition is 86% caucasian, 7% Asian-American, and 7% native Polynesian. All were referred for learning disabilities assessment from the public schools, the primary problem being significant discrepancy between intellectual potential and academic achievement. The most manifest learning disabilities were difficulties
in reading, the WRAT reading score being at least a year behind expected scholastic achievement. Auditory perceptual problems were also evident, as substantiated by poor performance on Wepan Auditory Discrimination Scores (mean error score = 6.28). Mixed laterality was also a characteristic. It can be assumed that the children are typical of a clinical population, as well as a school population, and that their learning problems were severe enough in the scholastic setting to warrant an outside referral. It is not known whether auditory discrimination problems caused the reading disabilities, or whether co-existing deficits in visual and auditory perception existed. Overall IQ mean was 99; standard deviation 10. Overall verbal IQ was 96, standard deviation 11. Overall performance IQ was 102, standard deviation of 11. Mean for WRAT-reading was 1.6; WRAT-arithmetic 1.6, and WRAT-spelling 2.1. All children were personally evaluated by William Tsushima, Ph.D., clinical psychologist, of the Psychiatry and Psychology Department of the Straub Clinic and Hospital, Honolulu, Hawaii. All children were deemed learning disabled, each individual being carefully screened for emotional disturbances, behavioral disturbances and any physical impairment that might contaminate test performance. All children were deemed not to have suffered any exogenous or organic brain damage of a toxic, infectious or traumatic process.
Instrumentation

Specific components of the Reitan-Indiana Neuropsychological Battery were used. These measures are designed to estimate a variety of psychological correlates of neurological dysfunction (Hartlage, 1982). Components consist of measures of level of performance (WISC-R), measures of central processing, cognitive flexibility, and concept formation; visual-spatial skills, memory, attention, and auditory and visual sequencing. Additionally, there are measures of gross motor strength, motor speed, tactile sensitivity, tactile memory and memory for location. The Wide Range Achievement Test was also employed to provide a means of comparing academic achievement to level of performance (IQ) to assess individual discrepancy in intelligence versus aptitude achievement (Hartlage, 1982).

Procedure (Data Collection)

Data were collected from files of 42 learning disabled children by Dr. Tsushima of Straub Clinic, containing scores of the WISC-R full scale IQ, the verbal IQ, the performance IQ, the ten subtests, the Halstead Category Test, the Tactual Performance Test, including Location and Memory, Finger Oscillation and Grip Strength, and the Wide Range Achievement Test, Reading, Arithmetic and Spelling.
Research Question

This study will answer the basic research question: Does factor analysis of specific components of the Reitan-Indiana Neuropsychological Battery yield different underlying factorial structures than the surface or factor traits it purportedly measures when used with learning disabled children?

Hypotheses to be Tested

$H_1$: Factor analysis of the Reitan-Indiana Neuropsychological Battery establishes factorial validity for learning disabled populations.

$H_2$: Factor analysis of the Reitan-Indiana Neuropsychological Battery establishes lack of factorial validity for learning disabled children. Factor analysis yields underlying factors or dimensions that explain performances of a learning disabled population, other than the surface factors the battery represents.

Statistical Analysis

Factor analysis of specific components of the Reitan-Indiana Neuropsychological Battery was applied, using a 4 factor solution. Principal component factoring was followed by principal factoring replacing the diagonal with the communalities. Varimax rotation with six iterations produced the desired reduction of the original correlation matrix with four factors accounting for 53%
of the variance.

Initially, a 20 x 20 correlation matrix was designed, using the variables (already described) of the battery. This determined the initial reduction to communalities, following a varimax rotation, using the varimax principal of Kaiser normalization (Kaiser, 1958). The principal objective of varimax rotation is to simplify the initial correlation matrix (product moment, i.e., "r") by reducing the number of variables or dimensions based on any factor contributing to covariance. Orthogonality is the concept behind varimax rotation, which simplifies the factor structure by maximizing the variance of a column given as many distinct underlying factors as possible (Kim and Mueller, 1978; Horst, 1965; Kaiser, 1958). Use of principal components factors, in this instance, presupposes the existence of "n" factors; the rationale being the prior determinance of factors. Following varimax rotation, according to the Kaiser normalization, the main diagonal elements of the matrix were replaced by estimates of communalities ("R^2") estimates.

The reduction of communalities in the diagonal increases the simplification of the factor (initial) matrix and determines the main factors or loadings that contribute to variance (Harman, 1967; Thurstone and Thurstone, 1941).

Communalities are shared variance; to maximize the variance six iterations occurred to decrease the factor
loadings. Once elements of the diagonal were replaced by initial estimates of communality, factors were extracted from the reduced matrix. The variance accounted for by these factors became communalities, and these new estimates replaced again the main diagonal elements. This process was repeated until there existed minimal difference between two successive communality estimates. The result was a 4-factor solution; the analysis will be discussed in the next chapter.

Assumptions of the Study

1. The Halstead-Reitan Batteries have become a highly regarded set of instruments used to detect neurological disorders (Hartlage, 1982; Filskov and Goldstein, 1974; Klove and Matthews, 1974, Reitan, 1968, 1974; Wheeler, Burke and Reitan, 1963; Wheeler and Reitan, 1963).

2. Underlying problems with methodology exist which allow for test item bias, such as sex, age, education, intelligence, and socio-economic status (Prigatano and Parsons, 1978) contaminating the batteries' predictive accuracy and validity.

3. Factor analytic studies have confirmed existence of underlying factorial dimensions other than the initial surface factors (Swiercinsky, 1979; Lansdell and Donnelly, 1977). Although these studies have been concerned with the adult battery, concerns regarding construct validity
can be generated to the children's versions.

4. Considering the heterogeneity of the learning disabled population, there is a need to determine the underlying factors that may exist in a learning disabled performance (Hevern, 1980).

5. Although determination of factors consistent with the surface factors would indicate lack of construct validity with a learning disabled population, the identification of the underlying factors would determine the neurological dysfunction(s) and enhance the clinical interpretation of the client's test performance (Hevern, 1980).

6. Learning disabilities are an aspect of neurological dysfunction(s) primarily manifested as perceptual-processing deficits in both auditory, tactile, and visual modalities. These deficits manifest themselves as difficulties with auditory memory, visual memory, auditory and visual sequencing, auditory and visual perception, and tactile imperception. These deficits also impact upon retrieval skills, such as deficits in expressive tasks such as oral language, dysgraphia, and the constructional dyspraxias (Rourke, 1985).

7. Although there is a dearth of research in the use of factor analysis to substantiate factorial validity with a learning disabled population (Hartlage, 1982; Hevern, 1980), concerns directed toward the use of
similar instruments with adult populations can be generated to its use with a child's battery, as the underlying methodology and interpretation of the batteries for adults and children are similar (Hallahan and Cruickshank, 1973).

Limitations of the Study

Limitations of the study rest in the use of factor analysis, which has had criticism directed against it for a variety of reasons: the arbitrary assignment of factors; the arbitrary assignment of the primary communality factor which determines the initial reduction of the primary correlation matrix (Kerlinger, 1982). In other words, the examiner constructs his or her own hypothetical entity; and a method is devised to determine its construct reality.

Aspects of heterogeneity in learning disabled populations will aid in factor delineation, and can be projected across all possible subgroups (Rourke, 1985). However, isolation of subdimensions and latent factors of the Reitan-Indiana Battery will not aid in determination of all subdivisions or classes of learning disabled populations unless extensive norming is done on the population and specific subdivisions can be demarcated according to individual patterns. Isolation of latent factors will aid in the clinical enhancement of this tool when applied to individual cases, and also aid in identification of specific types of learning disabilities sensitive to the variables and subdimensions measured by this battery.
Chapter Four
Results and Summary

This chapter presents the results and summary of the data analysis.

Results of Data Analysis

Analysis of the data with a four-factor solution, principal factor analysis with varimax rotation with six iterations produced four factors.

The first factor was labeled verbal intelligence since all the subtests in this cluster seemed to load on this variable. The scores ranged from a low of .39 on Object Assembly, .49 on Block Design and Similarities, .53 on Picture Arrangement. The highest loadings were .59 for Digit Span, .66 for Comprehension, .67 for Vocabulary, .71 for Information and .78 for Arithmetic.

The second factor for the group of learning disabled children was labeled psychomotor speed, as this factor was characterized by loadings above .52 on tests requiring psychomotor speed. The loadings ranged from .52 to a high of .77. The highest factor was .77 for Finger Tapping, and the second highest, .72 for Category Test. Grip Strength Dominant Hand was lowest, .52, followed by Grip Strength Non-dominant .59, and Finger Tapping
Non-dominant, .64. Picture Arrangement and Object Assembly had loadings of .36 and .35 respectively with Psychomotor Speed.

The third factor was labeled an achievement factor, since all tests of the Wide Range Achievement Test loaded significantly on this variable, being an .89 for Reading, .90 for Arithmetic, and .90 for Spelling. Picture Arrangement loaded at .39 with this factor, as well as Similarities at .30.

The fourth factor was labeled a memory factor, since the tests involved memory skills and loaded significantly on this factor. TPT localization was .80; TPT memory loaded at .77. Coding loaded at .39.
<table>
<thead>
<tr>
<th></th>
<th>X</th>
<th>SD</th>
<th>N=42</th>
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<tbody>
<tr>
<td>Verbal</td>
<td>96</td>
<td>11</td>
<td></td>
</tr>
<tr>
<td>Performance IQ</td>
<td>102</td>
<td>11</td>
<td></td>
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<tr>
<td>Full Scale IQ</td>
<td>99</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>Information</td>
<td>8</td>
<td>3</td>
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<tr>
<td>Comprehension</td>
<td>9</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Arithmetic</td>
<td>9</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Similarities</td>
<td>10</td>
<td>2</td>
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</tr>
<tr>
<td>Digit Span</td>
<td>8</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Vocabulary</td>
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<td>2</td>
<td></td>
</tr>
<tr>
<td>Coding</td>
<td>9</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Picture Completion</td>
<td>10</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Block Design</td>
<td>10</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Picture Arrangement</td>
<td>10</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Object Assembly WRAT</td>
<td>10</td>
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Table 2

Means and Standard Deviations of Wide Range Achievement

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<th>Test</th>
<th>$\bar{X}$</th>
<th>SD</th>
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<tr>
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<td>1.6</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>WRAT - Arithmetic</td>
<td>1.6</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>WRAT - Spelling</td>
<td>2.1</td>
<td>6</td>
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Table 3
Means and Standard Deviations of Reitan-Indiana Specific Components

<table>
<thead>
<tr>
<th>Category (Correct)</th>
<th>X</th>
<th>SD</th>
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</thead>
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<tr>
<td>TPT Dominant (Seconds)</td>
<td>305</td>
<td>130</td>
<td></td>
</tr>
<tr>
<td>TPT Non-Dominant (Seconds)</td>
<td>255</td>
<td>108</td>
<td></td>
</tr>
<tr>
<td>TPT Both Hands (Seconds)</td>
<td>141</td>
<td>82</td>
<td></td>
</tr>
<tr>
<td>Memory TPT</td>
<td>3</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Localization TPT</td>
<td>2</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Finger Tapping - Dominant</td>
<td>34</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>Finger Tapping - Non-Dominant</td>
<td>31</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Grip Strength Dominant (Kg)</td>
<td>16</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Grip Strength Non-Dominant</td>
<td>19</td>
<td>6</td>
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</tr>
</tbody>
</table>

(kilogram)
Table 4

Factor Structure for Learning Disabled Group

<table>
<thead>
<tr>
<th></th>
<th>I</th>
<th>II</th>
<th>III</th>
<th>IV</th>
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</thead>
<tbody>
<tr>
<td>Arithmetic (V)</td>
<td>.78</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Information (V)</td>
<td>.71</td>
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<td></td>
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<tr>
<td>Vocabulary (V)</td>
<td>.67</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Comprehension (V)</td>
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<td></td>
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<tr>
<td>Digit Span (V)</td>
<td>.59</td>
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<td></td>
</tr>
<tr>
<td>Picture Arrangement (V, P, A)</td>
<td>.53</td>
<td>.36</td>
<td>.39</td>
<td></td>
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<tr>
<td>Similarities (V, A)</td>
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<td>.30</td>
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</tr>
<tr>
<td>Block Design (V)</td>
<td>.49</td>
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<tr>
<td>Picture Completion (V)</td>
<td>.43</td>
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<tr>
<td>Object Assembly (V, P)</td>
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<tr>
<td>Finger Tapping - Dominant (P)</td>
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<tr>
<td>Category (P)</td>
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<tr>
<td>Finger Tapping - Non-Dominant (P)</td>
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<tr>
<td>Grip Strength Non-Dominant (P)</td>
<td>.59</td>
<td></td>
<td></td>
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<tr>
<td>Grip Strength Dominant (P)</td>
<td>.52</td>
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<tr>
<td>WRAT - Reading (A)</td>
<td></td>
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<td>.90</td>
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<tr>
<td>WRAT - Arithmetic (A)</td>
<td></td>
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<td>.89</td>
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</tr>
<tr>
<td>WRAT - Spelling (A)</td>
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<td>.80</td>
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<tr>
<td>TPT Localization (M)</td>
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<td>TPT Memory (M)</td>
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<tr>
<td>Coding (M)</td>
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<td>.39</td>
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Chapter 5
Discussion and Recommendations

This chapter includes a discussion of the data analysis and recommendations of research needs in the neuropsychological assessment of learning disabilities with the Reitan batteries.

General Summary

The purpose of this study was to examine the construct validity of specific components of the Reitan-Indiana Neuropsychological Battery when used with a learning disabled population.

Sample

42 learning disabled children, 4 female, 38 male, ranging in age from 6.2 to 8.8 years, mean age = 7.6 and all carefully screened and diagnosed as learning disabled were employed in this study. All were from the data files of Dr. Tsushima of the Psychiatry and Psychology Department of the Straub Clinic, Honolulu, Hawaii.

Statistical Procedure and Data Analysis

A correlation matrix (20 x 20) was designed based on test variables and a principal component factor analysis was utilized followed by a four-factor principal factor analysis which replaced the diagonal with communalities;
varimax rotation according to a principal of Kaiser (1958) was accomplished; varimax rotation with six iterations produced four factors that accounted for over 50% of the variance.

Results

Analysis of the data substantiated the hypothesis that specific components of the Reitan-Indiana lacked factorial validity when used with a learning disabled population. The most significant discrepancy was the high loading of Category with the psychomotor speed factor, indicating that the Category test when used with this population cannot be construed as a measure of abstract thinking ability and cognitive flexibility. Memory factor was consistent with the factorial structure of TPT memory, but indicated that TPT localization was a more strict measure of memory versus proprioception in space. The achievement factor was consistent with the factorial structure of the Wide Range Achievement Test; the verbal factor was consistent with the classification of components of the verbal and performance subtests that load with verbal; a discrepancy was noted in the high loading of arithmetic and digit span with verbal versus any correlation with memory; the implication being that when used with this population (i.e., sample dependent, Skinner, 1981) arithmetic and digit span may reflect a verbal comprehension factor which correlates highly with "g"
Discussion of Data Analysis

In this study the factor structure of the Reitan-Indiana as determined by the statistical analysis did not meet the overall construct paradigm as conceptualized by the author of the battery.

The most significant discrepancy is the high loading on psychomotor speed (.72) of the Halstead Category Test. The Category Test is one of the most striking components of the battery, measuring a child's ability to reason abstractly with material presented in a non-verbal format. Looking at Halstead's hierarchy of human intelligence (Reitan, 1955; Halstead, 1947), the category test is supposedly a measure of pure "g" and is a stronger indication of any intellectual potential than the Weschler scales (Selz and Reitan, 1979). However, with this sample group, the category test loaded highly on psychomotor speed, thereby demonstrating that the category test shared a large measure of variance with motor dexterity and coordination versus any shared variance with measures of general intelligence. Therefore, implications of this finding would indicate that the conventional interpretation of this test is invalid particularly with a learning disabled population.

The Achievement factor is consistent with the construct of the Wide Range Achievement Test (Jastak and
Jastak, 1976, 1968); and in view of neuropsychological interpretation of learning disabilities it can be stated that the use of the WRAT as an achievement indicator can be useful in determining if any discrepancy exists between intelligence and achievement.

The Memory factor is consistent with the structure underlying TPT memory as conceptualized by the author (Reitan and Wolfson, 1985). Localization loaded highly on this factor versus the argument that TPT localization measures proprioception in space (Reitan and Wolfson, 1985). In addition, few factor analytic studies have been done with this instrument; Swiercinsky (1979) using an adult population, demonstrated a high loading with TPT memory with verbal processing/retention capabilities. It can be argued that rather than proprioception in space, a strong memory factor is indicated. The implications are that with a learning disabled population, the conventional interpretation of localization as measuring proprioception in space is strongly dependent on tactile memory skills. Thus, a high tactile memory component is shared by components of this test, versus speed, lateralization, problem solving, or proprioception.

The fourth factor, Verbal Intelligence, is consistent with the Bannatyne (1968), Kaufman (1975) and Sattler (1982) factor analyses of the performance subtests which load on verbal. Also consistent are the loadings on
Vocabulary, Comprehension, and Similarities that correspond with the factor. Of interest is the high loading of Arithmetic (.78) and Digit Span (.59) with general intelligence; it can be hypothesized that in view of the items of the subtests in question, that when used with this testing population, a verbal comprehension factor may account for the high loading with verbal: the beginning items in arithmetic and digit span subtest being more simple, concrete, and less liable to distractibility. Of interest is the lack of laterality among this population, as evidenced by higher factor loadings on non-dominant hand performance, a finding akin to Tsushima's and Towne's (1977) in an investigation of characteristics of children with "questionable brain disorders" (i.e., learning disabilities). The results of this study are in contrast to the characteristics of learning disabled children as proposed by Selz and Reitan (1979a; 1979b). The Selz-Reitan studies regarding the characteristics of learning disabled children, and their proposed set of "neuropsychodiagnostic" rules for their detection, are still one of the most widely upheld and cited of their time (Sattler, 1982; Selz, 1981; Hevern, 1980). The purpose of their studies was to determine, using discriminant function analysis, tests that could "classify" children as learning disabled. The purpose was to demonstrate item sensitivity by a system of rules,
based on intra-test subset performance, that would enable an examiner to accurately classify children as "learning disabled." As a critique of the studies, the main issue is the use of discriminant function analysis. Accordingly discriminant function analysis is not a method by which to construe factorial validity for a given test (Tatsouka, 1970). It is a means to discriminate between two groups or more by significant differences on a test or subtest variable. This does not mean failure to classify an individual can occur based on poor construct validity. It can also mean that a subtest or variable has discriminating power, but perhaps to a degree of covariance shared by another variable. The less underlying factors to account for, the more powerful and accurate the discriminant analysis (Tatsouka, 1970). What is relevant here is the assumption of factorial validity of this battery; and therefore, the classification of learning disabled from normal and brain damaged hinges on the test performance; and the test performance, in turn, mediates the interpretation of the nature of learning disabilities. Selz and Reitan (1979a) contend that the learning disabled population resembled normal controls on motor performance skills, and resembled brain damaged, in terms of higher level cognitive skills (i.e., lower IQs, poor Category performance). However, the factor analytic results in this study demonstrate that a strong verbal
factor is evident in regards to total IQ value, while the Category test loads on psychomotor speed.

Construct validity is never to be assumed in the use of discriminant function analysis to determine group differences. Quite often, validity of a variable is assumed when used to differentiate groups. In summary, there need to be more studies done with the Reitan battery determining its underlying factors, and more studies using factor analysis with different age groups to seek out any developmental variation. These research needs will be addressed in the next section. Lastly, bearing in mind that the Reitan batteries might not be representative of the manifestation of learning disabilities (Hallahan and Cruickshank, 1973), the implications for further development and modification of a broader neuropsychological instrument, either incorporating the Reitan batteries with supplementary neuropsychological tests, or the possible development of a completely new battery, is evident when viewing the large diversity of learning disabilities in the school-aged population. Lastly, a strong implication is that diagnosis and remediation of the nature of the learning disabilities, either in a school or clinical setting, must be taken with caution as evidence exists from this study that construct validity does not exist.

These findings are meant to be viewed with caution,
as little factor analytic studies have been conducted with this battery with normal populations, and with learning disabled populations. Implications for further research will be discussed in the next chapter.

Recommendations for Further Research

1. Considering the relative homogeneity of the research population, it might be useful to carry out factor analytic studies using a similar statistical procedure on an older population. There is much controversy whether learning disabilities remain static or improve with age (Spreen and Haaf, 1986).

2. Considering the relatively small sample population, a replication of the study in hand may be attempted with a larger yet similar population to determine if similar factor loadings exist. This would reinforce the idea that this population was indeed homogeneous, and representative of learning difficulties that would present in a younger, predominantly white male middle class population.

3. Of utmost importance is the need to continue factor analytic studies, regardless of the population in question to determine the host of brain-behavior relationships that may be involved.

4. It must be kept in mind that further factor analytic studies may yield information as to the construct validity of the battery being used, but that further
delineation of the factor loadings vis a vis subtests will enhance the clinical utility of this instrument in the diagnosis and assessment of learning disabilities.

5. Considering the importance of determining subtypes of learning disabilities, once factor analysis of construct validity is determined, a similar study with a more select homogeneous group (based on sex, race, age, SES) may yield more information on subtypes.

6. If factor analysis of more heterogeneous groups yields similar factorial dimensions, then further investigation to validate the underlying constructs as hallmarks of specific learning disability will be needed, and add a significant contribution to the literature, as the extensive factor analysis of the WISC and WISC-R has done (Hartlage, 1982).

7. Considering the fact that any psychometric study is sample dependent (Skinner, 1981), it would be interesting to repeat a similar study with the same population size, same sex, age range, and socio-economic status. If different factor analytic results occurred, it may be hypothesized that the learning disabilities in this case were not dependent upon sex, SES, methodology, but may reflect developmental variation within the 6-8 year age group, which is still a highly "plastic" age in terms of perceptual and intellectual development (Piaget, 1970).
APPENDIX ONE

THE WESCHLER INTELLIGENCE SCALE FOR
CHILDREN-REVISED (WESCHLER, 1974)

WISC-R: The WISC-R is a measurement instrument of the intelligence of children from 6 years to 16.6 years. The standardization of the instrument is excellent, and includes a substantial minority population (Sattler, 1982). In addition to the 11 subtests, which will later be discussed in more depth, the test divides into two areas, verbal and performance, and provides an IQ estimate for these particular grouping of skills, as well as an estimate of full scale IQ. Reliability of the verbal, performance and full scaled IQ are excellent, .94, .90 and .96 respectively. The WISC-R has strong concurrent validity with other measures of intelligence, having a .82 with the Stanford-Binet, and a .68 with the McCarthy scales (Sattler, 1982).

Factor analysis has yielded three major factor structures underlying test performance. These consist of verbal comprehension, perceptual organization, and freedom from distractibility (Sattler, 1982). Similar factor structures were found by Kaufmann (1975) and Bannatyne (1968). Groupings of subtests into sequential,
conceptual and spatial subtests (Bannatyne, 1968) are consistent with neuropsychological use of the battery as being sensitive to deficits in specific areas of the brain (Sattler, 1974; Rourke, Young and Flewelling, 1971; Reed and Reitan, 1965).

WISC-R Subtest Description

**Information**

The information subtest is a measure of formal education; cultural endowment, and is also meant to measure average general knowledge that would be found in the average individual; however, high scores in this area do not reflect overall general intelligence. A broad range of questions reflecting general knowledge are administered, and are scored as either correct or incorrect. Its reliability is .85; and it correlates most highly with vocabulary. It is also the second best indicator of "g" after similarities (Sattler, 1982).

**Similarities**

The purpose of similarities is to measure verbal concept formation and abstract thinking. There is some linkage to cultural factors, the individual's own interests, and to some degree memory. Similarities consist of a series of a pair of words, and the testee is asked to say in what way they are alike. It is an analogies task. Scoring is 0 for incorrect, 1 for concrete reply, and 2 for correct. Its reliability is .81; it correlates highly
with vocabulary and information, and ties with information as the second best measure of "g" (Sattler, 1982).

**Arithmetic**

The purpose of arithmetic is not to assess arithmetic skills, but to assess mental computation and concentration. It consists of 18 items which are administered orally, and the testee must compute these in their minds without aid of pencil and paper. The items range in difficulty from simple math skills such as adding and subtracting to more complex tasks. Its reliability is .77; 42% of its variance is attributed to "g" while .58 is attributed to freedom from distractibility. It correlates somewhat lowly with verbal IQ (.58) and performance IQ (.48) (Sattler, 1982).

**Vocabulary**

Vocabulary consists of 32 words arranged in a hierarchy of increasing difficulty. The subtest purpose is to measure a richness of cognitive functions: learning ability, fund of information, ideas, memory, concept formation and language development. It is an excellent estimate of intellectual capacity. It is considered the best measure of "g" (64% of its variance accounts for it) and it is the most reliable subtest (.86) in the scale. It correlates most highly with information, similarities, and comprehension, and a somewhat low correlation with performance IQ (.58). The items are scored with either a
2 for correct, 1 for more concrete answers and 0 for incorrect (Sattler, 1982).

**Comprehension**

The purpose of the comprehension subtest involves comprehension of social situations and specific problems that might occur, e.g., seventeen items range in simplicity to complexity, involving such social awareness and common sense tasks as what to do if you find a wallet, to an understanding of more complex questions as to the advantage of loving senators and congressmen. Comprehension is considered a good measure of "g" (52% of its variance accounts for "g"); it is a fairly reliable subtest (.77) and correlates more highly with vocabulary and similarities. It has a moderate correlation with the performance scale IQ. The questions are administered in order of complexity, and scored on a 2, 1, or 0 criteria, representing a correct answer, a more concrete answer, and a 0 answer. It is important to remember that comprehension primarily reflects knowledge of conventional standards of behavior, and reflects cultural opportunities, and development of conscience or moral sense (Sattler, 1982).

**Digit Span**

Digit span is primarily a measure of short-term memory and attention. Digits Forward reflects primarily rote learning and memory, while Digits Backwards requires
a mental transformation or holding of the previously administered stimulus. Sattler (1982) describes this as the ability to remanipulate and reorganize encoded information. Digit Span is a poor measure of "g" (24% of its variance), and correlates most highly with arithmetic (.45) another measure of aural tasks. It correlates lowly with verbal, performance and full scale IQ. It must be kept in mind that anxiety can highly impact on performance in Digit Span, rendering low scores (Sattler, 1982).

**Picture Completion**

Picture Completion involves gestalt recognition of an object, and ability to discern missing elements; it also involves ability to differentiate essential from non-essential details. It requires concentration, a fair measure of "g" (37% of its variance). It has fairly good reliability (.77). It has the highest correlation with Block Design (.52) than with any other subtest. In general, it correlates lowly with full scale IQ, as well as both the verbal and performance scales.

Administration consists of showing the testee a picture and asking to describe what is missing. Time limits are imposed. Scoring is either 1 for correct or 0 for incorrect (Sattler, 1982).

**Picture Arrangement**

The purpose of Picture Arrangement is to measure the
child's ability to comprehend and size up a total situation. The general idea of a task must be grasped as a whole. It is considered a strong non-verbal reasoning task which involves planning ability and visual organization. The subtest consists of 12 series of cards that when arranged in correct sequence represent a picture configuration that tells a story similar to that seen in a comic strip. It is considered a fair measure of "g" (36% of its variance); its reliability is somewhat high (.73) and correlates most highly with Block Design. It has an overall low correlation with full scale IQ, and verbal and performance IQ.

The administration of the test consists of timing the response, and assigning a correct answer or incorrect answer. In the later subtests, credit is given for sequential arrangements, even if they are of a different order (Sattler, 1982).

**Block Design**

The rationale behind Block Design involves the ability to measure the skills needed to perceive and analyze forms by breaking down a whole (the design) and then assembling them into the design presented in front of the testee. It combines visual organization, visual-motor coordination, and spatial logic and reasoning. It is conceived as a non-verbal concept formation task that also includes demands on abstract conceptualization. It has extreme
reliability (.85) and correlates most highly with Object Assembly. It has a moderate correlation with full scale IQ (.68), and with the performance IQ (.68) and a low correlation with the verbal scale (.58).

Administration consists of showing a design that can be replicated by arranging a set of blocks. Tasks vary from four blocks to use of all 9. Block Design is a test that is timed; failed responses usually are incurred by exceeding time limit or producing wrong design within acceptable time frame (Sattler, 1982).

Object Assembly

Object Assembly is what Sattler calls a test of synthesizes (Sattler, 1982). It involves a high degree of visual-motor coordination, and perceptual organization. Visual perceptual skills and sensory-motor feedback are crucial in these tasks. It consists of 4 jigsaw problems; all tasks are timed, and credit is given for complete and correct arrangement of the patterns, and partial credit in some instances. Failure is incurred if the time limit is exceeded and items are incorrectly placed. It is considered a fair measure of "g" (.38); has somewhat high reliability (.70), and correlates most highly with Block Design and moderately with performance IQ (.60) (Sattler, 1982).

Coding

Coding requires the ability to learn an unfamiliar
task. It primarily involves speed and accuracy of eye-hand coordination, attentional skills, short-term memory, psychomotor speed (speed of mental operation) and also visual acuity. Motivation is critical with this test. It measures most poorly with "g"; is somewhat reliable (.72), correlates lowly with the other subtests, and the verbal, performance and full scale IQ. The testee is asked to look at a series of nonsense figures and view the corresponding digit above it. Then the digits are displayed and the child asked to write the corresponding nonsense symbol. The trial is timed for two minutes. The number correct is tallied (Sattler, 1982).

Wide Range Achievement Test

The Wide Range Achievement Test (WRAT) is a short, individually administered achievement test in the areas of reading, writing and spelling. It provides limited information about these achievement skills in terms of specific types of reading, arithmetic or spelling disabilities. However, its adequate standardization (Jastek and Jastek, 1978; 1965), and its high concurrent validity with achievement tests such as the Peabody Individual Achievement Test make it a useful, quick screening device to assay academic and achievement levels in spelling, arithmetic and writing. Its reliability is excellent, from .94 to .98 for the three subtests at both levels (Sattler, 1982).
One of the advantages of the WRAT is as a "hold" item (Hartlage, 1982); if neurological problems are suspected, the IQ will drastically lower while achievement remains stable (Golden, 1979). In addition, its use in learning disabilities detection follows a converse pattern in which achievement discrepancy is looked for in view of higher IQ values than one would expect with relatively lower WRAT scores. Golden (1979) also urges that the WRAT/IQ discrepancy not be examined as a sole indication of learning disabilities, due to emotional factors that could impede on scholastic performance.

Reitan-Indiana Neuropsychological Battery

The Halstead Category Test

The Halstead Category Test was designed to measure cognitive flexibility, concept formation, abstract intelligence of a non-verbal nature (Reitan and Wolfson, 1985). It is specifically designed to measure an individual's capacity to deduce general principles from experience with specific items (Golden, 1979). A series of slides is presented; for example, slide 1 presents Roman numeral I on a screen directly in front, and the child must press a corresponding switch; there are four switches and each are labeled 1, 2, 3, or 4. If the correct answer is deduced by the child, the child presses the corresponding switch (1) and is reinforced by a bell. If the wrong switch is pressed, a disagreeable buzzer sound is emitted.
In the children's Category Test (age 8 and below) five series of slides are presented, the total test consisting of 80 items. Each subtest has a specific theme or principal. The child is told to try to figure out the right switch to press. The last subtest consists of items reflecting principals in the other subtest, and the child is told to try to remember the previous items. Scoring is based on error rate. Information about the reliability and validity of this test, and the overall battery, the Reitan-Indiana, is scarce; attempts at norming are also extremely limited (Sattler, 1982). Interpretation of the Category Test relies much on the clinical judgment of the examiner. As a rule, an error score of 40 (about half the number of items in the test) is considered an indication of brain damage.

**Tactual Performance Test**

The Tactual Performance Test is a modification of the Goodard-Sequin formboard. The child sits in front of a board in which 8 objects of various shapes are placed in grooved spaces. The objects are laid in front of the child, who is blindfolded throughout the exam. Three trials are allowed, the child using the dominant hand, then the non-dominant hand, and finally both hands in attempts to place the objects in their correct spaces. After the blindfold is removed, the child then is asked to draw what he remembers, the items scored for number
remembered, and for memory for location. Interpretation is based on comparison of performance between dominant and non-dominant hand, a severe discrepancy indicating lateralization of brain damage. Practice effect is determined by performance with both hands. The test is a measure of comparison of laterality, in indice for determination of brain damage, a test of tactile memory, and proprioception in space (Reitan and Wolfson, 1985). Again, reliability and validity for children has not been actually determined, and norming is scarce (Sattler, 1982).

**Finger Oscillation**

Finger Oscillation is a measure of fine motor speed. It serves as a comparison of performance between dominant and the non-dominant hand. Severe discrepancy in performance between either hand (dominant hand slower than dominant, or non-dominant hand much slower than expected) is indicative of a contra-lateral lesion in the motor strip of the brain. Five trials, 10 seconds each for each hand are computed and averaged (Reitan and Wolfson, 1985).

**Grip Strength** (Dynometer)

A measure of gross motor strength. Like Finger Oscillation, it serves as a comparison of laterality. Five trials each are given for each hand, an average scored in kilograms (Reitan and Wolfson, 1985).
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