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A validity study of the Quick Neurological Screening Test-Revised for learning-disabled students

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A VALIDITY STUDY OF THE QUICK NEUROLOGICAL SCREENING TEST- REVISED FOR LEARNING DISABLED STUDENTS

by

Shannon Bridget Finlayson

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As members of the Final Examination Committee, we certify that we have read the dissertation prepared by Shannon Bridget Finlayson

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STATEMENT BY AUTHOR

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ABSTRACT

In the past two decades, a great deal of information has been amassed in the area of developmental neuropsychology and central processing deficiencies in children. There is evidence that brain dysfunction can play a major role in the etiology of such deficiencies. Also recognized is the direct association between brain deficits and their etiological relationship to an individual's learning problem. Current definitions of learning disabilities reflect a variety of psychological correlates of neurological dysfunction.

There is a general lack of research into the precise nature of the underlying functions that may be detected by neuropsychological assessment. Presently only one brief neuropsychological screening instrument measures performance using age-corrected norms: the Quick Neurological Screening Test - Revised (QNST-R; Mutti, Sterling, Spalding, & Crawford, 1978).

This study was designed to determine the construct validity of the QNST-R with a learning disabled (LD) population. Scores of 122 children, 40 females and 82 males, ages six years, four months to 13 years, five months were collected on 14 subtests from the QNST-R. Principal components factoring of the original correlation matrix disclosed a five factor solution, which accounted for 57% of the original variance. Analysis of the initial correlation matrix revealed very low loadings between the 14 subtests, suggesting that each subtest measures a disparate aspect of student performance. Only one extractible factor exhibited high enough loadings to be interpretable, which was labelled Tactile-kinesthic-motor/left-right differences. This factor accounted for 21% of the variance.

Factor analysis substantiated the hypothesis that limited factorial validity does exist for the QNST-R; however, the analysis also suggested that the test lacked the capability of assessing a range of diverse and independent functions, when used with this LD population. A number of diverse independent functions which are claimed to be measured by the QNST-R, and which need to be measured in order to produce a useful neuropsychological screening instrument, do not appear to exist for this LD population. Finally, age differences were revealed which suggest that younger children have greater difficulty successfully completing the QNST-R items than do older children.

The need for further study is discussed. Alternative explanations for the results of the present study are presented.

CHAPTER 1

INTRODUCTION

In the past two decades, a great deal of information has been amassed in the area of developmental neuropsychology and central processing deficiencies in children. There is evidence that brain dysfunction can play a major role in the etiology of such deficiencies (Rourke & Gates, 1981). Also recognized is the direct association between brain deficits and their etiological relationship to an individual's learning problem (Fisk & Rourke, 1979; Petrauskas & Rourke, 1979; Satz & Morris, 1980). It is estimated that the incidence of underachievers in major western countries such as the United States, Canada and parts of Europe is approximately 15% (Gaddes, 1976), and about 7% of these have demonstrable neurological deficits (Myklebust, Boshes, Olson & Cole, 1969).

In 1975, after years of disagreement as to what constitutes a learning disability, Federal legislation (P.L. 94-142) created a consensus definition:

> ...a disorder in one or more of the basic psychological processes involved in understanding or in using language spoken or written, which may manifest itself in an imperfect ability to listen, think, speak, read, write, spell or do mathematical calculations. The term includes such conditions as perceptual handicaps, brain damage, minimal brain dysfunction, dyslexia, and developmental aphasia. (*Federal Register,* 1976, p. 56977)

However, controversy regarding this definition also exists, due to the heterogeneous nature of learning disabilities (Hallahan & Cruickshank, 1973; Johnson & Myklebust, 1967). One of the implications contained in the Federal definition is that a learning disability may be due to some form of neurological dysfunction, since it includes such conditions as minimal brain dysfunction and dyslexia. In 1981, the National Joint Committee for Learning Disabilities (NJCLD) was formed, in part, in order to provide a more precise definition. Learning disabilities were defined by the NJCLD as a

> ...generic term that refers to a heterogeneous group of disorders manifested by significant difficulties in the acquisition and use of listening, speaking, reading, writing, reasoning or mathematical abilities. These disorders are intrinsic to the individual and *presumed to be due to central nervous system dysfunction.* Even though a learning disability may occur concomitantly with other handicapping conditions (e.g., sensory impairment, mental retardation, social and emotional disturbance) or environmental influences (e.g., cultural differences, insufficient/inappropriate instruction, psychogenic factors), it is not the direct result of those conditions or influences. (Hammill, Leigh, McNutt, & Larsen, 1981, p. 336, emphasis added)

It is clear upon examination of these definitions that learning disabilities reflect a variety of psychological correlates of neurological dysfunction. The NJCLD definition requires an awareness and knowledge of neuropsychology in order to properly diagnose and create successful interventions for learning disabled (LD) students, whose deficits are neuropsychologically based. Difficulties arise based on either definition; the neurological and the psychoeducational aspects often present contradictions as to the specific criteria needed for classification as LD (Benton, 1973; Hartlage, 1982). The neuropsychological model has focused upon the measurement of all cortical areas which mediate cognitive functions of educational relevance (Benton,1973; Gazzaniga,1973; Hynd & Hartlage, 1983; Rourke, 1985); whereas the psychoeducational approach has focused primarily upon discrepancies between adequate intellectual ability and academic dysfunction, and the assessment of cognitive processes more or less independent of their cortical substrates (Hynd & Hartlage, 1983).

Historically, the assessment of learning disabilities subscribed to the neuropsychological model (Strauss & Lehtinen, 1947; Strauss & Kephart, 1955). Early efforts to diagnose learning disabilities usually focused on deviations in performance on particular psychological correlates of neurological dysfunction, such as visual-spatial perception (Bender, 1938) or visual memory (Benton, 1963).

During the 1970's and 1980's, greater emphasis was placed upon the psychoeducational model than that of the neuropsychological model. Within the last decade, however, even greater credence has been accorded within the field of educational psychology to the neuropsychological model of learning disabilities in educational settings, (Hartlage, 1982; Obrzut & Obrzut, 1982) to such an extent that Hynd, Obrzut, Hayes and Becker stated:

> If a neuropsychological evaluation conducted on a child suspected of suffering a learning disability reveals a significant discrepancy between intellectual potential and measured levels of academic achievement, but no neurologic deficits are evident that are

> consistent with a neurologically-based learning disability, then the child should not be diagnosed as LD (In Wedding, Horton, & Webster, p. 473, 1986).

However, the paradigmatic shift from a psychoeducational to a neuropsychological model has occurred primarily at the research level, and has yet to filter down in any systematic manner to educational delivery systems. As Gaddes (1981) pointed out, although the neuropsychological approach shows promise for special education populations in particular, some educators continue to distrust its efficacy. Some educators argue that attempts to relate behavior to the central nervous system is speculative and not useful. As the psychoeducational approach is still the approach most commonly adhered to by school systems, a number of children who are diagnosed as evidencing perceptual deficits or other "soft signs" are not able to gain entry into special education programs. Yet these same students, often assessed as having problems with motor integration, neuromaturational functions, laterality, gross and fine motor skills, etc. have been found to be academically "at risk" (Sterling & Sterling, 1980). The student who reveals solely a discrepancy between intelligence and achievement is continuing to be placed in learning disability classrooms.

Due to the heterogeneity of learning disabilities, comprehensive and efficient neuropsychological assessment batteries were created in order to substantiate the variety of dysfunctions observed in learning disabled (LD) populations. Among the first tests developed to meet this need were the Halstead-Reitan Neuropsychological Test Battery (Reitan & Davison, 1974), the Reitan-Indiana Neuropsychological Test Battery (Reitan, 1969), and the Luria-Nebraska Neuropsychological Battery (Golden, Hammeke & Purisch, 1980). Unfortunately, these tests' administration times (2.5 to 14+ hours) often precludes their full administration in initial assessment situations. The batteries have been found to be useful in the diagnosis of learning disabilities (Satz & Morris, 1980); however, they fail to provide much educationally relevant information (Hynd & Snow, 1986; Selz, 1981). In addition, these batteries appear to be contaminated by their high correlations with intellectual ability (Seidenberg, Giordani, Berent, & Boll, 1983).

Recently a number of shorter procedures have been developed in order to enable the evaluation of neuropsychological functioning in a much briefer period of time, varying from approximately 15 minutes to an hour and a half. Presently only one of these instruments measures performance using age-corrected norms, the Quick Neurological Screening Test-Revised (QNST-R; Mutti, Sterling, Spalding, & Crawford, 1978), which will be discussed later in greater depth. The areas typically measured by neuropsychological screening procedures are general level of performance (i.e., cut-off scores which determine how well or how poorly an individual performs a certain task), memory, language, attentional, motor, and spatial-perceptual capabilities (Brooker, 1984). One of the purposes of a screening test is to provide inexpensive and readily obtained data to assist a clinician in deciding whether to recommend more expensive and more comprehensive diagnostic procedures. Due to the existence of certain neuropsychological disabilities of children without obvious neurological signs of impairment, early, efficient and accurate assessment of these children needs to be made in order to identify deficits that may interfere with learning. A neuropsychological perspective appears to be the best method for understanding the complexity of possible neurological deficits and the manner in which these specific dysfunctions work against the acquisition of other skills (Gaddes, 1975; Rourke, 1975).

Statement of the Problem

A number of researchers (Boll, 1974; Reed, Reitan, & Klove, 1965; Satz, Friel, & Rudegeair, 1974) have suggested that, to quote Rourke (1975)"...a very crucial aspect of brain-behavior relationships, and the study thereof, is a developmental one... (p. 916)." From the neuropsychological perspective, a troubling question continues to plague theoreticians and researchers: how can the link between the brain and behavior be validly measured? The majority of neuropsychological tests for children have not been specifically developed for assessing brain-behavior processes. Although several attempts have been made to incorporate developmental concepts of children's brain-behavioral processes into the quantitative assessment of cortical functions (Birch & Lefford, 1963; Epstein, 1978; Milner, 1976; Spalding, 1976), the validity of neuropsychological procedures for this purpose remains questionable (Benton, 1974; Obrzut & Hynd, 1986).

The QNST-R (Mutti, Sterling, Spalding, & Crawford, 1978) is an instrument which was developed in order to assess the developmental aspects of children's neuropsychological abilities. An individually administered test which is meant to tap neurological integration as it relates to learning, the QNST-R was designed for use as a screening device for early identification of children with learning disabilities. The test, which takes approximately twenty minutes to administer, consists of a series of tasks adapted from pediatric neurological examinations and from neuropsychological and developmental scales. The authors claim that the procedure measures a child's maturity of motor development, skill in controlling large and small muscles, motor planning and sequencing, sense of rate and rhythm, spatial organization, visual and auditory perceptual skills, balance and cerebellar-vestibular function, and disorders of attention. The test authors state that "the test has been found to be useful for screening purposes in that it indicates possible deficit areas; however, it does not label a child as neurologically handicapped, nor does it diagnose brain dysfunction or damage" (Mutti, Sterling, Spalding, & Crawford, 1978).

The authors of the QNST-R have stated that they are interested in children who have academic problems but seem to be of average or higher intelligence, and who may have something wrong with their central nervous system (Mutti, et al., 1978). These children most often have no physical disabilities, but appear to be lagging in neurological development, which consequently affects such developmental areas as language, perception, impulse and motor control, and adaptability. As time goes on, the situation gets progressively worse, and the process of learning becomes more and more difficult (Mutti, et al., 1978). The authors have also suggested that each subtest has educational implications which will effectively assist in teaching tested individuals. Numerous examples of various kinds of errors and their possible significance are provided for each subtest in the manual (Mutti, et al., 1978). While a number of studies have provided support for the QNST-R (Chou, 1984; Geiser & Spalding, 1978; Sterling & Sterling, 1980), more information from studies using LD students are needed. Specifically, no factor analytic study has been reported with the QNST-R. Factor analysis is the most significant statistical tool in the determination of a test's construct validity (Anastasi, 1982; Lyman, 1978). Considering the wide use of the QNST-R, and the lack of clinical research into the validity of this instrument, the focal concern of this study was to ascertain whether or not adequate construct validity exists for the QNST-R, when used with LD children.

Significance of the Problem

As differentiation of learning disorders must include adequate assessment of neuropsychological functioning, school psychologists are now being called upon to provide neuropsychological assessments based on an awareness of brain-behavior relationships. Unfortunately, school psychologists who are trained in and use neuropsychological evaluation procedures remain relatively few in number and generally have not acquired the requisite level of professional preparation necessary to conduct a complete neuropsychological evaluation (Craig, 1979; Hynd, Quackenbush, & Obrzut, 1980; Hynd, Obrzut, Hayes & Becker, 1986). Whether in the process of receiving graduate-level training, or already employed in the public school system, school psychologists and other school professionals must redress this imbalance, and acquire the necessary skills. Professional educators need acquire not only a thorough knowledge of neuropsychology and psychometrics, but also an awareness of available educational procedures and the relationships between varied abilities and deficits and the requirements of such educational procedures.

In 1977, federal legislation mandated schools to become responsible for all handicapped children from three to 21 years of age (Federal Register, 1977). Schools have been slow to adapt to this inclusion of preschool-aged children under their aegis; however, greater efforts are currently under way (Obrzut, 1981a). The need for comprehensive and efficient neuropsychological assessment procedures has therefore increased, to aid in the identification of children with handicapping conditions such as developmental dyslexia or aphasia (Obrzut & Obrzut, 1982). Neuropsychological screening could have a significant impact in terms of early identification and remediation of high-risk children, with the development and application of well-researched measures (Levine, 1982).

There is a general lack of research into the precise nature of the underlying functions that may be detected by neuropsychological assessment (Hallahan and Cruickshank, 1973; Hevern, 1980; Lezak, 1983). In addition, although the QNST-R is purported to be a screening test for learning disability, the authors of this test never define what they mean by the term learning disability (Adams, 1985). Therefore a need exists for greater precision in the definition and selection of LD subjects used in further studies of the QNST-R. It is necessary and important to investigate the merits of neuropsychologically-based instruments, particularly those endeavoring to include a greater focus upon developmental factors, such as the QNST-R. In order to explore the factors underlying this test, to ascertain whether or not the theoretical expectations we hold are accurate (Kerlinger, 1973), and to determine whether construct validity exists for the QNST-R, it is important that factor analytic studies be carried out with this neurodevelopmental procedure.

Purpose of the Study

It is the purpose of this study to determine the factor structure of the QNST-R with LD children of approximately seven to eleven years of age, and in doing so, attempt to determine whether construct validity exists for the QNST-R.

Research Questions

This proposed study will answer the exploratory research question: what is the nature and minimum number of dimensions necessary to describe subject's scores on the QNST-R? In addition, do these dimensions represent the domain that is characterized and identified by other neuropsychological instruments? Will the factor structure for this LD sample represent distinct functions of sensory-motor skills, spatial organization, visual and auditory perceptual skills, balance and cerebellar-vestibular function, as its authors claim it can?

Justifications for the Study

1. The QNST-R has become a well-regarded instrument used to detect neurological disorders (Yamahara, 1972; Mutti, et al., 1978; Sileo, 1978).

2. Due to the lack of conceptualization by many people in the field of special education and school psychology regarding the neurological basis of learning problems, continued efforts towards confirmation and clarification of already accepted as well as newer neurological instruments is a valuable focus (Fisk & Rourke, 1979; Satz & Morris, 1980).

3. A general lack of research into the precise nature of the underlying functions that may be detected by neuropsychological assessment exists (Hallahan & Cruickshank, 1973; Hevern, 1980; Lezak, 1983).

4. Due to the existence of certain neuropsychological disabilities of children without obvious neurological signs of impairment, early and efficient assessment of these children needs to be made in order to identify deficits that may interfere with learning.

5. A need exists for the incorporation of developmental concepts of children's brain-behavioral processes into neuropsychological procedures.

6. Working within an educational environment, the professional with a neuropsychological perspective can provide better integration of behavioral and educational

data and develop a more appropriate and relevant individual education plan (IEP) than those from other fields, such as hospital-based neurologists (Obrzut & Hynd, 1987).

Definition of terms

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

Brain damage: Intellectual, ability or personality defects due to such varied etiology as: traumatic assault upon the brain, cerebral underdevelopment, malformation, disease, metabolic dysfunction, toxicity, degenerative brain disease, demyelinating disease, cerebral vascular disease, convulsive disorders, neoplasms, and other factors.

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

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

Learning disability: A generic term that refers to a heterogeneous group of disorders manifested by significant difficulties in the acquisition and use of listening, speaking, reading, writing, reasoning or mathematical abilities. These disorders are intrinsic to the individual and presumed to be due to central nervous system dysfunction. Even though a learning disability may occur concomitantly with other handicapping conditions (e.g., sensory impairment, mental retardation, social and emotional disturbance) or environmental influences (e.g., cultural differences, insufficient/inappropriate instruction, psychogenic factors), it is not the direct result of those conditions or influences (Hammill, Leigh, McNutt, & Larsen, 1981).

Minimal Cerebral Dysfunction (also known as 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.

Mirror (or overflow) movement: While performing a motoric behavior with one side of the body, the other side of the body involuntarily mirrors this behavior (Schnelle, 1983).

Nystagmus: An involuntary, rapid and repetitive movement of the eyeball (MacDonald, 1986).

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

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

Perseveration: Repetitive behaviors, including motoric movements, verbal expressions, etc. (Pothier, 1982).

Soft signs: Soft signs are distinct, even if minor, neurological signs such as poor balance, involuntary movement, general clumsiness, clear-cut difference in function between the two sides of the body, deficits in reciprocal, rapidly alternating, or selective movement, or disorders of control of movement, such as tremor, or ataxia, among others (Svirsky, 1969).

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

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

CHAPTER 2

REVIEW OF THE RELATED LITERATURE

A literature review of the past fifteen years reveals a significant increase in the number of studies concerned with the assessment of the neuropsychological functioning of children. This review initially will focus on theories underlying the neuropsychological model of assessment, as well as a number of factors which affect developmental variables, such as brain injury, gender differences, and socio-economic status. Next, theories and the history of neuropsychological screening will be reviewed. Finally, an examination of validity and reliability studies of the QNST and the QNST-R will be presented.

Neuropsychological Theories of Assessment

The approach to neuropsychological assessment in the United States grew out of the behavioral model of psychology. Early attempts at developing neuropsychological instruments reflected basic statistical application and design (Fletcher, Rice, & Roy, 1978; Reitan, 1955, 1958, 1959). In Russia, Alexander Luria viewed the issue from another vantage: examination of brain-behavior relationships based primarily on clinical inference and extensive investigation into individual case studies, including a literal "mapping of the brain" (Luria, 1973). Luria's neurological model is particularly useful for educators, as it describes the concept of functional systems that interact to produce behavior, rather than attempting to assign one-to-one correspondence between a specific brain area and a resulting behavior. The Luria Nebraska and the Halstead-Reitan Batteries reflect the theories of their respective authors. The Luria Nebraska Battery is clinical in nature, relying upon the examiner's experience and insight that would otherwise not be accounted for if the examiner relied solely on strict statistical inference. On the other hand, the

Halstead-Reitan and the Reitan-Indiana Battery are much more functionally oriented, examining a wide range of neurological processes such as abstraction, memory, and sensory-perceptual areas which have actuarial or quantitative data backing them up. Lezak (1983) has suggested that an ideal model would take both of these extremes into account, and would consist of both qualitative and quantitative aspects.

The neuropsychological model states that all behavior is mediated by the central nervous system (CNS) and its integrated and supporting physiological systems (Gaddes, 1985). Disruption of normal perception, cognition, or motor response can occur when physiological systems do not function properly. In addition, this model contends that learning disorders are problems in the acquistion of developmental skills, academic achievement, social adjustment, and emotional growth, all of which may be the direct result of perceptual and linguistic processing deficits.

The majority of consequences of head injury influence functioning in the cognitive, perceptual, motor and linguistic areas (Reitan & Davison, 1974; Smith, 1975; Christensen, 1975; Obrzut, 1981b). Thus the primary focus of neuropsychological and neuroeducational assessment is to describe an individual's current level of performance in these areas. One important form of assessment used by neuropsychologists is that of traditional psychometric tests, such as intelligence tests which offer well-established validity, reliability, and adequate standardization. Empirical research has repeatedly supported the validity of predictions made on the basis of psychometric and neuropsychological tests in such areas as diagnosis and prediction of outcome (Reitan, 1958; Reitan, 1959; Russell, Neuringer, & Goldstein, 1970; Klove, 1974; Meier, 1974; Kane, Parsons, & Goldstein, 1985; Sutter, Bishop, & Battin, 1986; Teeter, Boliek, Obrzut, & Malsch, 1986), as well as in the work on subtypes of learning disorders (Satz & Morris, 1980).

However, the vast amount of neuropsychological research which has been done is based upon the study of the adult brain on subjects with traumatic occurrences such as brain lesions, schizophrenia, and epilepsy (Reitan, 1966; Benton, 1969; Luria, 1973, 1980). The awareness which has come from studying adults has not been particularly helpful in the understanding of the neuropsychological functioning of the developing child. As a child's brain is in the process of constantly evolving and adapting, it is neither realistic nor useful to compare it to the adult static brain (Obrzut & Hynd, 1986).

Neuropsychological batteries have become increasingly popular in determining brain-behavior relationships in children. Most of the research on formal neuropsychological test batteries has involved the Luria-Nebraska Neuropsychological Battery (LNNB) and/or the Halstead-Reitan Neuropsychological Test Battery (HRNTB), both originally developed for adults. More recently, these neuropsychological batteries have been extended downward for children. Based on Halstead's battery, Reitan developed two batteries for children: the Halstead-Reitan Neuropsychological Test Battery for Children (H-RNTBC) (for nine to 14 year olds) and the Reitan-Indiana Neuropsychological Test Battery for Children (R-INTBC) (for five to eight year olds). In addition, the Luria-Nebraska Neuropsychological Battery has been revised and now provides a children's version (L-NNB-CR).

In order to discover whether these and other kinds of tests are valid, factor analyses, either through analysis of factors underlying a single battery or the comparison of a series of tests or batteries are often done. Factor analysis is considered the most significant statistical tool to use in determining a test's construct validity (Lyman, 1978; Anastasi, 1982). In the case of an instrument which has not yet had factor analytic studies reported, exploratory factor analysis will derive the minimum number of dimensions necessary to describe a subject's performance on a series of subtests. Due to the paucity of factorial studies involving the childrens' editions of these instruments (i.e., HNTB-C, the R-INB, and the LNNB-CR), factor analysis and validity studies based on the adult versions will be reviewed in addition to studies involving children.

Swiercinsky (1979) conducted a factor analysis of 36 neuropsychological test variables with an adult population, consisting primarily of those tests developed by Halstead (1947) and added to by Reitan (1966), and the Wechsler Adult Intelligence Scale (WAIS; Wechsler, 1955). He isolated eight factors underlying these variables: a general verbal information processing factor, a spatial relations skills factor comprised of both visual and nonvisual abilities, a rapid motor coordination factor, a bilateral tactile acuity factor (based on handwriting and finger skills), a bilateral gross motor speed factor, a right and left grip strength factor, a chronological age factor (i.e., maturation, experience, or other cerebral changes), and a lateral dominance factor. Factors corresponding to Swiercinsky's general verbal information processing factor and the spatial relations factor were uncovered in two earlier studies (Goldstein and Shelly, 1972; Royce, Yeudall & Bock, 1976).

Crockett, Klonoff and Bjerring (1969) and Klonoff (1971) conducted factor analyses of the Halstead-Reitan Neurological Test Battery for Children, and other neuropsychological tests such as the Wechsler Intelligence Scale for Children - Revised (WISC-R) and two Benton tasks (1959). Klonoff's study, as well as the previous study (Crockett, et al., 1969) identified dimensions which closely resembled the Verbal-Performance abilities of the WISC-R. However, ten of the HRNTB-C subtests were found to represent distinct neuropsychological functions, separate from those measured by the WISC-R. These studies provided support for the usefulness of the HRNTB-C, in that the instrument does not merely duplicate information obtainable from the WISC-R.

Karras (1985) factor analyzed the results of over 700 LNNB-CR's, and revealed factors comprised of reading/academic skills, motor skills, tactile skills, and expressive and receptive speech. Using LNNB-CR results from the testing of 100 LD students, a factor analysis was done by Snow and Hynd (1985); a language-general intelligence factor, a reading-written expression factor, and a sensory-motor factor accounted for the majority of the variance. The three factors identified in this study were interpreted as providing some evidence for the factor validity of the LNNB-CR. Using the LNNB-CR, several studies (Geary & Gilger, 1984; Geary, Jennings, Schultz & Alper, 1984; Hyman, 1984) suggested that expressive language, reading, and writing subtests are particularly sensitive in discriminating LD from nondisabled children.

Gamble, Mishra and Obrzut (1988) factor analyzed the Reitan-Indiana Neuropsychological Test Battery for Children, the WISC-R, and the Wide Range Achievement Test (WRAT) on a population of LD students. The data did not confirm the overall construct paradigm as conceptualized by Reitan, suggesting cautious use of this battery with subjects different from normative samples, such as LD subjects (Gamble, et al., 1988). The study did reveal four underlying factors for this LD sample: verbal intelligence, psychomotor speed, achievement and memory.

In summary, the majority of factor analytic studies done with the Halstead-Reitan batteries which were revised for children (HNTB-C, R-INB-CR, and the LNNB-CR), have been done with normal children. These studies yield factors which most often represent sensory-motor skills, verbal and nonverbal intelligence, and relatively independent neuropsychological "adaptive abilities" (Crockett, Klonoff, & Bjerring, 1969). In other words, these batteries appear to measure neuropsychological functions relatively independent of those tapped by measures of intelligence. In addition, the factors have often been found to be congruent with the underlying construct paradigm, as conceptualized by Reitan (Reitan & Wolfson, 1985).

A number of other characteristics and factors must be taken into account when dealing with the assessment of an area as complex as that of brain-behavior relationships. Among the most important of these factors are: developmental variables, brain injury, gender differences, and socio-economic status. Pertinent studies focusing upon such variables are reviewed below.

As emphasized by Boll and Barth (1981), a number of important developmental variables must be taken into account in the attempt to understand children's neuropsychological dysfunction: age of the child at the time of injury, type and size of lesion, and extent and location of damage. In addition, Wilkening and Golden (1982) have shown such factors as the socioeconomic status of the family, previous CAT-scan results, presence and length of unconsciousness, and treatment of injury, including surgery, irradiation, or chemotherapy can influence the eventual outcome of injury. The relationship of brain injury to later development is a complex issue, and must be understood and assessed as such.

Hevern (1980) noted gender differences in the use of the Halstead-Reitan battery with children, particularly in the area of motor strength. This finding suggests that females would be misdiagnosed as developmentally delayed based on neuropsychological norms that were based on and contaminated with high male performance.

Socio-economic status (SES) must be considered in the issue of test bias (Anastasi, 1982). Parsons and Prigatano (1978) called for investigation of the impact of SES in child subjects and occupational background in adults on neuropsychological test performance, while noting the relationship between SES and intelligence. Hevern (1980) suggested that there continues to be a lack of data in this area and called for further research to look at the effect of SES on test performance.

In addition, it is necessary to include a knowledge of developmental stages of learning acquisition in the neuropsychological assessment of children. Myklebust and Johnson (1967) view learning as a hierarchy of information processing, involving, from lower to higher order functions: sensation, perception, memory, symbolization, and conceptualization. If breakdown or lags occur at any level of this hierarcy, school-related problems often occur. Often the result of brain dysfunction, a deficit at any one of these levels of information processing interferes with a child's ability to form concepts and abstractions. It is therefore important that neuropsychological batteries comprehensively test a wide range of higher and lower level cerebral functions. Regardless of the theoretical or psychometric approach used, all sophisticated neuropsychological procedures involve multidimensional evaluations of human ability structures and brain-behavior relationships.

Theories and History of Neuropsychological Screening

Within the realm of neuropsychological assessment, various approaches have been taken to aid in conducting rapid and standardized screening. Until fairly recently, psychologists often relied on the use of individual, unidimensional instruments such as the Bender Visual Motor Gestalt Test as a screening for possible brain damage (Bender, 1938; Eno & Deichmann, 1980). This strategy implied that there is one human ability which will always be affected as a result of brain damage no matter what neuropathological characteristics it may measure (Boll, 1981). This assumption clearly does not take into account the complexity of human brain-behavior relationships. Such single test approaches do not sample a reasonable range of human abilities. Certainly, an examiner would be hard pressed to make remedial suggestions or interventions based on such a unidimensional model. The use of unidimensional tests or tasks for the assessment of brain damage has been largely rejected, with most neuropsychologists advocating the use of either a fixed or flexible test battery (Reitan, 1966).

Recent developments in the understanding of the complexity of brain functioning have led most clinical neuropsychologists to adopt a second screening approach, which is built upon the use of multiple tests to assess a variety of skills (Lezak, 1976; Golden, 1978; Craig, 1979). It is believed that several tests used in collaboration are usually more effective than single tests (Spreen & Benton, 1965).

Two basic principles have been suggested by Smith (1975) as necessary for guiding selection of such tests: 1) the tests should include standardized and objective measures of a broad range of language, verbal and nonverbal reasoning and auditory and visual memory functions, and 2) the tests should be selected as to permit differentiation of the sensory and motor modalities involved in perception and execution of the task (or lower level functions) they were designed to measure.

Parsons and Prigatano (1978) went on to suggest a larger number of criteria as vital in the development of a valid and efficient screening device. First, these guidelines include the requirement that all of the tests/subtests within the battery have been used extensively in previous neuropsychological research and have been found to be effective in identifying individuals with cerebral dysfunction. Second, the subtests need to be brief, easily administered, objectively scored, commonly used in clinical settings, and portable. Third, tests must be chosen that conceptually represent a broad range of cortical functions, including both left and right hemisphere activities. Last, the battery needs to include measures for the most important neuropsychological skills, focusing on the areas of auditory, tactile, visual, spatial, verbal, fine and gross motor, and memory skills.

The majority of neuropsychological screening procedures in use, including the Halstead-Reitan and the Luria-Nebraska Neuropsychological batteries, do not fulfill one or several of these criteria. Either they test a limited number of cognitive and neuropsychological skills (Vega, 1969; Golden & Anderson, 1977; Dodrill, 1978), require difficult to transport materials or materials not commonly found in clinical settings (Goldstein & Kyc, 1978; Goldstein, Rennick, Welsh, & Shelley, 1981), require extensive training to administer and interpret in a competent manner (Barrett, Wheatley, & Laplant, 1982), or often generate data which is excessive in a screening situation (Wysocki & Sweet, 1985).

As mentioned earlier, the Halstead-Reitan and the Luria-Nebraska were among the first tests developed in order to screen for and to assess neuropsychological deficits and brain damage in both adults and children. They have also become a widely accepted means of detecting learning disabilities in school-aged children (Hallahan & Cruickshank, 1973; Hartlage, 1982). In addition to the limitations mentioned above, although they are often referred to as screening procedures, the length of time required for administration and interpretation (2.5 to 14+ hours) often obviates their usefulness as a screening measure. A much shorter amount of time is required for a few recently developed screening batteries, which assess neuropsychological functioning in approximately 15 minutes to an hour and a half. Unfortunately, the great number of these shorter screening batteries were created and are used for adult psychiatric or brain-damaged populations, and are therefore not considered useful nor applicable with children (Kapur, 1978; Barrett, Wheatley, & LaPlant, 1982; Delaney, 1982; Goldstein, Tarter, Shelly, & Hegedus, 1983; Wysocki & Sweet, 1985).

Among the few screening instruments which have been specifically developed for use for children is that of the Miller Assessment for Preschoolers (MAP; Miller, 1982).

The MAP is a standardized screening instrument in which neuromaturational variables compose one of five developmental subtests (i.e., Coordination, Verbal, Nonverbal, and Complex Tasks). The neuromaturational subtest is referred to as the Foundation subtest. Scant validational research has been done with the MAP; however Miller and Lemerand (1986) correlated the Foundation subtest with the four other subtests and the Total test score, and demonstrated the psychometric value of the inclusion of a neuromaturational indices. Very little overlap between the six subtest scores occurred, indicating valid measurement of six individual behavioral domains; in addition, each of the subtests was found to be a good predictor of the Total test score.

In an attempt to discover if neurodevelopmental screening could successfully identify children academically "at-risk", Horner (1984) correlated a neurodevelopmental screening procedure called the Pediatric Examination of Educational Readiness with an achievement test of reading, grammar, and mathematics (Hoffman Learning Problem Indication Index). Using kindergarteners through third graders, she uncovered a strong relationship (.71) between the two instruments . Horner suggested the strength of this result provided support for mass neurodevelopmental screenings of kindergarteners, in order to identify and remediate children with potential neurologically-based learning problems.

The QNST-R remains the only standardized neuropsychological screening procedure in use today. According to Ozer (1968), neurological screening should:

> ...Attempt to objectively identify children with possible learning problems on a large scale and modify school environments early, preventing many of the emotional and behavioral difficulties which make later modification and treatment so difficult. Children selected

by this sort of examination can also then be examined more thoroughly by the appropriate psychological and educational tests. (p. 86)

The QNST-R is an instrument designed to do these tasks (Mutti et al., 1978). The QNST-R appears to have face validity and seems to measure abilities similar to those determined by the Halstead-Reitan and the Luria Nebraska (Yamahara, 1972; Mutti, et al., 1978; Sileo, 1978; Stannard, 1981): general level of performance, memory, language, and attentional, motor, and spatial-perceptual capabilities (Brooker, 1984). However, as Parsons' and Prigatanos' (1978) criteria for selection of screening batteries suggests, face validity is not a sufficient basis for selection and usage of any psychometric instrument. During a thorough review of the literature, no factor analytic studies of the QNST-R or other shorter screening batteries were unearthed. In order to explore and describe the factors underlying these tests, to ascertain whether the theoretical expectations we hold are accurate, and to attempt to provide greater construct validity for these screening instruments (Kerlinger, 1973), it is important that studies employing factor analysis be carried out with recently developed shorter neuropsychological batteries.

In summary, it is vital that neuropsychological screening instruments assess functions in the auditory and visual receptive modalities, and the spoken, written, graphic and constructional response modalities (Meier, 1981). Screening for perceptual and/or organic problems needs to occur as efficiently and as quickly as possible. The human cortex and its major parts must be assessed by the specific selection of tests, including cognitive, language and sensory-motor skills, that then may show dysfunction in the various forms of learning disorders. Much as is the case with full-fledged neuropsychological batteries, the use of a multidimensional, systematic examination of sensory-perceptual, motor, linguistic and problem-solving abilities currently appears to characterize a number of neuropsychological screening instruments.

A Review of Validity studies of the QNST-R

The QNST-R was developed in the mid-seventies in an attempt to provide classroom teachers with a means of identifying those children (ages five and over) in their classrooms who have learning disabilities caused by neurological insufficiency. In other words, this instrument was not intended to replace a pediatric exam or psychological testing, but rather to identify children who may experience learning difficulties through various motor tasks. The test requires approximately 20 minutes for administration. A Revised Edition of the QNST appeared in 1978.

The QNST-R consists of 15 observed tasks: Hand Skill, Figure Recognition and Production, Palm Form Recognition, Eye Tracking, Sound Patterns, Finger to Nose, Thumb and Finger Circle, Double Simultaneous Stimulation of Hand and Cheek, Rapidly Reversing Repetitive Hand Movements, Arm and Leg Extension, Tandem Walk, Stand on One Leg, Skip, Left-Right Discrimination, and Behavioral Irregularities. The test was adapted for the most part from a typicial pediatric neurological examination. In addition, a few of the tasks were derived from developmental scales or neuropsychological tests. However, the test contains no systematic measures of intellectual, cognitive or academic functioning. The test requires that the examiner be highly observant of the child's behavior and make subjective ratings concerning the child's performance. Although subjective scoring is involved in the test, no direct measure of scorer reliability is presented in the manual. As the reader or prospective test user has no way of determining to what degree scoring is influenced by examiner bias, this omission is a significant deficit.

Since the test's initial dissemination, some 20 critical studies of this test have been published, many of which were done by the authors or their associates in an attempt to validate the effectiveness of the QNST-R. These focus on its diagnostic accuracy, its predictive accuracy, its norming procedures, its reliability, and rarely, its construct validity.

Normative Studies

Using data from 1,231 undifferentiated subjects and 1,008 "LD suspect" subjects gathered from a series of studies, age-related performance norms for both groups were produced (Sterling & Sterling, 1977a); these norms range from five to seventeen years of age. Although normative data for this instrument begin at the age of five, a number of the tasks which subjects are asked to perform are actually able to be proficiently accomplished only by the age of seven and older. Difficulties with the subtests Figure Recognition and Production, Rapidly Reversing Repetitive Hand Movement, Thumb and Finger Circle, Sound Patterns, and Arm and Leg Extension were considered most characteristic of LD populations. The brevity with which the data are presented by the authors leaves them difficult to interpret. The subjects who were classified "learning disabilities suspect" were termed such if they were placed in a learning disabilities class, were referred for placement in such a class, or were even screened for possible placement. Subjects were considered to be in the "undifferentiated" group if they were in a regular classroom. The manner in which subjects were chosen leaves something to be desired; the "learning disabilities suspect" group may not have been LD subjects as classified by P.L.94-142 (*Federal Register*, 1976, p. 56977). The authors also noted that in the LD group more of the subjects were older than those in the undifferentiated group. Yet the norms which one is given to follow, which claim to differentiate LD children from normals are based on these poorly classified subjects.

Validity Studies

The first research study published focused on establishing discriminant validation; in this case, in the identification of LD children (Mutti, et al., 1978). A battery of psychoeducational tests, including the QNST, was given to 176 children, half of whom were LD, half of whom were normal students (reading at or above grade level). A discriminant analysis indicated that the QNST was most useful for children between the age of seven and nine years, but that it also discriminated between LD and normal older children. In addition, a multiple linear discriminant analysis was performed on the subtest data to identify which subtests were most valuable. The analysis indicated that the subtests' effects varies at different ages, demonstrating the developmental nature of the QNST-R subtests; however, Finger to Nose, Figure Recognition and Production, Rapid Hand Movements, Eye Tracking, Arm and Leg Extension, Tandem Walk, and Stand and Skip were the most discriminatively effective subtests.

A replication of this study was done by Sileo (1978) with 14 LD and 17 normal children. The author found the QNST successfully discriminated between the two groups. A test of discriminant function indicated that the subtests Hand Skill, Figure Recognition and Production, Rapidly Reversing Repetitive Hand Movements, Thumb and Finger Circle, Arm and Leg Extension, Left-Right Discrimination, and Behavioral Irregularities contributed the most variance to the difference between the two groups.

In a study by Spalding (as cited by Mutti, et al., 1978), normal and LD students matched on age, sex, socioeconomic status and intelligence were given the QNST. Using a discriminant analysis, both total groups (LD and normal) and students grouped by age were analyzed. Significant differences for all groupings were uncovered. Finger to Nose was identified as the single most discriminating subtest.

Spalding (1976) also studied the QNST as a vehicle for the identification of high-risk children in kindergarten and first grade. Assessing 198 children, the test was not found useful in the prediction of low reading scores at the end of first grade, with six month intervals used as predictors. The data indicated that the QNST has too many subtests on which all children have not matured enough in order to be useful before the age of six years in differentiating children who are LD. However, the test was used successfuly to identify normally achieving children. In other words, children who were able to perform well on the QNST demonstrated average or better reading/spelling scores at the end of first grade.

The QNST was used by Crawford (1974) in a predictive validity study; he correlated the neurological scores with twenty-one measures of behavior and achievement (cited in Mutti, et al., 1978). He found high scores on the QNST (which indicate neurological impairment) correlated significantly with low grade point averages as well as with measures of social deviance.

The correlation between scores on the Bender Visual Motor Gestalt and the QNST was studied by Landon (cited in Mutti, et al., 1978). The tests are both brief measures of neurological integration, but differ significantly in that the Bender must be scored by a certified school psychologist, and the QNST can be administered and scored by a classroom teacher. Using the Koppitz Developmental Scoring System (1964) for the Bender, Landon found a low but positive correlation of .51 between these two instruments.

The Wide Range Achievement Test (WRAT) and the QNST were compared by Meyer (1976) with 21 LD students. On the Reading and Spelling portions of the WRAT, the correlations (.50 and .48, respectively) were not high but were considered significant. These results indicate that high scores on the QNST may be predictive of academic deficits, in the areas of reading and spelling. The correlation of scores between the QNST and the WRAT Arithmetic subtest was not significant.

Bell (1975) analyzed one subtest from the QNST, the Double Simultaneous Stimulation of Hand and Cheek with 194 children ranging in age from four years three months to six years nine months. The study isolated a strong age-to-success relationship, indicating further support for the developmental nature of this test. Sterling and Sterling (1977b) replicated Bell's work with 250 children of similar age and found similar results.

The QNST was compared with the Denver Developmental Screening Test (DDST) in order to determine its usefulness as a screening instrument (Sterling & Sterling, 1977a). The DDST was meant to be used as a device for identifying children at risk of evidencing developmental delay. This instrument had also been used in some mass screening programs as a tool to identify neurologically handicapped children, which it was not designed to do. With an unnamed number of subjects, the DDST failed to "flag" more than half of those children showing positive neurological findings on a medical physical examination. The QNST correctly identified the neurologically impaired students, as well as isolating a number of children with high scores who showed no definable medical neurological abnormality. However, it was unclear whether or not this later group of children were developmentally impaired, or what characteristics or traits their high QNST scores actually measured.

Sterling and Sterling (1977b) compared results from QNST screenings, complete medical-neurological examinations and extensive assessment of language skills. With 66 children "known to be doing poorly in school", data suggested that slightly over half of these subjects were found to suffer from moderately severe to severe auditory-receptive impairment, eight evidenced borderline impairment, and 22 were shown not to have auditory-receptive impairment. In addition, 42 of the 44 children who showed problems with auditory-receptive skills also evidenced impaired balance; whereas, of the 12 subjects showing satisfactory balance, only two showed impairment of auditory receptive skills.

Lambric (1979) used the QNST-R to discriminate between normal, LD and emotionally disturbed subjects using Total test scores. He determined that the QNST-R would differentiate between individuals who were normal and either LD or emotionally disturbed, but not between LD and emotionally disturbed subjects (Lambric, 1979).

Sterling and Sterling (1980) compared QNST-R results from 550 subjects with the findings of medical-neurological examinations. In the authors' terms, 350 of these subjects came from an "undifferentiated" population, while 200 were "suspected" of, or known to have, "learning problems". Fifty-nine subjects from the group with learning problems received abnormally high scores on both the QNST-R and the medically-based examination. No subject having positive neurological findings (i.e., indication of brain damage) on physical examination had QNST-R scores in the normal range. Thus it appears that the test is exceptionally good at identifying subjects with abnormal neurological physical examinations. However, an important problem with the QNST-R is that in this study a large, unspecified number of subjects had abnormally high QNST-R scores and no positive findings on neurological examinations. It would appear that there may be a relatively large number of false positives on the QNST-R in subjects without positive neurological physical examinations. Just as importantly, this study revealed abnormally high QNST-R scores on only 29% of the "learning problem" subjects, despite the fact that the test is purportedly a screening test for learning disabilities. The researchers suggested that the overly high QNST-R scores were caused by the greater significance given to soft neurological signs in the QNST-R than in a neurological examination; this explanation would appear somewhat insufficient, considering the "learning problem" subjects' scores (Sterling & Sterling, 1980).

The QNST-R was used in an effort to statistically differentiate normal, LD, emotionally disturbed, and other non-handicapped students who were performing below average in school (Stannard, 1981). The author concluded that the Total score of the QNST-R can be used to separate students (six to nine years of age) who succeed in school from those who do not. It remains unclear as to what kind of student these terms refer to. Based on her data, Stannard suggested that the QNST-R cannot be used to separate students performing below average in school achievement and behavior into distinct handicapping conditions. In other words, the claim that the QNST-R can be used as a screening device for early identification of children with learning disabilities was not substantiated by this study.

A similarly focused study was done by Heslin in 1982. Sixty students, ranging in age from eight to 19, 30 of whom were identified as LD, and 30 of whom were identified as normal were tested on the QNST-R. This instrument successfully classified 56 of the 60 subjects. However, there were no statistical blinds built into this study, and the researcher was the sole examiner, with complete awareness of each individual's identification. It would appear that these results need to be replicated incorporating statistical blinds prior to being viewed as valid. In addition, stepwise regression was applied to the data, and a reduced model consisting of the following six subtests was identified: Figure Recognition and Production, Sound Patterns, Finger to Nose, Rapidly Reversing Repetitive Hand Movements, Stand on One Leg and Skip. The reduced model resulted in 55 students, or 92% of the students being classified accurately.

In 1981 Fabian and Jacobs used the QNST-R and the Canter Background Interference Procedure (BIP) of the Bender Gestalt Test, and discriminated specific neurological and organic signs in an adolescent LD population. Of 23 LD subjects, 82.6% (19 subjects) were found to be neurologically abnormal by the QNST-R, whereas only 11 subjects were identified as having neurological abnormalities as measured by the BIP. The QNST-R identified a number of neurological soft signs: clumsiness reflected in inadequacies of balance, coordination, or gait; adventitious motor overflow; difficulties in executing fine motor imitative movements; manifestations of extinction to double simultaneous tactile stimulation; and inadequate graphesthetic and stereognostic responsiveness.

A significant difference was found between 15 children diagnosed as having articulation problems and a normal control group of 15 children (aged five to eight) on the QNST-R and a test of motor impairment (Cermak, Ward, & Ward, 1986). The authors interpreted these results as supporting the hypothesis that subjects with articulation disorders would have more motor coordination problems and soft neurological signs than subjects with normal speech.

A number of QNST-R subtests are thought to be negatively affected by choreoathetoid movements (a nervous disease in which there are irregular, jerking movements caused by involuntary muscular contractions). Cermak and Nelson (1982) compared 43 6-8 year olds, half of whom were identified as LD. On the six subtests which are thought to be affected, the LD subjects performed significantly less well than the normal students. Neither the presence of a learning disability nor the presence of choreoathetoid movements was a significant factor in performance on the remaining nine items.

Reliability Studies

In 1972, Yamahara conducted two research projects which attempted to establish whether the QNST scores remained closely similar in test-retest situations six to eight weeks apart. The first project studied scores when tests were administered by two different examiners; a reliability correlation coefficient of .71 was obtained. Due to the fairly small number of subtests (15), and also the fact that the "soft" signs the QNST attempts to measure often tend to be variable, this result was considered significant. Yamahara's second project used one researcher as an examiner, over a time lapse of six to eight weeks. This time period was chosen as short enough to control for maturation, and long enough to eliminate any learning effect. The correlation coefficient was measured at .81, a strongly significant measure of reliability. However, it is important to note that this high correlation figure may represent a measurement of examiner bias just as easily as it may represent scorer reliability. It would appear obvious that a single examiner is likely to exercise the same scoring bias on two administrations, particularly two which are given only a month or so apart. In Yamahara's research, the most reliable subtests were found to be Figure Recognition and Production, Double Simultaneous Stimulation of Hand and Cheek, and Behavioral Irregularities.

Geiser and Spalding (1978) researched differences in scores when the QNST-R was administered by "experts" and classroom teachers. The two groups of examiner's scores resulted in a correlation of .69, which is significant at the .001 level. This research indicates that the QNST-R can be a reliable instrument in the hands of teachers who have been minimally trained in its use.

Although this test is marketed as a screening test for learning disability, the authors of the test never precisely define what they mean by the term learning disabilities, either in their manual or in their research. An ongoing controversy continues concerning the meaning of the term, and the disability has been conceived of as heterogeneous in nature (Boder, 1971). For instance, there are at least three, possibly more, subtypes of reading disabilities alone, each with a distinct neuropsychological pattern or profile of abilities and disabilities (Kinsbourne & Warrington, 1963; Mattis, French, & Rapin, 1975). It appears obvious that greater care needs to be exercised in the selection, definition and analysis of subjects upon whom research and normative work are based. Although an impressive number of subjects (2,239) were evaluated in the initial QNST normative study, the results are difficult to interpret given the problems mentioned above.

In summary, the QNST-R contains no systematic measures of cognitive, intellectual or academic functioning. These abilities are important in the assessment of learning disabilities. It appears to be an excellent tool for matching the findings of a standard pediatric neurological examination, although it has a tendency to come up with overly large numbers of false positive findings (Sterling & Sterling, 1980). The QNST-R would appear to be best used as one test in a battery of neuropsychological tests for learning disabilities. On an overall basis, the QNST-R appears to be a well-validated measure, and has been shown to be a useful tool in the hands of teachers and psychologists interested in the identification and remediation of LD children. It is a screening test, and therefore must not be considered an in-depth study of a child's neurological insufficiencies; it does not replace the standard neurological examination or psychological assessment. Rather it appears to be able to aid in early identification; and, combined with other psychological, academic and behaviorial instruments, may be able to facilitate the planning of remedial interventions.

CHAPTER 3

METHODOLOGY

This chapter will describe the research method applied to the hypotheses to be investigated. Included is a description of the sample, the instruments that were used, and the treatment of the data.

Sample and Description of Subjects

The selection of subjects was made from the Tucson Unified School District, a large, Southwestern urban school district. Principals and teachers from each of the 70 elementary and 15 middle school LD classrooms in the district (both resource and self-contained classrooms) were asked if they were willing to participate in the study. Consent forms developed in accordance with human subjects guidelines were then sent home with every student in order to gather both student and parental permissions (see Appendix A). LD teachers were asked to remove any students from the subject pool who had Full Scale IQ scores which fell below the average range. A total of 134 subjects were tested; however, the data from twelve additional students were dropped after ascertaining that their IQ scores fell well below the required level of a Full Scale IQ score of 80 or above. The final sample in this study consisted of 122 subjects who were selected on the basis of age and of their enrollment in LD classrooms according to P.L.94-142. Subjects ranged in age from six years, four months to 13 years, five months, with a mean age of 10 years, four months (SD = one year, six months). The mean grade placement was 4.1 (SD = 1.5), with students representing grades one through six. The distribution of of subjects included: six students from Grade one, 15 students from Grade two, 18 students from Grade three, 28 students from Grade four, 28 students from Grade five, and 27 students from Grade six. Of the subjects selected, 82 were boys, and 40 were girls. Special educational services were provided to 91 subjects through resource programs, and to 43 subjects through self-contained programs. The ethnic backgrounds of the subjects included: 59 Caucasians, 42 Hispanics, 13 Blacks, six Native Americans, and two Asian Americans. Those subjects who came from non-English backgrounds were tested on the Language Assessment Scales (LAS; Duncan & De Avila, 1987) by school district personnel, and had to have obtained a score of four (i.e., proficient in English) or higher in order to participate in this study. As a secondary criteria in order to ensure English proficiency, school developmental records were checked, and only those subjects from households with primarily English spoken in the home were retained in the study.

Instrumentation and Description

The measurements used in this study included quantifiable components of the Quick Neurological Screening Test, Revised (QNST-R) (Mutti, Sterling, Spalding, & Crawford, 1978), the Wechsler Intelligence Scale for Children-Revised (WISC-R) (Wechsler, 1974), and the Woodcock Johnson Psycho-Educational Battery (WJPEB) (Woodcock & Johnson, 1977).

Quick Neurological Screening Test-Revised. The QNST-R protocol is shown in Appendix B. The QNST-R was developed as a screening device to identify children with possible neurological disorders which interfere with learning. It consists of 15 subtests that help identify persons, as young as five years old, who have learning disabilities. The tasks have been adapted from neurological pediatric examinations and from neuropsychological and developmental scales. The Behavioral Irregularities Subtest was excluded, due to the subjective nature of the determination of the criterion.

According to the test's authors, the subtests of the QNST-R Battery measure the following:

Hand Skill: "Measures the ability of the individual to hold and use a pencil in writing her/his name, and writing a sentence from dictation (see Appendix C, for sentences). It is a measure of motor maturity and planning, fine-hand and eye-hand skills, and hand preference."

Figure Recognition and Production: "This subtest screens for awkwardness in copying five geometric figures, in addition to visual discrimination and perception, motor maturity and planning, fine-hand and eye-hand skills, and visual-spatial perception."

Palm Form Recognition: "This subtest is not considered to be a discriminative test, rather it was added to provide length and strength to the test by finding those who fail to follow directions or are inadequate or unready to learn numbers, as well as categorization (i.e., numbers vs. letters), names and shapes of numbers, symmetry (i.e., left-right differences), and sense of touch."

Eye Tracking: "This subtest measures the adequacy and coordination of eye movement."

Sound Patterns: "This subtest screens for the ability to transfer an auditory pattern into a motor pattern, as well as auditory-motor integration, auditory-spatial orientation, and symmetry."

Finger to Nose: "This is a measure of the subject's sense of position in space, motor planning and maturity, proprioceptive and kinesthetic sense, fine control of large and small muscles, rate, rhythym and sequence, smoothness of motion, and symmetry."

Thumb and Finger Circle: "This subtest measures left-right discrimination, symmetry and balance in the use of the hands and fingers, an important task for fine and visual-motor coordination."

Double Simultaneous Stimulation of Hand and Cheek: "This subtest measures the ability of the individual to discriminate touch, in addition to multiple-tactile stimuli, brain maturity (craniocaudal progression), and symmetry."

Rapidly Reversing Repetitive Hand Movement: "This subtest measures the demonstration of agility and balance in rapidly accelerating hand movements, as well as fine control of large and small muscles, rate, rhthym and sequence, smoothness of motion, and symmetry."

Arm and Leg Extension: "This subtest measures and identifies tremor and random movement in stretched muscles, in addition to motor maturity and planning, fine control of large and small muscles, proprioceptive and kinesthetic sense, a sense of body in space, and symmetry."

Tandem Walk: "This measures balance and random body movement, and clumsiness in gross motor movements, as well as motor maturity and planning, proprioceptive and kinesthetic sense, a sense of body in space, rate, rhythm, sequence, and symmetry."

Stand on One Leg: "A measure of balance and agility, in addition to fine control of large muscles, motor maturity and planning, proprioceptive and kinesthetic sense, a sense of body in space, rate, rhythm, sequence, and symmetry."

Skip: "This measures coordinated movement in the feet and legs, as well as motor maturity and planning, proprioceptive and kinesthetic sense, a sense of body in space, rate, rhythm, sequence, and symmetry."

Left-Right Discrimination: "This subtest is composed of measures of left-right discrimination, taken from Finger to Nose, Thumb and Finger Circle, Stand on One Leg, and Skip subtests, and also measures motor and sensory maturity."

Scoring the QNST-R

The test Total score for the QNST-R is obtained by tabulating the error scores on the 15 subtests which places the individual in the High (H), Suspicious (S) or Normal (N) category of neurological functioning. There are 91 items in all.

The authors state that an H score (a total exceeding 50) indicates that a child is likely to have trouble learning in the regular classroom, and is an indication of neurological insufficiency. An H Total score also must have some individual tasks scored in the H range. Only 2% (N = 3) of the 122 LD subjects in this study received a High Total score.

The S score requires a Total score of 26-50, and must have some scores in the H or S range. The authors suggest that a S score usually results from one or more symptoms which may be developmental or neurological, depending on the age of the child and the severity of the symptom. This category includes persons who do not perform at the level predicted for their age. A severe symptom rarely occurs alone; rather it is apt to appear in clusters or patterns involving combinations of deficits in visual and auditory perception; in fine and gross motor skills; or in such sensory areas as touch (Mutti, et al., 1978). Approximately 41% of the LD students (N = 50) in this study received a Suspicious Total score.

The N score (a score of 25 or less) is almost always achieved by persons who are not likely to have specific learning disabilities. The N Total score must have no individual tasks scored in the H range. These subjects are assumed to be neurologically normal. Of the LD subjects in this study, 59% of them (N = 69) received a Normal Total score. The categorical divisions of Normal, Suspicious and High Total scores for this population are shown in Figure 3. These data suggest that, for this LD population, the test was not able to successfully identify the presence of learning disabilities in children already labelled as LD.

Wechsler Intelligence Scale for Children-Revised(WISC-R). WISC-R IQ scores were gathered from each child's most recent psycho-educational evaluation report. The WISC-R Verbal and Performance IQ scores measure various aspects of verbal and visual spatial abilities, as well as motor and attentional components, all of which are psychological correlates of neurological dysfunction (Anastasi, 1982; Wechsler, 1949). No intelligence test was administered earlier than three years prior to the 1989 school year. All intelligence tests were administered by certified school psychologists or supervised interns. The mean WISC-R Full Scale IQ score of the subject group was 91.8 (SD = 10.2). The mean Verbal IQ was 88.9 (SD = 11.3), and the mean Performance IQ was 96.5 (SD = 11.0). The mean Verbal, Performance and Full Scale IQ scores fell within one standard deviation (SD = 16) of the average score of 100.

Woodcock Johnson Psycho-Educational Battery (WJPEB). WJPEB Achievement scores (reading, mathematics and written language) were also collected, in order to ascertain whether students exhibited criteria representative of visual-spatial or auditory-linguistic deficits (Pirozzolo, 1981). Most of the achievement data came from tests administered less than a year from the date of this study, and none of the scores were administered earlier than two years prior to the 1989 school year. Achievement tests had been administered by learning disabilities teachers. Based on two of the 12 criteria that Pirozzolo has suggested, (average or above average performance IQs relative to lower than average verbal IQs, and at least 1.5 to two years delay in reading acquisition) the majority of the subjects appeared to be of the auditory-linguistic subtype. Only two of Pirozzolo's 12 criteria were able to be ascertained within the constraints of this particular data collection. Students with at least 1.5 to a two year delay in reading achievement were selected from TUSD special education files, with the exception of children in the first and second grades. As Woodcock Johnson scores do not go below the age-level of 1.0, nor are they considered very precise at these younger age levels, the 1.5 to two year delays are difficult to document prior to the onset of the 3rd grade. This additional delimitation of subjects sought to provide a more precisely defined population, in an attempt to reduce the intrasubject variability (heterogeneity) that traditionally typifies LDR samples (Lyon, 1985), and to provide further investigation of this subtype of learning disability. The majority of the WJPEB achievement scores collected from subjects' files were notated in grade equivalent score form. By referencing tables in the WJPEB manual in a backwards manner, the grade equivalent scores were converted to standard scores. WJPEB scores were available for only 113 of the 122 subjects. WJPEB achievement mean scores for reading, mathematics and written language are presented in Table 1.

Table 1

Means and Standard Deviations of Woodcock Johnson Achievement Grade Level and Standard Scores

N=113	Grade Level		Standard Score	
	$\overline{X}$	SD	$\overline{X}$	SD
Reading	2.1	0.8	77.6	8.5
Mathematics	2.8	1.2	83.2	11.4
Written Language	2.3	1.1	80.0	13.0

Note: All measures are scaled to a mean of 100 and a standard deviation of 15.

Measurement of Processing Deficits. As both the federal (P.L. 94-142) and the district definition of a learning disability from which this population of LD students was drawn includes a perceptual handicap or processing deficit, a relatively gross measurement of processing deficits was gathered from individual student records. Based upon any one of 20 or so widely varied instruments used by the subjects' Learning Disabilities teachers to assess the presence of such deficits, the decision was made to structure this variable in a dichotomous manner. As student records yielded approximately 35 differing processing labels, LD subtyping literature (Breen, 1986; McKinney, 1984) was used to select five major processing categories, or a "multiple syndrome paradigm", which accommodates the range of disorders within heterogeneous samples of LD children (Doehring, 1978; Satz & Fletcher, 1980). The processing categories were termed: 1) perceptual deficit (including visual, spatial and perceptual aspects), 2) language deficit, 3) memory deficit, 4) auditory memory deficit, and 5) visual memory deficit. The numbers of students evidencing processing deficits, as well as the number of deficits manifested are shown in Appendix D.

Procedures

Prior to the initiation of data collection, this researcher was trained in the administering of the QNST-R, through the means of a video tape produced by the authors of the QNST-R. All LD subjects were administered the QNST-R by the researcher under standardized conditions. Specifically, each subject was examined individually in a quiet room at each elementary school where permission had been received. Approximately 20 minutes per subject was required for testing, which was scheduled at the recommendation of each teacher. In addition, WISC-R IQ scores and WJPEB achievement scores were collected from each subject's special education folder at school district centers.

Hypotheses to be Tested

H1: Factor analysis of the QNST-R establishes construct validity for its use with this LD population.

H2: Factor analysis of the QNST-R establishes lack of construct validity for its use with this LD population.

Type of Analysis

Exploratory factor analysis of the QNST-R was applied to the data, using as a model the procedure developed by Lansdell and Donnelly (1977) and Swiercinsky (1979). Principal factoring of the main axes of the original correlation matrix was calculated. The principal objective of factor analysis is to simplify the initial correlation matrix (product moment, i.e., r) by reducing the number or dimensions based on any factor contributing to covariance. Orthogonality is the concept behind this method, as orthogonality is much easier and simpler to interpret (Kaiser, 1958; Horst, 1965; Kim and Mueller, 1978).

Treatment of the Data

The factor analysis was accomplished with data collected from QNST-R test scores of LD children in this study. Comparisons of loadings within the QNST-R subtests permitted examination of the factors underlying the performance of LD children, as well as yielding information on an initial establishment of construct validity for the QNST-R.

Delimitations of the Study

1. The subjects for this study were confined to the population of available LD students from the Tucson Unified School District (TUSD) in Tucson, Arizona. Only those students for whom both parental and student consent for testing was received participated in the study.

2. The sample was comprised of children who were:

a) six to 13 years of age, with an Full Scale IQ of at least 80 or higher

b) free from gross sensory disturbances, primary emotional disturbance, and/or apparent neurological difficulties

c) defined as LD by school district policy, whose criteria include: 1) evidenced a discrepancy between intellectual ability and actual achievement; 2) exhibited difficulties with information processing abilities and/or the basic psychological processes involved in understanding or in using language; 3) the elimination of exclusionary factors, such as mental retardation, of emotional disturbance, of environmental, cultural or economic disadvantage, or of learning problems which are primarily the result of visual, hearing or motor handicaps; and 4) the need for special education services that are required because the student cannot learn through ordinary methods of instruction (this need is validated by the Child Study Team who have already assisted in designing instructional adaptations for the regular classroom)

d) appeared to exhibit auditory-linguistic characteristics, with at least a 1.5 to a 2 year delay in reading acquisition

e) non-bilingual, with English being their primary language

<u>Limitations of the Study</u>

1. Limitations of the study in question 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; and the degree of nomology which indicates whether primary or secondary factoring should be considered (Kerlinger, 1973). Stated simply, the examiner constructs her or his own hypothetical entity; and a method is devised to determine its construct reality.

2. The assumption was made that all students in this study were free from gross sensory impairment or gross neurological handicap based on teacher and examiner observation.

CHAPTER 4

RESULTS

This chapter will present the results and summary of the data analysis. The study's hypotheses focused upon whether or not factor analysis of the Quick Neurological Screening Test - Revised (QNST-R) could establish construct validity for its use with a specific LD population. Scores of 122 children, 40 females and 82 males, ages six years, four months to 13 years, five months were collected on 14 subtests from the QNST-R. Results of the exploratory factor analysis are presented and interpreted in relation to the hypotheses. Assumptions of factor analysis are discussed and QNST-R results are provided.

Data Analysis

A principal components factor analysis of the correlation matrix (14 x 14), for this sample, revealed a five factor solution. Only subtests with factor loadings of more than .50 were retained. The criterion used for inclusion of eigenvalues in the final solution (known as Roots Greater than One Rule) was that the magnitude of the eigenvalue be greater than one (Kaiser, 1970). The eigenvalues which were generated indicated that these factors accounted for 57% of the original variance (Factor 1, 21.4%; Factor 2, 10.3%; Factor 3, 9.2%; Factor 4, 8.6%; and Factor 5, 7.5%). The factor structure for the QNST-R is shown in Table 2.

Factor analysis can only determine the extent to which a composite of variables is logically homogeneous, (i.e., measuring the same universe of content) when the loadings on the variables are relatively high. It is commonly assumed that only when at least 70% of the variance can be accounted for, is the factor analytic process actually providing a useful

Table 2

Unrotated Factor Structure for QNST-R

Subtest	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5
Hand Skill	.140	.290	.045	.477	.383
Figure Recognition and Production	.474	-.174	.068	-.290	.085
Palm Form Recognition	.592	.094	-.254	-.140	-.037
Eye Tracking	.514	-.252	-.101	.563	-.182
Sound Patterns	.353	.636	-.078	-.088	-.175
Finger to Nose	.547	.141	.415	-.236	-.046
Thumb and Finger Circle	.442	-.175	.563	-.024	-.336
Double Simultaneous Stimulation of Hand and Cheek	.363	-.340	-.533	-.053	.383
Rapidly Reversing Repetitive Hand Movements	.492	-.122	.086	.535	-.107
Arm and Leg Extension	.554	-.080	.149	.187	.247
Tandem Walk	.678	.127	-.026	-.247	-.079
Stand on One Leg	.597	.190	-.391	-.190	.075
Skip	.107	-.321	.451	-.206	.607
Left-Right Discrimination	-.064	.710	.212	.161	.349

reduction of factors (Gorsuch, 1976). In the present study, retaining factors accounting for 70% of the variance would have included nearly as many factors as there were original variables, contrary to the reductive intent of factor analysis. A scree test technique, which plots the incremental variance accounted for by each successive factor, suggests the retention of a one-factor solution, as shown in Figure 1. The failure of the factor analysis to identify reliably more than one factor was directly related to the low correlation coefficients obtained from the original data. Very low loadings were revealed between the 14 subtests, suggesting that the majority of the subtests measured a disparate aspect of student performance. The correlation matrix for the 14 QNST-R subtests is shown in Table 3, together with the level of significance for each correlation.

On the basis of the considerations listed above, there was only one extractible factor revealed for this population, which accounted for 21% of the total variance. This factor was labelled Tactile-kinesthetic-motor/left-right differences, as five of the six subtests in this cluster loaded on these two domains. The factor loadings ranged from a high of .68 on Tandem Walk, to .60 on both Stand on One Leg and Palm Form Recognition, .55 on both Arm and Leg Extension and Finger to Nose, and .52 on Eye Tracking. The five specific subtests included in this factor were: Tandem Walk, Stand on One Leg, Arm and Leg Extension, Finger to Nose, and Palm Form Recognition (this subtest appears to measure tactile-kinesthetic sense and left-right differences, but not motoric coordination). The subtest in this cluster which does not appear to load on kinesthetic-motor coordination is Eye Tracking, which seems to tap visual-motor coordination.

One cannot speculate as to what constructs may be being measured by the QNST-R beyond the initial factor. Although it is not possible to assign underlying constructs or labels to the additional factors, the second factor loaded .71 on the subtest Left-Right

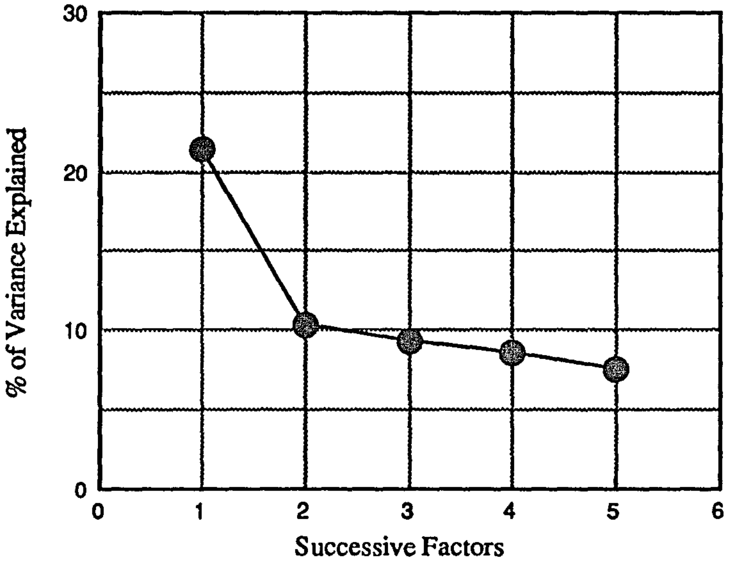


Figure 1 Scree curve for successive factors.

Table 3

Correlation Matrix for QNST-R

	Hand Skill	Figure Recognition and Production	Palm Form Recognition	Eye Tracking	Sound Patterns	Finger to Nose	Thumb and Finger Circle
Hand Skill	1						
Figure Recognition and Production	.012 p = .865	1					
Palm Form Recognition	.043 p = .641	.237 p = .009	1				
Eye Tracking	.138 p = .125	.129 p = .152	.165 p = .066	1			
Sound Patterns	.001 p = .935	.081 p = .380	.257 p = .005	.046 p = .624	1		
Finger to Nose	.042 p =.650	.210 p = .019	.130 p = .149	.213 p = .018	.212 p = .018	1	
Thumb and Finger Circle	.012 p = .864	.184 p = .040	.185 p = .039	.206 p = .022	.044 p = .638	.305 p = .001	1
Double Simultaneous Stimulation of Hand and Cheek	-.013 p = .858	.187 p = .037	.210 p = .019	.242 p = .007	-.031 p = .733	.017 p = .828	-.062 p = .504
Rapidly Reversing Repetitive Hand Movements	.076 p = .412	.164 p = .067	.191 p = .033	.397 p = .0001	.16 p = .074	.076 p = .410	.17 p = .058
Arm and Leg Extension	.024 p = .783	.098 p = .281	.243 p = .007	.235 p = .009	.069 p = .454	.225 p = .012	.223 p = .013
Tandem Walk	.083 p = .367	.300 p = .001	.321 p = .0008	.134 p = .138	.141 p = .118	.390 p = .0001	.264 p = .004
Stand on One Leg	.096 p = .292	.143 p = .112	.348 p = .0002	.198 p = .027	.298 p = .001	.237 p = .008	.021 p = .805
Skip	-.007 p = .894	.128 p = .157	-.002 p = .934	-.076 p = .411	-.093 p = .310	.147 p = .101	.110 p = .224
Left-Right Discrimination	.184 p = .040	-.072 p = .440	-.044 p = .637	-.135 p = .134	.235 p = .009	.045 p = .628	-.097 p = .290

Table 3 cont'd ...

	Double Simultan-eous Stimulation of Hand and Cheek	Rapidly Reversing Repetitive Hand Movements	Arm and Leg Extension	Tandem Walk	Stand on One Leg	Skip	Left-Right Discriminatio n
Double Simultaneous Stimulation of Hand and Cheek	1						
Rapidly Reversing Repetitive Hand Movements	.053 p = .566	1					
Arm and Leg Extension	.199 p = .026	.296 p = .001	1				
Tandem Walk	.183 p = .041	.190 p = .034	. 280 p = .002	1			
Stand on One Leg	.237 p = .008	.131 p = .145	.209 p = .020	.419 p = .0000	1		
Skip	.057 p = .540	.075 p = .415	.138 p = .126	-.069 p = .456	.012 p = .866	1	
Left-Right Discrimination	-.129 p = .151	-.043 p = .646	.067 p = .468	-.007 p = .895	-.082 p = .374	-.044 p = .639	1

Discrimination, and .64 on the subtest Sound Patterns. The third factor loaded .56 on the subtest Thumb and Finger, and -.53 on Double Simultaneous Stimulation of Hand and Cheek. The fourth factor loaded .56 on Eye Tracking, and .54 on Rapidly Reversing Repetitive Hand Movements. The fifth factor loaded .61 on the subtest Skip.

Factor analysis of the data established a limited form of construct validity for the QNST-R in its use with this LD population. Specifically, it appears that one factor of a sensory-motor and left-right differences nature is being assessed by the QNST-R. In addition, data analysis suggested that the QNST-R lacked the capability of assessing a range of diverse and independent neurological functions, when used with this LD population. Thus, the various subtests of the QNST-R have not been found to be independent dimensions of neurological screening for this learning disabled population.

Means and standard deviations of the QNST-R for each subtest and the Total scores are presented in Table 4. The subtest scores form the basis for both the correlation matrix and the factor analysis. The QNST-R Total score mean, based on 122 LD subjects, was 24.7 (SD = 11.0). The QNST-R subtest means ranged from a low of 0.32, (SD = .9) on Skip, to a high of 5.14, (SD = 2.9) on Sound Patterns. The scoring of the QNST-R is organized in such a manner that the range of subtests' obtainable scores varies from subtest to subtest, with a common basal score of 0, to an upper score reaching as high as 21 (on Arm and Leg Extenstion). Lower subtest scores are assigned a "Normal" label, intermediate scores are assigned a "Suspicious" label, and higher scores are assigned a "High" score, indicating the presence of neurological insufficiency. Thus, a High scoring obtained on one subtest may not receive a High scoring on another subtest. Regardless, these individual subtest scores are then added to produce Total scores of Normal, Suspicious and High for the entire battery. With the exception of Sound Patterns, the range of scores received on each subtest, as well as the Total score ranges were positively

Table 4

Means and Standard Deviations of QNST-R Subtests

N=122	Maximum Score	$\overline{X}$	SD
Hand Skill	6	0.8	0.7
Figure Recognition and Production	14	1.7	1.4
Palm Form Recognition	9	2.6	2.0
Eye Tracking	10	1.6	2.2
Sound Patterns	15	5.1	2.9
Finger to Nose	10	1.0	1.5
Thumb and Finger Circle	10	1.7	1.5
Double Simultaneous Stimulation of Hand and Cheek	11	1.3	1.5
Rapidly Reversing Repetitive Hand Movement	9	1.9	2.3
Arm and Leg Extension	21	1.6	2.2
Tandem Walk	14	2.7	2.4
Stand on One Leg	4	1.0	1.0
Skip	6	0.3	0.9
Left-Right Discrimination	3	1.2	0.9
Total Score	142	24.7	11.1

skewed for this population. The scores on the subtest Sound Pattern appeared to be normally distributed. For this population, these skewed distributions indicate that the QNST-R exhibited a ceiling effect, and that the majority of the LD subjects were able to perform the tasks asked of them without difficulty. This skewedness is reflected in the distribution of Total scores as shown in Figure 2 and the categorical divisions of Normal, Suspicious and High scores for this population, shown in Figure 3. The distributions of the obtained scores of each subtest are presented in Appendix E and clearly exhibit a ceiling effect.

Age and gender differences on the QNST-R Total scores are presented in Table 5. The ages of the subjects were divided at the mean of the sample into "younger" (less than 10-3) and "older" (greater than 10-3) categories. Statistically significant differences were obtained between the two age groups, with younger children having higher scores ($p = .0001$). No significant differences related to the gender of the subjects were uncovered ($p = .9426$). Figure 4 shows the correlation of Total scores with age. This scattergram reveals a negative correlation of -.45, strongly suggesting that the QNST-R is easier to successfully complete as one gets older.

In summary, factor analysis of 122 LD subjects' QNST-R scores revealed one factor which was labelled Tactile-kinesthetic-motor/left-right differences. Analysis of the data substantiated the hypothesis that the QNST-R lacked the capability of assessing a range of diverse and independent functions, when used with this LD population. Thus, the various subtests of the QNST-R have not been found to be independent dimensions of neurological screening for this learning disabled population. In addition, younger children were found to experience greater difficulties than older children in successfully completing QNST-R tasks; on the other hand, girls and boys scores did not significantly differ.

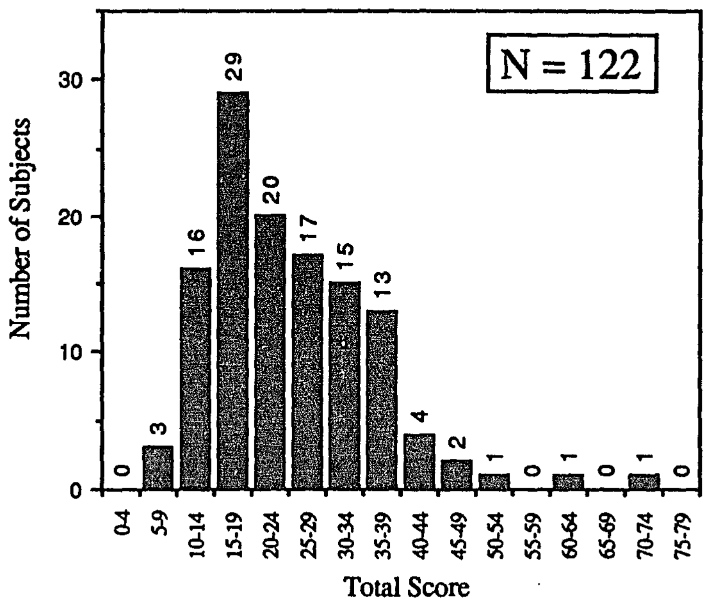


Figure 2 Distribution of total scores.

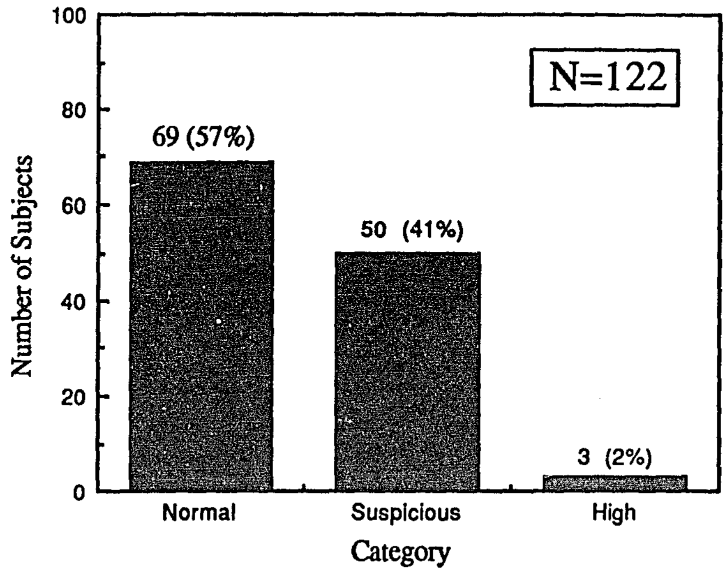


Figure 3. Distribution of categories.

Table 5

Independent T-Tests of Age and Gender

Group	N	$\overline{X}$	SD	t	p
Younger (6-4;10-3)	57	29.42	11.95	4.773	.0001
Older (10-4;13-5)	65	20.60	8.33		
Female	39	24.62	12.73	-.072	.9426
Male	83	24.77	10.28		

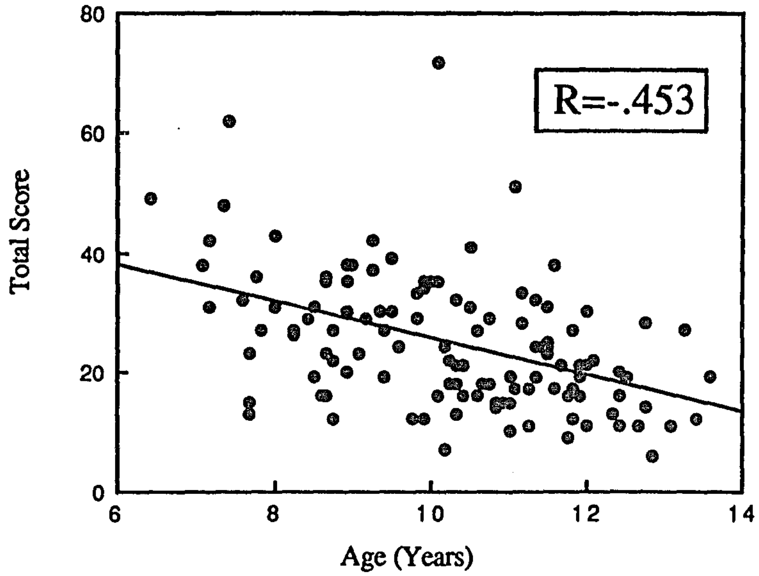


Figure 4. Scattergram of Total Score versus age.

CHAPTER 5

SUMMARY, DISCUSSION, AND RECOMMENDATIONS

This chapter will include a summary and discussion of the statistical procedure and data analysis, the results, discussion and theoretical implications for the use of the Quick Neurological Screening Test-Revised (QNST-R), and recommendations for further research needs in the neuropsychological assessment and screening of LD students.

Purpose of the Study

The purpose of this research was to determine if factor analysis would provide construct validity for the use of the QNST-R with this LD population. Specifically, such an analysis of the QNST-R would need to reveal a number of underlying neurological factors related to a series of independent dimensions of neurological screening in order to prove useful in the diagnostic process of LD assessment.

Summary of Results

A correlation matrix (14 x 14) was developed based on 14 of the QNST-R's subtests, and a principal components factor analysis of the correlation matrix was performed. Five factors were produced which accounted for 57% of the variance. It was determined that only one factor accounted for a sufficient amount of the variance to be interpretable. This factor was labelled Tactile-kinesthetic-motor/left-right differences, as five of the six subtests appeared to load primarily on those kinds of skills. Factor analysis of the data established a limited form of construct validity for the QNST-R in its use with this LD population. Specifically, it appears that one factor of a sensory-motor and left-right differences nature is being assessed by the QNST-R, although the authors of the QNST-R claim that the test allows for sampling of a child's maturity of motor development, skill in controlling large and small muscles, motor planning and sequencing, sense of rate and rhythm, spatial organization, visual and auditory perceptual skills, balance and cerebellar-vestibular function, and disorders of attention. Although the motorically-oriented skills included in the QNST-R claims did appear to be measured from the results of this study, the other independent functions did not appear to be measured with this LD population.

Discussion and Theoretical Implications

As mentioned earlier, the factor analysis of the QNST-R revealed one factor which was labelled as relating to a Tactile-kinesthetic-motor/left-right differences function. The subtests with relatively high loadings on this factor primarily appeared to measure sensory perception or sensory processing and fine and gross motoric skills; they included Figure Recognition, Palm Form Recognition, Eye Tracking, Finger to Nose, Arm and Leg Extension, Tandem Walk, and Stand on One Leg. It is conceptually possible that sensory and motoric aspects are indeed correlated. Haywood (1967) reported that the mediation of many important peripheral motor functions occurs in the most posterior portions of the frontal lobes, in an area referred to as the motor strip. The sensory strip (corresponding area just posterior to the motor strip), located along the most anterior portion of the parietal lobes, is the region of the brain that mediates important peripheral somata-sensory functions, such as somesthesis (sense of touch); in addition, the sensory strip is important for processing arithmetical and directional tasks. Although it may be quite difficult to separate motoric and sensory functions in this area of the brain, as Smith (1975) has suggested in his criteria for selection of neuropsychological screening instruments, tests should be designed to permit differentiation of the motor and sensory modalities involved in perception and in the execution of the task. It appears that the QNST-R may be primarily a measure of these correlated functions, and not a measure of independent components as described by the authors.

It would appear that neurologically-oriented screening instruments such as the QNST-R, which tap primarily lower-order or subcortical functions, do not provide psychologists and educators with the depth and breadth of information which is obtained from a comprehensive neuropsychological assessment battery. The complaints that many have levied against screening instruments in general include: perhaps most importantly, the testing of a limited number of cognitive and neuropsychological skills (Vega, 1969; Golden & Anderson, 1977; Dodrill, 1978), difficulties in transporting materials or materials not commonly found in clinical settings (Goldstein & Kyc, 1978; Goldstein, Rennick, Welsh, & Shelley, 1981), the need for extensive training to administer and interpret in a competent manner (Barrett, Wheatley, & Laplant, 1982), and also the generation of data which is excessive in a screening situation (Wysocki & Sweet, 1985). It appears that the limited testing of neuropsychological and cognitive skills is the problem which most characterizes the QNST-R.

Although the examination of the motor system has long been the traditional measure of brain function by the pediatrician and neurologist, it now appears clear that, at the very least, testing for motor incoordination or clumsiness should focus on more complex coordinated motor skills and their discreteness. Motoric difficulties, however, are but one measure of brain function. Disturbances of higher cortical functions, such as perceptual deficits, dysfunctions of analysis and synthesis of certain kinds of information, memory, spatial orientation, etc., which are required of most school tasks, must be measured as well. The neuropsychological evaluation and screening of children should then involve tasks utilizing the diverse modalities which are available for learning, including functions in the visual and auditory receptive modalities, and the written, spoken, graphic and constructional response modalities. Specific areas of the brain as they relate to the cortex must also be assessed and screened, including those of occipital, parietal, temporal and frontal lobe functioning, left-right hemispheric differences, and anterior-posterior differences (Obrzut, 1981).

Although the authors of the QNST-R do not claim that their instrument is able to measure the diverse aspects mentioned above, other screening instruments do come closer to the range required of a neuropsychological battery. Studies investigating the validation of more comprehensive neuropsychological assessment batteries with LD students have demonstrated various underlying factors which are measured by these instruments. For example, Snow and Hynd (1985) conducted a factor analytic study of the Luria Nebraska Neuropsychological Battery-Children's Revision (LNNB-CR), which revealed three factors, and provided some evidence for the factorial validity of this instrument: a language-general intellectual factor, a reading-written expression factor, and a sensory-motor factor. Gamble, Mishra and Obrzut (1988) factor analyzed the Reitan-Indiana Neuropsychological Test Battery for Children (R-INB-C), the WISC-R, and the Wide Range Achievement Test (WRAT) on a population of LD students. The data did not confirm the overall construct paradigm as conceptualized by Reitan, suggesting cautious use of this battery with subjects different from normative samples, such as LD subjects (Gamble, et al., 1988). The study did however, reveal four underlying factors for this LD sample: verbal intelligence, psychomotor speed, achievement and memory.

In addition, a number of studies have ascertained that the LNNB-CR (Snow & Hynd, 1985; Teeter, Boliek, Obrzut & Malsch, 1986) and the Halstead-Reitan Batteries (Rourke, 1975; Selz & Reitan, 1979) can successfully identify LD children. Using the LNNB-CR, several studies (Geary & Gilger, 1984; Geary, Jennings, Schultz & Alper, 1984; Hyman, 1984) suggested that expressive language, reading, and writing subtests are particularly sensitive in discriminating LD from nondisabled children.

It is possible that efforts to save time, and provide a brief battery of subtests for the measurement of an area as complex as that of the brain is not as efficacious as we had once hoped. In an attempt to reduce the amount of time involved in assessment, it appears likely that vital information is not being acquired by neurological screening instruments such as the QNST-R. The value of instruments such as the QNST-R may lie in their application as preschool screening tools, in the effort to locate children, as early as possible, who are at-risk for academic failure. By attempting to objectively identify children with possible learning problems on a large scale, screening instruments may prove useful toward preventing many of the emotional and behavioral difficulties which make later treatment and modification so difficult. Children selected by this sort of examination must then be examined more thoroughly by the appropriate psychological, educational and neurological tests (Ozer, 1968).

Reitan and Boll (1973) found that LD subjects performed similarly to normal control subjects in sensory-motor areas but were more closely aligned with brain damaged subjects in measurements of nonverbal intelligence, attention, and abstraction, when measured by the Reitan-Indiana Neuropsychological Battery for Children. Further, deficits in verbal language were evidenced by the LD subjects on the same instrument. The major underlying functions which appear to be measured by the QNST-R are those of kinesthetic and motoric aspects, on which LD children primarily have been determined to perform similarly to normal children [i.e., on portions of the Halstead Neuropsychological Battery for Children with substantial motor components, such as the Tactual Performance Test for Time, Trails B, Tapping Preferred (Hand), Tapping Nonpreferred (Hand)] (Reitan & Boll, 1973). Thus, it appears the QNST-R may not have sufficient diagnostic and identificatory efficacy for the purposes for which it is currently being used.

The authors of the QNST-R have stated that "each item on the QNST-R has educational and classroom implications" (Mutti, Sterling, Spalding, & Crawford, 1978). Although the authors appear to be referring primarily to the effects of poor sensory-motor skills on educational tasks, they do suggest that reading readiness, reading skills, memory, language, and auditory perception are able to be measured by QNST-R subtests. For instance, claims for the subtest Sound Patterns include the measurement of memory, linguistic and auditory perceptual skills. Based upon the results of this study, it is not possible to categorically support or refute these claims. However, as other studies have included achievement data in their factor analyses, (Gamble, Mishra, & Obrzut, 1988) an additional factor analysis was calculated including scores from the QNST-R and the Woodcock Johnson Psycho-Educational Battery (WJPEB). This factor analysis did not reveal high enough loadings to suggest that the QNST-R correlated with WJPEB subtests related to reading and reading subskills. The factors which did result clearly separated the QNST-R subtests from the WJPEB standard scores.

Specific examples of QNST-R subtests which have been claimed (Spalding, in Mutti, et al., 1978; Heslin, 1982) to be excellent indicators of learning disabilities and relate to educational tasks include "Finger to Nose" and "Figure Recognition and Production". One of the authors of the QNST-R, Spalding (in Mutti et al., 1978) conducted a study using discriminant analysis that identified " Finger to Nose" as the single best QNST-R indicator of learning disability. Independent from the test authors, Heslin (1982) stated that LD students experience difficulty in naming objects, and that this problem was clearly evidenced on the "Figure Recognition and Production" subtest in her study. "Figure Recognition and Production" is scored in such a manner that zero to one is a "Normal" score, two to five is a "Suspicious" score, and six and above is a "High" score. The mean score on Figure Recognition for the current LD population was 1.7. Similarily, "Finger to Nose" is scored in such a manner that zero to one receives a Normal score, two to three receives a Suspicious score, and four and above receives a High score. The current study's mean subtest score was 1.0. The scores from subjects in the current study (See QNST-R Subtest Score Distributions in Appendix E) indicate that, for this population of LD subjects, neither of these subtests are difficult to perform successfully. Therefore, the possibility exists that these subtests may not be useful in differentiating LD from normal children. For the LD students involved in this study it appears that one can say little about educational implications, based on their QNST-R results.

Although the authors of the QNST-R do not specifically state age levels, they do recommend employing the test with children from the ages of five through 18. The statistically significant age differences which were obtained in this study, with younger children having significantly higher scores, lend support to the use of this test with children from approximately four to six, but also indicate that the test may not be warranted for children approximately seven and older. Developmentally younger children usually do evidence "soft signs" and problems in successfully completing QNST-R items. However, these children often evidence soft signs indicating neurological immaturity, which are developmental in nature, and do not necessarily lead to later difficulties in school. The QNST-R may provide quick assistance in the screening of pre-schoolers and kindergartners who are likely to experience future academic difficulties; however, additional research would need to be carried out in order to ascertain whether the QNST-R would be an effective pre-school screening instrument. It would appear that children aged seven and older have learned compensatory skills which enable them to successfully complete these items.

In summary, factor analysis substantiated the hypothesis that limited factorial validity does exist for the QNST-R; however, the analysis also suggested that the test lacked the capability of assessing a range of diverse and independent functions, when used with this LD population. One factor was revealed which appeared to measure Tactile-kinesthetic-motor/left-right differences. A number of diverse independent functions which are claimed to be measured by the QNST-R, and which need to be measured in order to produce a useful neuropsychological screening instrument, do not appear to exist for this LD population. Finally, age differences were revealed which suggest that younger children have greater difficulty successfully completing the QNST-R items than do older children.

Recommendations for Future Research and Neuropsychological Test Usage

1. The QNST-R may not be efficacious as a tool for the measurement of a variety of independent, higher-order neurological dimensions. It is possible that the test could be used for screening purposes for children aged approximately four to six, to separate those who are later likely to be at risk for school failure from those who are likely to perform at an average or above average level in school. However, further validity studies of the QNST-R with this age group would be required in order to substantiate its usefulness with such a heterogeneous population. As younger children can manifest soft signs indicating neurological immaturity regardless of whether they later experience difficulties or success in school, research relating to this topic would need to be longitudinal and developmental in nature.

2. It is very important that further factor analytic studies be carried out with other neuropsychological instruments, rather than relying on the less rigorous statistical tests which have traditionally been employed in initial studies attempting to establish construct validity. The factor analytic procedure is recommended for both fixed batteries as well as screening instruments.

3. A need continues to exist for a screening procedure that assesses neurological integration as it relates to behavior and to school learning. Such a measurement device should evaluate the functions of sensory motor integration as they relate to the cognitive and symbolic information processes required for successful school performance.

4. Further research examining the subtyping of LD students, including such categories as Pirozzolo's visual-spatial or auditory-linguistic groups, and the

neuropsychological status of such subjects should prove valuable, as LD subtyping holds an ongoing interest in the psychological and educational fields.

APPENDIX A

CONSENT FORM

School ______________________

Classroom Teacher ______________________

I have read the attached research procedures and purposes and hereby consent to the participation of my son/daughter, ____________________, in "A Validity Study of the QNST-R Test for Learning Disabled Children". I have explained the procedures to my child, and in keeping with his/her level of understanding, he/she has agreed to participate in this study. I understand that all information gathered about my child will be kept in strictest confidence. On that basis, I agree to let you have access to my child's test records. In case I have any additional questions about the study, I will contact Shannon Finlayson at 327-3454.

____

Parent or Guardian Signature

____

Date

Please return this form to school with your child as quickly as you can.

Minor Subject's Assent Form

Your mother/father has told me it was okay for you to be part of the group of students who will get these tests. We are trying to see kids use their fingers, their eyes, their hands, their arms, and their legs, and how they all work together. This will tell us something about how you read and write, how you do numbers, and even something about how you get along in P.E., or on the playground. You may have done some of these things before. They won't take us long, about 20 minutes in all.

If this is OK with you, please sign below.

Subject's Name

Date

APPENDIX B

QUICK NEUROLOGICAL SCREENING TEST-REVISED

(PROTOCOL)

QUICK NEUROLOGICAL SCREENING TEST–REVISED EDITION

Recording Form

NAME ____________________ DATE ____________

ADDRESS ____________________ AGE ________ SEX ________

EXAMINER ____________________ GRADE ____________

SCHOOL (and/or source of referral) ____________________

____________________ TOTAL SCORE ____________

(Indicate letter H, S, or N in box above each subtest category)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15

H = High (above 50)
S = Suspicious (26-50)
N = Normal (0-25)

1. *Hand Skill (Circle Hand Preference R L)*		*Score*	
Holds pencil clumsily, tightly (circle which)		1	
Prints		1	
Keeps eyes close to paper		1	
Exhibits observable tremor		3	
Comments:		*Total*	
	4 or above	H	
	2 or 3	S	
	0 or 1	N	

2. *Figure Recognition and Production*		*Score*	
Names fewer than five figures		1	
Draws figures on horizontal plane		1	
Executes very slowly or very rapidly (circle which)		1	
Draws figures too large, too small, irregularly (circle which)		1	
Rotates paper to write or draw		1	
Biases figures left or right (circle which)		1	
Self-directs drawing orally		1	
Demonstrates poor closure		1	
Demonstrates poor angle execution		3	
Exhibits observable tremor		3	
Comments:		*Total*	
	6 or above	H	
	2 to 5	S	
	0 or 1	N	

3. Palm Form Recognition (Note instructions for under age 8)				Score	
Responds with letters rather than numbers (if numbers fail, try letters)				1	
Right Hand	3	(A)		1	
	9	(C)		1	
	5	(E)		1	
	7	(O)		1	
Left Hand	2	(B)		1	
	8	(T)		1	
	4	(H)		1	
	6	(N)		1	
Comments: (Also note L-R difference in item 15.)				*Total*	
			7 or above	H	
			4 to 6	S	
			0 to 3	N	

4. Eye Tracking (Circle Eye Preference R L)		Score	
Moves head while eye tracking		1	
Exhibits horizontal jerkiness		3	
Exhibits vertical jerkiness, incoordination		3	
Displays distractibility		3	
Comments:		*Total*	
	7 or above	H	
	4 to 6	S	
	0 to 3	N	

5. Sound Patterns	*Motor* | *Oral*		Score	
Succeeds only with rhythmic pattern			1	
Misses any one sequence			1	
Alternates hands, uses one hand, claps hands (circle which)			1	
Affected by loudness or softness (circle which)			1	
Uses reversals (e.g., does 1-3-2 for 2-3-1)			1	
Reveals speech irregularities (e.g., lisps)			1	
Perseverates (doesn't know when to stop)			3	
Misses oral reproduction (two or more patterns)			3	
Misses motor reproduction (two or more patterns)			3	
Comments:			*Total*	
		10 or above	H	
		6 to 9	S	
		0 to 5	N	

6. *Finger to Nose*

	Score	
Exhibits poor left-right discrimination (holds up mirror hand) (score in item 14; check here)		
Is unusually fast or slow (circle which)	1	
Moves hand consistently to right or left of target in space (examiner's hand)	1	
Moves hand consistently to top or bottom of target in space (examiner's hand)	1	
Misses tip of nose by one-half to one inch	1	
Misses tip of nose by more than one inch (note if consistently does so in one place)	3	
Random or unsteady control of movement	3	
Comments: (Note L-R difference in item 15.)	*Total*	
4 or above	H	
2 or 3	S	
0 or 1	N	

7. *Thumb and Finger Circle*

	Score	
Exhibits poor left-right discrimination (holds up mirror hand) (score in item 14; check here)		
Reverses pattern (goes from little finger to index)	1	
Shows overflow or slight movement in fingers of opposite hand	1	
Indicates flat circle, constricted small circle, incomplete circle (circle which)	1	
Holds hand facing him, concentrates intently, often with body tense	1	
Registers random body movement, twitching in opposite side	3	
Manifests confusion regarding next finger, skips fingers	3	
Comments: (Note L-R difference in item 15.)	*Total*	
6 or above	H	
4 or 5	S	
0 to 3	N	

8. *Double Simultaneous Stimulation of Hand and Cheek*

	Score	
Jerks involuntarily when cheek is touched	1	
Occasionally does not feel hand stimulation	1	
Does not feel hand stimulation on both sides (normal under age 6)	3	
Consistently does not feel hand stimulation on one side (abnormal at any age)	3	
Displays unusual sensory behavior (names inappropriate location)	3	
Comments: (Note L-R difference in item 15.)	*Total*	
3 or above	H	
1 or 2	S	
0	N	

9. Rapidly Reversing Repetitive Hand Movements		Score	
Uses floppy rotation or finger motion		1	
Employs unusually fast or slow rate (circle which)		1	
Displays double hand bounce, rigid or tense finger position		1	
Distinct left-right difference (note also in item 15)		3	
Manifests asymmetry (one side differs from other)		3	
Comments:		*Total*	
	4 or above	H	
	1 to 3	S	
	0	N	

10. Arm and Leg Extension		Score	
Displays random body, hand, or tongue movement (circle which)		3	
Reveals extreme muscle tension (note hypo-or hypertonic tendencies)		3	
Unable to hold position (extremities move lower involuntarily)		3	
Unable to hold position (whole body moves forward involuntarily)		3	
Reveals unusual finger position (e.g., clawing of fingers)		3	
Demonstrates wrist dip		3	
Exhibits observable tremor or twitch (circle which)		3	
Comments: (Note L-R difference in item 15.)		*Total*	
	9 or above	H	
	3 or 6	S	
	0	N	

11. Tandem Walk (10 feet)		Score	
Harder to do backward		1	
Harder to do with eyes closed		1	
One hand curls in, other hand curls out		1	
Leans left or right (circle which)		1	
Takes wide steps or steps on own toes (circle which)		1	
Exhibits pigeon-toed stance and bent knees		3	
Demonstrates poor balance (note arm waving)		3	
Displays random body movement (note if more movement in upper or lower extremities)		3	
Comments: (Note L-R difference in item 15.)		*Total*	
	7 or above	H	
	4 to 6	S	
	0 to 3	N	

12. *Stand on One Leg (Circle Foot Preference R L)*

		Score	
Exhibits poor left-right discrimination (mirrors leg stance) (score in item 14; check here)			
Demonstrates poor balance		1	
Impossible to do with eyes closed		1	
Harder to do on left or right leg (circle which and note also in item 15)		1	
Stands with body contorted		1	
Comments:		*Total*	
	3 or 4	H	
	2	S	
	0 or 1	N	

13. *Skip*

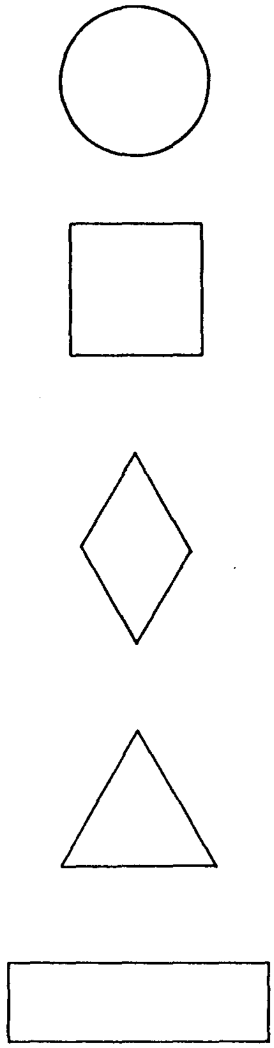
		Score	
Demonstrates poor balance		1	
Reveals left-right differences (note also in item 15)		1	
Hops or skips on one foot		1	
Unable to perform (significant after age 6 with girls—after age 8 with boys)		3	
Comments:		*Total*	
	4 or above	H	
	2 or 3	S	
	0 or 1	N	

14. *Left-Right Discrimination (Score from items 6, 7, and 12)*

		Score	
Poor left-right discrimination (mirroring) from item 6		1	
Poor left-right discrimination (mirroring) from item 7		1	
Poor left-right discrimination (mirroring) from item 12		1	
Comments:		*Total*	
	2 or 3	S	
	0 or 1	N	

15. *Behavioral Irregularities*

		Score	
Demonstrates unusual behavior patterns (e.g., hair twisting, scratching)		1	
Perseverates		1	
Talks excessively		1	
Exhibits withdrawal symptoms		1	
Fidgets, touches (circle which)		1	
Shows defensiveness, anxiety		1	
Displays excitability, distractibility, impulsivity (circle which)		1	
Comments: (Note S's approach to motor planning, sequencing, and rhythm throughout subtests. Circle L-R differences for items 3 6 7 8 9 10 11 12 13 .)		*Total*	
	3 or above	H	
	2	S	
	0 or 1	N	



APPENDIX C

SENTENCES DICTATED TO SUBJECTS IN SUBTEST #1, HAND SKILL

The following sentences were based on the Fry Graph for Estimating Readability. They vary in number of words and number of syllables appropriate to age and grade placement.

First grade sentence. The cat has a long tail.

Second grade sentence. The children like to pat the big horse.

Third grade sentence. One morning, a boy wore two different shoes.

Fourth grade sentence. Late last summer, seven children built themselves a clubhouse.

APPENDIX D

NUMBERS OF STUDENTS EVIDENCING PROCESSING DEFICITS AND NUMBER OF STUDENT PROCESSING DEFICITS

Table D.1

Number of Students Evidencing Processing Deficits

N=121

Processing Deficits	Number of students	Percentage
Students with Perceptual Deficits	35	29
Students without Perceptual Deficits	86	71
Students with Language Deficits	13	11
Students without Language Deficits	108	89
Students with Memory Deficits	21	17
Students without Memory Deficits	100	83
Students with Auditory Memory Deficits	50	41
Students without Auditory Memory Deficits	71	59
Students with Visual Memory Deficits	17	14
Students without Visual Memory Deficits	104	86

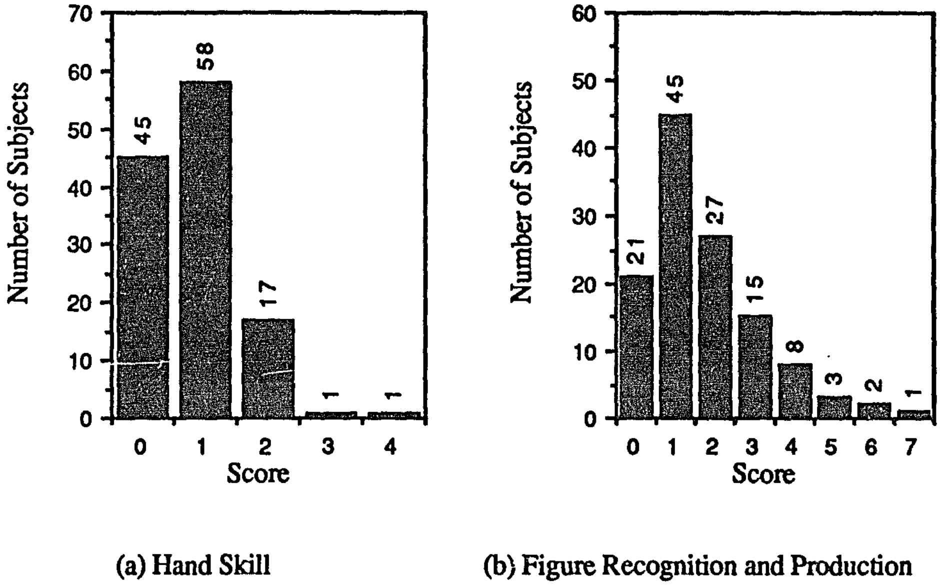
Table D.2

Number of Student Processing Deficits

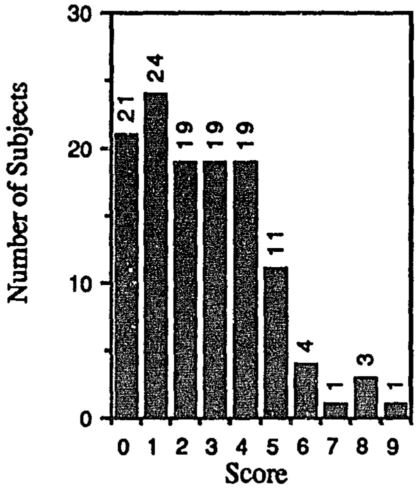
	Number of students	Percentage
One processing deficit	60	50
Two processing deficits	56	46
Three processing deficits	5	4

APPENDIX E

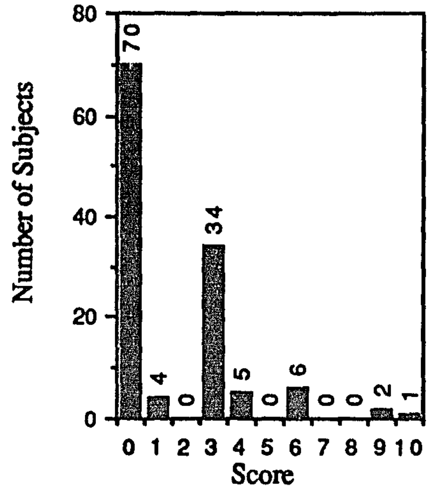
QNST-R SUBTEST SCORE DISTRIBUTIONS



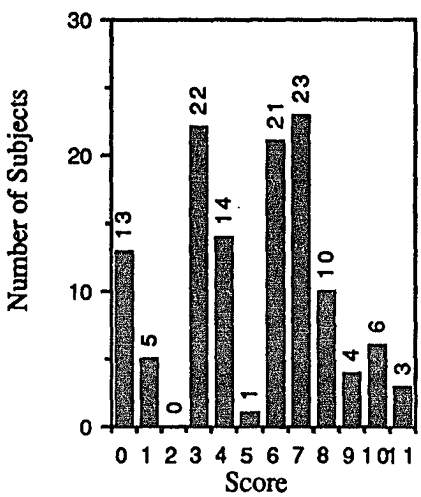
<u>Figure E.1</u> QNST-R Subtest Score Distributions.



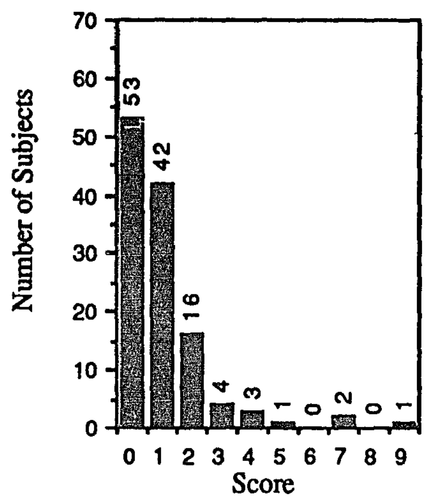
(c) Palm Form Recognition



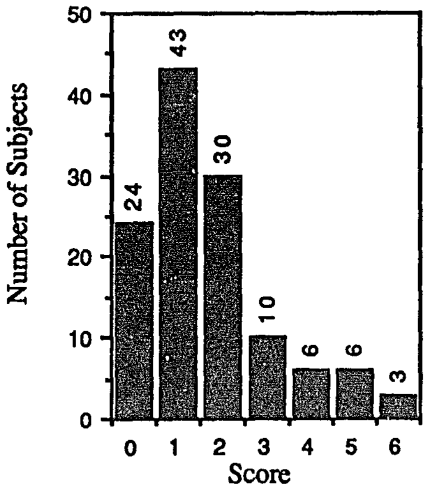
(d) Eye Tracking



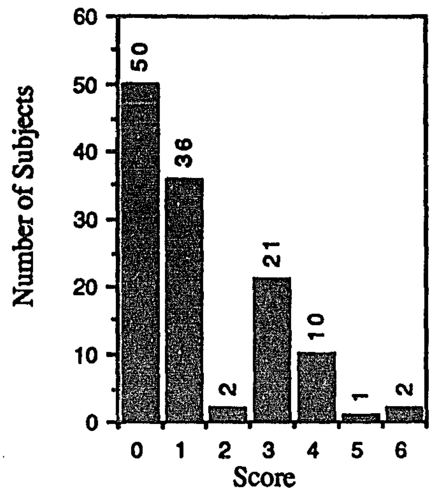
(e) Sound Patterns



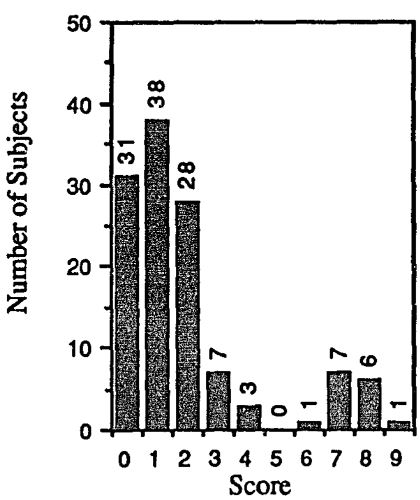
(f) Finger to Nose



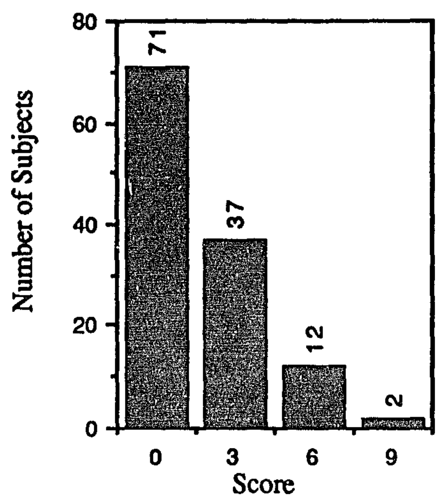
(g) Thumb and Finger Circle



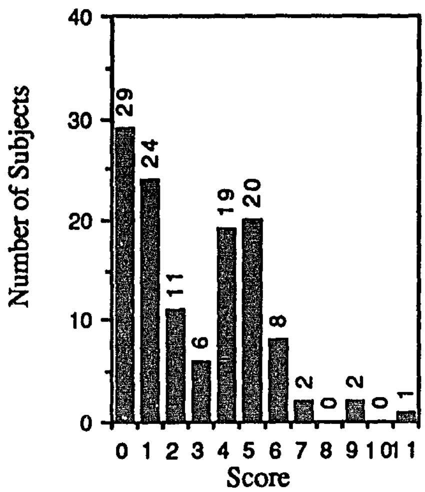
(h) Double Simultaneous Stimulation of Hand and Cheek



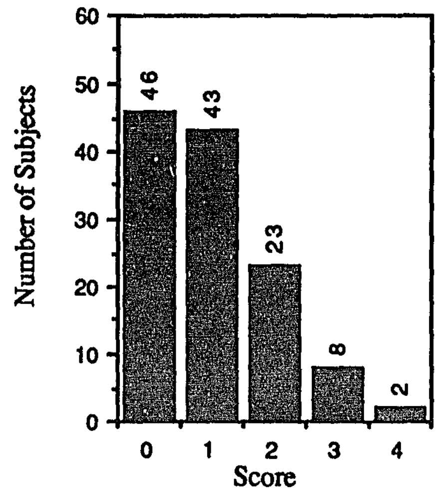
(i) Rapidly Reversing Repetitive Hand Movements



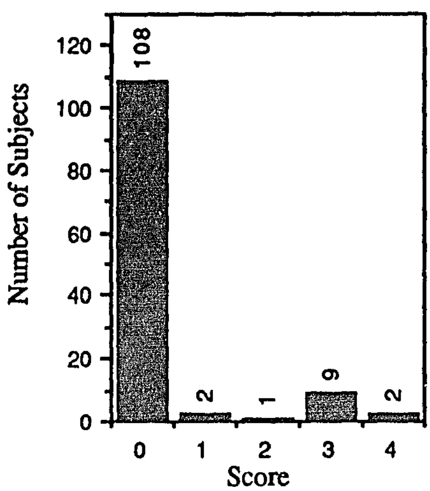
(j) Arm and Leg Extension



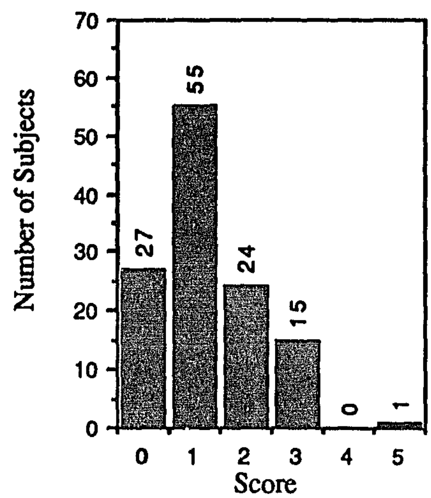
(k) Tandem Walk



(l) Stand on One Leg



(m) Skip



(n) Left-Right Discrimination

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