6-1996

An Analysis of the Auditory-Verbal and Visual-Figural Learning and Memory Patterns of College Students with Learning Disabilities

Robert K. Eckert
Western Michigan University

AN ANALYSIS OF THE AUDITORY-VERBAL AND VISUAL-FIGURAL LEARNING AND MEMORY PATTERNS OF COLLEGE STUDENTS WITH LEARNING DISABILITIES

by

Robert K. Eckert

A Dissertation
Submitted to the
Faculty of The Graduate College
in partial fulfillment of the
requirements for the
Degree of Doctor of Philosophy
Department of Psychology

Western Michigan University
Kalamazoo, Michigan
June 1996

AN ANALYSIS OF THE AUDITORY-VERBAL AND VISUAL-FIGURAL LEARNING AND MEMORY PATTERNS OF COLLEGE STUDENTS WITH LEARNING DISABILITIES

Robert K. Eckert, Ph.D.

Western Michigan University, 1996

The validity of the California Verbal Learning Test (CVLT) has been established with most clinical neuropsychological populations; however, no published work in the area of CVLT performance in adults with learning disabilities (LD) exists, despite the authors' assertion that the test is a useful psychometric measure for this population (Delis, Kramer, Kaplan, & Ober, 1987). Likewise, the validity of a recently restandardized test of visual-figural learning, the Rey Visual Design Learning Test (RVDLT; Spreen & Strauss, 1991), has yet to be investigated in LD populations. Motor deficiencies have been associated with LD in children, but little evidence exists to extend these findings to LD adults. Accordingly, the purpose of this study was to investigate the validity and utility of the CVLT, RVDLT, and Purdue Pegboard in LD college students.

Twenty-two college students with confirmed learning disabilities of various subtypes and a control group of 22 students matched for age, sex, prorated intelligence, socioeconomic status, and educational level were administered the CVLT, RVDLT, and Purdue Pegboard. Results indicated that the LD group displayed lower recall consistency ($F = 15.01$, $p = .0004$) and generated more intrusion errors ($F = 9.02$, $p = .0045$) on the CVLT than the control group. On the RVDLT the LD group reproduced fewer correct designs by the fifth learning trial ($F = 6.92$, $p = .01$) and after a 20 minute delay ($F = 6.93$, $p = .01$). The LD group also showed a trend towards

significantly more erroneous reproductions across trials ($F = 5.54$, $p = .02$). Both groups were significantly but equally influenced by their speeded non-verbal visuoconstructional ability as measured by the Block Design subtest on the RVDLT ($r = .395$, $p = .008$). The CVLT and RVDLT indices produced 32 of 252 (13%) significant intercorrelations. Purdue Pegboard dominant hand performance was sensitive to the presence of LD ($F = 7.29$, $p = .01$), and non-dominant hand performance approached significance ($F = 3.27$, $p = .078$). The CVLT and RVDLT appear to be sensitive measures of learning and memory style and ability in LD college students, and the Purdue Pegboard test appears to be sensitive to motor inefficiencies in LD college students.

ACKNOWLEDGMENTS

I have many people to thank for the support and encouragement they have provided through the past several years in helping me to accomplish this feat. The realization of this achievement simply would not have occurred if it were not for the endearing love, attention, and guidance of my mother, Eileen A. Eckert, or the work ethic instilled in me by her and my father, the late Kurt Eckert. I dedicate this to both of you. Also critical to this accomplishment were my uncle Tom, my homeboy Todd, my brothers Ed, Tom, and Michael, my sister Kathy and her husband Dave. Collectively, you have been the best support network imaginable.

I would especially like to thank my primary advisor Dr. M. Michele Burnette for providing the superb feedback and support that continues to make significant contributions to my professional development. Her commitment and expectations for excellence are qualities I will adopt and pass on to my students as well. I would also like to thank my entire committee for their time and effort: Dr. Malcolm Robertson, Dr. Richard Spates, Dr. Lisa Baker, and Dr. Ennis Berker. Finally, I extend my thanks to Jim Dagan, who put in many hours as a research assistant for this study. Applause for you. God bless.

Robert K. Eckert

TABLE OF CONTENTS

Table of Contents - Continued

LIST OF TABLES

LIST OF FIGURES

CHAPTER I

INTRODUCTION

Learning Disabilities

An ever-increasing number of individuals at all levels of the educational spectrum, from elementary through secondary to collegiate level, are being diagnosed with a learning disorder of some type. Prevalence estimates of learning disabled children range from 5% (U.S. Department of Education, Ninth Annual Report to Congress, 1986) to 15-25% when including all learning disorders (Pennington, 1991). The most common learning disability is reading disability, or "dyslexia" (Sattler, 1988). Accompanying this increase in prevalence, which is certainly due to an increase in public and professional recognition of these disorders as a distinct diagnostic entity warranting proper evaluation and management, has emerged a major consideration in school budgeting. Financial expenditures for special education rose an average of 14% annually after passage of Public Law 94-142 (Education for all Handicapped Children Act of 1975) and continues to rise (Stark, 1982, in Keogh, 1990). The cost of learning disability evaluations by school psychologists and neuropsychologists coupled with the ensuing specialized instruction mandated by PL 94-142 (which often requires a much lower instructor to student ratio and increased one-to-one interaction) results in a substantial monetary burden. These associated costs continue across the educational spectrum, as the prevalence of learning disabilities in college students increased tenfold between 1978 and 1985 (Mangrum & Strichart, 1988). Grade point averages are also consistently and significantly lower in college students with learning disabilities (e.g., Beers, Goldstein, & Katz, 1994). Accordingly, the need for enhanced efficiency in the provision of services is desirable. Assessment that not only leads to a diagnosis but provides guidance in optimizing instructional techniques based on an individual's cognitive strengths and weaknesses or learning characteristics is one potentially powerful way to make a contribution to the efficient management of learning disabilities.

The field of learning disability identification and classification is clearly a complex and inconclusive one. Learning disabilities have been defined in various ways by several national organizations, with both conservative accounts and more liberal, all-encompassing accounts of disturbances of learning efficiency (Sattler, 1988). According to Sattler (1988), in the broadest sense a learning disability refers to a learning difficulty that can be associated with any type of factor, such as mental retardation, brain injury, sensory difficulties, or emotional disturbance; in the narrowest sense it refers to the failure to learn a scholastic skill not attributable to intelligence, maturational level, cultural background, or educational experience. This narrower definition was federally defined as a specific learning disability in PL 94-142 (1975):

> "Specific learning disability" means 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 to do mathematical calculations. The term includes such conditions as perceptual handicaps, brain injury, minimal brain dysfunction, dyslexia, and developmental aphasia. The term does not include children who have learning problems which are primarily the result of visual, hearing, or motor handicaps, of mental retardation, of emotional disturbance, or of environmental, cultural, or economic disadvantage (in Sattler, 1988).

Sattler (1988) also makes the important point that the federal definition indicates the designation should only be applied to children who have a severe discrepancy between achievement and intelligence, which has since been the hallmark heuristic involved in making a learning disability diagnosis. This discrepancy model forms the basis of many State Department of Education guidelines for the identification of learning disabilities. Most clinicians and researchers use either a criterion of achievement test scores two or more years below expected levels for age (Council of Scientific Affairs, 1989), or a significant achievement-intelligence (IQ) score discrepancy for an affirmative diagnosis (Fletcher, 1992). The degree of severity which satisfies the "significant" discrepancy criterion varies by state, and is influenced by multiple policy issues (Fletcher, 1992). The advantage of such models is that they offer easy, objective, and consistent criteria. However, even these models have been criticized by various researchers. As recently as 1993 the Council for Learning Disabilities (CLD) Research Committee noted "relatively slow progress has been made toward overcoming problems involving the definition and identification of learning disabilities" (p. 210). Part of this problem, they note, is related to vague participant descriptors in research involving individuals with LD. For example, they cite Hammil, Bryant, Brown, Dunn, and Marten (1989) who found that only 4 of 277 published investigations between the years of 1984 and 1987 included all the subject information recommended by the 1984 CLD Research Committee report. These 1984 CLD guidelines suggested that all LD research include the following subject variables: (a) the number participating, (b) the number of male and female participants, (c) participants' ages, (d) the race or ethnicity of the sample, (e) the socioeconomic status of the sample, (f) the intellectual (i.e., IQ) status of the participants, and (g) the participants' relevant achievement levels (cited in CLD Research Committee, 1993, p. 211). Consequent to the findings of low compliance with these recommendations, the CLD Research Committee's conclusion was that such deficiencies in LD research means that most research conducted during this period "lacks generalizability, and, therefore, has suspect external validity" (p. 177).

Stanley, Clark, D'Amato, & Maricle (1994) state that little data support the use of the discrepancy model for the identification of learning disabilities. For example, Epps, Ysseldyke, & Mcgue (1984) and Keogh (1983) found that professionals were not able to use this model to successfully discriminate between slow learners or poorly motivated students from LD students (cited in Stanley et al., 1994). In criticizing problems related to test and prediction error inherent in the achievement-intelligence discrepancy criterion, Alessi (1981) suggests that learning disabilities instead be defined as follows: "A learning disabled pupil is one for whom an IQ test is not a good predictor of achievement, given the school's curriculum" (p. 2).

Perhaps an even stronger argument surrounds the manner in which we measure or operationally define the constructs of achievement and intelligence. A series of research projects investigating the redundancy between intellectual and achievement measures found considerable overlap between these measures (Stanley et al., 1994). An early study (Dean, 1977) found two significant canonical correlations suggesting a total of 65% overlap between functions measured by the Peabody Individual Achievement Test (PIAT) and the Wechsler Intelligence Scale for Children - Revised (WISC-R), and that 37% of the WISC-R variance was redundant (cited in Stanley et al., 1994); it was concluded that little additional information was gained by administering all of the subtests from both measures. The "construct blurring" between intelligence and achievement was recognized as a problem in need of critical examination. Extending this line of research into minority populations, the study was replicated with 100 Mexican-American children. Forty-three percent of the WISC-R subtest variability was explained by 63% of the PIAT subtest variance (Dean, 1982, as cited in Stanley et al., 1994)). In this study, Dean found that 72% of the PIAT variability was redundant with the WISC-R subtests for the 100 Caucasian children in the control group. Svanum & Bringle (1982, cited in Stanley et al., 1994)) found a high correlation of $r = .67$ between the WISC and Wide Ranging Achievement Test (WRAT) in 979 African-American and 6,049 Caucasian children, with the magnitude of the difference being similar for black and white children. Finally, McGrew (1987, as cited in Stanley et al., 1994)) found a degree of redundancy of almost 32% between the WISC-R and the Woodcock-Johnson Psychoeducational Battery, and this finding was replicated in a study of 132 LD students by Stanley et al. (1994). In all of these studies a "verbal-educational" content component was inferred as the underlying factor structure shared by the intelligence and achievement tests used. In their conclusions, Stanley et al suggested a regression formula or model may be most appropriate for determining eligibility for psychoeducational services, and that achievement and intelligence may best be reconceptualized as two ends of a single continuum rather than discrete entities. They also suggested the importance of using tests to characterize each subject's individual content-related strengths and weaknesses as well as the most efficient methods for teaching such students, since discrepancy models are not necessarily the most adequate tool for placement. Various authors suggest conducting a more cognitively detailed approach to learning disability assessment, such as an analysis of the processes, strategies, and error types associated with persons with learning disabilities, so as to better assist in placement decisions and individualized instructional planning (Delis et al., 1987, Kaplan, 1988).

Definitions and the level of strict adherence to these definitions are also known to vary by state and school district (CLD Research Committee, 1993). For example, it is not uncommon for individuals to receive a learning disability diagnosis because they need special services. It is often the case that an individual with a clear history of impoverished home or educational environments receives a learning disability diagnosis, despite the fact that these reasons for academic inefficiencies are at variance with definitions of learning disabilities by scientists, practitioners and national boards alike. Although this practice is perhaps a noble gesture in terms of entitlement to necessary educational services, havoc is created for the theoreticians and researchers investigating specific learning disabilities. Conversely, it is also not uncommon that strict adherence to a discrepancy model rules out people who have bona fide learning disabilities. In fact, estimates of the number of students with reading impairments who would not be classified as such if only IQ-based discrepancies were used range from 44 to 64%, depending on the specific criteria used (Fletcher, 1992).

The science of LD subtyping has generated additional questions as well as answers. The federal definition of learning disability (LD) suggested by PL 94-142 includes seven specific developmental learning disabilities: math computation, math reasoning/application, basic reading, reading comprehension, listening comprehension, written expression, and oral expression (Council on Learning Disabilities Research Committee, 1993). However, there is now consistent empirical research delineating three major types of dyslexia, all of which fall under "basic reading" from the federal definition. Sattler (1988) outlined three types of dyslexia: (1) those attributable to auditory-linguistic deficits, (2) those attributable to visual-spatial deficits, and (3) those attributable to mixed deficits in auditory linguistic and visual-spatial abilities. There is also well-documented evidence for the presence of a syndrome of non-verbal learning disabilities that is not articulated in the federal definition (Rourke, 1995). Rourke (1987, 1988, 1993, & 1995) delineates a syndrome of non-verbal learning disabilities based on achievement, intellectual, and neuropsychological data that is characterized by deficits in visual-spatial-organizational skills, mechanical arithmetic, conceptual/problem-solving abilities, and complex psychomotor and tactile-perceptual skills. The non-verbal nature of these deficiencies, as well as the fact that the psychomotor and perceptual deficits are usually more marked on the left side of the body, led Rourke and his colleagues initially to infer right-hemisphere dysfunction as a cause for the syndrome. It was also postulated that disordered myelinization is the "final common pathway" eventuating in the non-verbal LD syndrome (Rourke, 1993, p. 223).

As subtyping research progresses, so do the correlative neuroanatomical foundations of such disorders. For example, Pennington (1991) includes all disorders possibly leading to disturbances in learning in his definition of LD and has developed a neuropsychological nosological scheme consisting of five types of learning disorders based on five functional domains of brain function. The five functional domains and their corresponding clinical disorders and neurological bases include (1) phonological processing, a deficit which leads to dyslexia, corresponding to a neuropsychological dysfunction in the left peri-Sylvian cortex; (2) executive functions, deficiencies which lead to Attention Deficit Disorder, and corresponding to dysfunction in the prefrontal cortex; (3) spatial cognition, deficiencies which lead to specific math and handwriting disabilities, and corresponding to dysfunction in the posterior right hemisphere; (4) social cognition, deficiencies which lead to the Autism Spectrum Disorders, and corresponding neuroanatomically to limbic, orbital, and right hemisphere dysfunction, and (5) long-term memory, deficiencies which lead to amnestic difficulties, and corresponding to dysfunction in the hippocampus and amygdala (Pennington, 1991). This model has gained considerable popularity among neuropsychological researchers and practitioners due to its equal emphasis on structural localization as well as the rudimentary underlying cognitive functions involved. It appears to account for all of the major subtypes of LD discussed above, although there are clearly subtypes within each of his classifications, e.g., the three types of dyslexia delineated by Sattler (1988). A notable disadvantage in the use of Pennington's scheme is its relative disuse by non-neuropsychologists involved in the practice of LD evaluations.

The cause of learning disabilities is unclear, but presumed to be multifactorial. Sattler (1988) and Kolb & Whishaw (1991) each cite five of the most common factors postulated to be responsible for the etiology of LD, four of which overlap: (1) structural damage or the deficit model, which posits that organic conditions such as brain disease or maldevelopment, or vestibular or ocular difficulties impair learning; (2) brain dysfunction or the disruption model, which posits that non-structural factors such as deficient arousal mechanisms, abnormal metabolism, severe depression, anxiety, or psychosis disturbs learning; (3) maturational lag or the delay model, which posits that learning difficulties are associated with immaturity in development and will eventually dissipate; and (4) environmental deprivation or the personal-historical model, which posits that basic cognitive skills never developed due to inadequate educational exposure or cultural disadvantage. Kolb & Whishaw (1991) also cite an "abnormal cerebral lateralization model", proposed by Geschwind & Galaburda (1985) on the observation that reading disabilities are more common in males, who also have less cerebral asymmetry in the planum temporale than their female counterparts. Sattler (1988) also cites an "individual differences model", wherein individual differences in cognitive ability are thought to be normally distributed and that specific learning disabilities are simply a reflection of this natural variance. None of these models can single-handedly account for all learning disabilities, and they are not mutually exclusive. Indeed, elements of each cause can be related to another, for example, maturational lag is more common in environmentally deprived populations (Sattler, 1988).

A more general question concerning the etiology of learning disabilities centers around the consideration of a genetic basis. Though it is difficult to prove inheritability, many authors have commented on the familial nature and incidence of learning disabilities and therefore speculated that there may be a genetic pathway. Twin studies have found a higher incidence of dyslexia in identical rather than fraternal twins, and the consistently reported 4:1 male to female ratio in the incidence of dyslexia have traditioianally argued against an explanation based solely on environmental factors (Kolb & Whishaw, 1991). However, as with other diagnostic entities researched via the use of twin studies, it can be argued that because of their similar physical, intellectual, and personality characteristics, identical twins have more similarity in terms of their social environments than do fraternal twins. Conversely, it is clear that males and females are treated differently from birth within and across families, and across many generations in most cultures; therefore environmental differences cannot be ruled out on the premise of this ratio alone. Also, evidence is now mounting that the presence of dyslexia in females is higher than originally thought, with the male to female ratio being reduced to 2:1 or even lower (cited in Berkelhammer, 1996).

Pennington (1991) presented convincing data in an exhaustive review of the literature using nuclear family, twin, and adoption studies as well as genetic research supporting the notion of the inheritability of dyslexia. Briefly, he cited evidence that dyslexia is:

> familial (about 35-40% of first degree relatives are affected), heritable (with a heritability of about 50%), heterogeneous in its mode of transmission (with evidence for both polygenic and major gene forms of the disorder), and linked in some families to genetic markers on chromosome 15 and possibly in others to genetic markers on chromosome 6 (p. 48).

Of the many potential genetic and environmental influences contributing to learning disability development, it is important to note that from a clinical perspective the appropriate evaluation and ensuing treatment appears to be similar regardless of presumed etiology (Pennington, 1991). Thus, etiological issues are much more important to basic science and theory than they are to clinical management.

Bigler (1992) recently cited several findings from neurobiological and neuropsychological assessment research strongly suggesting that dyslexia in adults is a neurologically based disorder. Although Orton (1928) suggested a brain dysfunction model for LD many years ago, and the current (1989) National Joint Committee on

Learning Disabilities (NJCLD) statement holds that LD is "presumed to be due to central nervous system dysfunction" (p. 1), little physical evidence for this assertion has been found until recently (Bigler, 1992). For example, Galaburda, Sherman, and Rosen (1985) found a large number of cytoarchitectonic (arrangement of cells in brain tissue) abnormalities upon the histological examination of four consecutive patients with adulthood dyslexia, mostly in the peri-Sylvian regions of the left hemisphere. These patterns of abnormality are similar to those that would be predicted from adult aphasic models developed through studies of patients with tumors or strokes to circumscribed brain regions (Bigler, 1992). Also, Duffy and McAnulty (1990) have found abnormal EEG patterns in both the dominant left-hemisphere language areas and in the anterior frontal regions in dyslexic adults. Currently there are three published studies that have used MRI technology to study adults with dyslexia (Bigler, 1992). Each of these studies independently documented anatomic irregularities in the posterior left cerebral hemispheres of persons with late childhood and adulthood dyslexia, suggesting that the effects are permanent and not just developmental in nature (Duara et al., 1990; Jernigan, Hesselink, Sowell, & Tallal, 1991; Larsen, Hoien, Lundberg, & Odegaard, 1990).

The association of motor proficiency deficits with learning disabilities is well documented (Denckla, 1991, in Preface of Pennington, 1991). Although there has been some controversy surrounding this issue, e.g., Critchley (1964) notes that "for every LD child with coordination problems, there is a child with better than normal coordination" (p. 781, in Kolb & Whishaw, 1991), most clinicians agree that LD children tend to show fine motor problems manifested by clumsiness and poor handwriting among other anomalies. Motor inhibitory capacity has been noted to be an observable "tip of the iceberg" relating to mental inhibitory capacity in ADHD (Attention Deficit Hyperactivity Disorder) children and is seen as a reflection of executive dysfunction (Denckla, 1991). Further, motor dysfunction commonly seen in dyslexics in the form of slow tongue wiggles and finger sequencing, persisting even into adulthood, tap functions mediated by the left hemisphere and are characterized as "neighborhood markers" by behavioral neurologists (Denckla, 1991).

Psychometric data also exist to support the presence of motor system dysfunction in LD individuals. Kane & Gill (1972) found that the Purdue Pegboard test successfully discriminated between learning disabled and non-learning disabled children. Seventy-three percent of their LD sample (n = 15) produced "significant" scores, i.e., at or below the cut-off score, compared to only 29% of a control group (n = 45). Leslie, Davidson, & Batey (1985) found that dyslexic children performed less well on the Purdue Pegboard test bilaterally. Dyslexic children performed at the 24th and 26th percentiles on the dominant and non-dominant hands, respectively, compared to 36th and 46th percentiles in the non-dyslexic control group.

As empirical evidence continues to mount regarding centrally mediated motor problems in LD individuals, the support for the hypotheses that brain dysfunction is causal in many learning disabilities has gained momentum and become accepted in most circles. However, it is also known that there is great variability in the expression of brain function and dysfunction and that success is commonly realized by LD individuals in other (i.e., non-academic) facets of life. This emphasis on special skills and individual differences takes the focus away from the notion of general intelligence and represents the hallmark of modern neuropsychological assessment (Kolb & Whishaw, 1991).

For scientist practitioners, the accurate and thorough testing of learning and memory functioning is also a necessary component of an LD evaluation. Still, the vast majority of individuals who receive an LD evaluation do not receive a full neuropsychological evaluation, of which learning and memory as well as motor proficiency testing are integral components. Instead, they receive the minimum amount and type of testing required to satisfy federal definition and state guidelines, namely, intellectual and achievement testing. Often, this testing approach neglects observation of the active process of completing tasks, which is sometimes necessary to detect focal and neurological "soft signs". Bigler (1992) notes that strength and deficit measurement is both essential and well-suited for LD individuals "because neuropsychological assessment techniques provide the most sensitive and comprehensive methods for detecting cerebral dysfunction based on behavioral and cognitive measures" (p. 498). In addition, learning and memory deficits are more likely to be detected in LD subjects with co-existing neurological or psychiatric disorders, (e.g., those with temporal-lobe epilepsy, or bipolar disorder), and such individuals often experience memory difficulties well into adulthood (Aram & Nation, 1980). Neuropsychologists are uniquely qualified to conduct LD evaluations because of their clinical training in the traditional areas of psychopathology, psychotherapy, and psychometrics, as well as specialized training in functional neuroanatomy and neuropathology. Clearly, detailed information on the neuropsychological learning and memory profiles of persons with learning disabilities requires a knowledge base in all of these areas.

Issues in Learning and Memory Testing

In the past decade or so, criticisms of currently used clinical learning and memory tests have blanketed the neuropsychological literature (Delis, 1989; Erickson & Scott, 1977; Larrabee, Kane, Schuck, & Francis, 1985; Lezak, 1983; Loring, 1989; Loring & Papanicolau, 1987; Russell, 1975; and Zielinski, 1993). Clinical memory tests criticized include the Wechsler Memory Scale (WMS; Wechsler, 1945), Russell's revision of the WMS (Russell, 1975), the new Wechsler Memory Scale-

Revised (WMS-R; Wechsler, 1987), the memory scales of the Luria-Nebraska Neuropsychological Battery (LNNB; Golden, 1981), and the new Memory Assessment Scales (MAS; Williams, 1991). Criticisms take place at theoretical and psychometric levels (Loring & Papanicolau, 1987), and most recently at a more pragmatic level (Heinrichs, 1990).

Theoretical Considerations

At the theoretical level, it is now known that amnesia or memory loss is not a unitary disorder. Indeed, Butters (1984) notes that amnesia is as heterogeneous a disorder as the aphasias and apraxias. Various patient groups manifest their memory dysfunction in different ways, with characteristically different breakdowns in one or more of the multiple components that constitute memory function. A global achievement or composite score such as an "Impairment Index" (Reitan, 1981), "Memory Quotient" (MQ; Wechsler, 1945), or even a WAIS-R (Wechsler, 1981) subtest score, will not reveal these important differences (Delis, 1989; Kaplan, 1988). Delineating such cognitive-behavioral distinctions via neuropsychological investigations are helpful in diagnosis, prognosis, and treatment planning of persons suffering from learning and memory disorders, regardless of their neuropathological etiology (Butters, 1984). For example, a patient with a memory problem may have difficulty in free recall of previously presented verbal or non-verbal information, but not in recognition recall of the same material as measured by a multiple-choice task. In this case, the differential diagnosis will consider neurologic correlates of retrieval (e.g., frontal and subcortical systems) rather than acquisition/encoding and storage mechanisms (e.g., medial temporal lobe and surrounding structures), and treatment recommendations might include suggestions to have sufficient and salient environmental cues ("cognitive prosthetics") to aid in recall of important information. Conversely, failing at recall and recognition tasks suggests problems in the initial acquisition and storage of information (verses retrieval) and have unique neurologic implications associated with different diagnostic entities. In terms of rehabilitation, treatment recommendations may include the suggestion that the client write everything down and not expect or be expected to memorize important information. Unrealistic expectations lead to frustration for the amnesic, his/her family, and the rehabilitation staff. It can lead to even greater problems when the amnesic returns to work and can no longer carry out tasks requiring adequate new learning and memory retrieval ability.

Loring & Papanicolau (1987) assert that several cognitive and neuropsychological constructs [e.g., those resulting from Buschke's (1973) "selective reminding" procedure or the verbal versus visual/figural memory distinction] are suspect when put to an empirical test, as experimental results are often inconsistent, yet are assumed to be correct in the course of everyday neuropsychological investigations of memory dysfunction. They note that memory has come to be defined in terms of what memory tests measure (much in the same manner as LD has come to be defined as an arbitrarily derived "significant" IQ-achievement discrepancy). These tests and discrepancy models are often mistakenly considered valid when they successfully discriminate between normals and neurologically impaired groups. What is lacking, they say, is an understanding that "an unambiguous operational definition of a psychological construct is completely independent of construct validity" (p. 341). For example, the controversial verbal versus visual or figural distinction in learning and memory testing has stimulated a great deal of research, yet findings are inconsistent and the utility and validity of the distinction remain controversial (Chelune & Bornstein, 1988). It has been argued that declarative learning and memory (i.e., the acquisition of facts, knowledge, and events which are directly accessible to conscious awareness) should be best conceptualized as a unitary process regardless of content rather than positing a "verbal versus visual" dichotomy (Malec, Ivnik, & Hineldey, 1991). Accordingly, investigations of verbal and non-verbal learning processes that trace the sequential and simultaneous cognitive and behavioral components continue to be carried out so as to provide an empirically and conceptually integrated model of memory function and dysfunction in normals and neurologically compromised individuals, while simultaneously contributing to a rehabilitative treatment plan.

Construct validity, a measure of the degree to which a test measures what it purports to measure, is a necessary hurdle to pass in test development. Thus, the validity of a test can only be measured in light of what questions it purports to answer. As argued above, IQ and achievement tests appear inadequate to the task of unambiguously determining the presence of LD. In terms of test validity, the type of referral question should be the first important consideration in the selection of tests given to a patient and ought to be considered when new tests of learning and memory are developed (Heinrichs, 1990; Loring & Papanicolau, 1987). It is also essential that the assessment consider the testing as part of the entire clinical picture, and the results integrated with the client's biopsychosocial history, current test behaviors and mood, and work and social environments.

The way a construct is operationally defined varies by test; hence, even tests designed to measure the same functional process may tap different processes and thereby not load on the same factor as measured in factor-analytic studies. In addition, the theoretical construct itself may be flawed in terms of its usefulness as a way of describing and categorizing behavior. For example, the academic and intelligence tests commonly used in psychoeducational evaluations are often considered incomplete, especially when treatment recommendations are to be made; the addition of traditional neuropsychological tests and techniques has added additional cognitive detail and biopsychosocial context to the LD evaluation (Kolb & Whishaw, 1991; Pennington, 1991). The continued state of inconclusiveness regarding the number and nature of learning disability subtypes also calls into question the integrity and utility of currently used cognitive constructs.

In the field of memory testing, which has a history dating back to Ebbinghaus's initial self-experiments in the 1800's on the nature and parameters of learning and memory, debate regarding relatively basic theoretical and psychometric issues continue. For example, the Memory Assessment Scales (MAS) have been criticized by Zielinski (1993) for not including a delayed recall (operational definition) summary scale for long-term memory (theoretical construct). The author of the MAS (Williams, 1991; as cited in Zielinski, 1993) reportedly contends that this is unnecessary. However, it would seem important from a functional standpoint to test general retention of new learning after some time has elapsed, as delayed recall measures have been some of the most sensitive indices to the presence of brain dysfunction. Indeed, the distinction between immediate recall (short-term memory) and delayed recall (long-term memory) has been found to be a useful operational definition as well as theoretical construct in successfully discriminating between organic disorders and depression in the elderly (Coughlan & Hollows, 1984) and detecting dementia (O'Donnel, Drachman, Lew, & Swearer, 1988). The dissociation also has a neurological basis, as patients with damage to the medial temporal lobe structures of the brain consistently perform adequately on digit span tests (short-term memory) but poorly on digit supraspan tests (long-term memory; Butters, 1984). The recently developed MAS has also been criticized due to the neuropsychologically counterintuitive finding in the normative sample that found no significant differences in performance between the 70-79 and 80 and over age groups, a finding that is not consistent with memory testing research conducted over the past 45 years beginning with Wechsler's (1945) findings in his initial normative study of the Wechsler Memory

Scale (Zielinski, 1993). As the development of new tests improve, so should the connection between theoretical constructs and operational definitions. Further, these connections will become more consistent between tests, thereby improving convergence or consensual validity.

Psychometric Considerations

Standardized tests designed to parse out the constituent components that comprise memory function have been tainted due to problems at the psychometric level (Loring & Papanicolau, 1987). For example, tests designed to assess visual memory are often verbally encodable, hence confounding the measurement of the proposed underlying construct and its associated localization of function in the brain (i.e., the right hemisphere in most right handers). Further, most visual memory tests require the subject to draw a design from memory, thus making constructional/graphomotor skills a possible reason for poor performance, rather than visual memory per se. In addition, drawing from memory adds a procedural learning and memory component to a task that is often thought of as a task of declarative learning and memory. Finally, the inability of a subject to make visual discriminations may be manifested in a low visual memory score, although the reason for this poor performance may be more appropriately attributable to problems in visual acuity than visual memory. In fact, this problem is common in aging adults (Spreen & Strauss, 1991; Terryberry-Spohr, Wands, Rohling, & Cole, 1993). Larrabee et al. (1985) note such problems in the WMS visual memory scales and on Benton's Visual Retention Test (BVRT; Benton, 1974). His arguments have led to the development of the Continuous Visual Memory Test (CVMT; Trahan & Larrabee, 1988), a visual recognition memory test (i.e., a drawing response is not required) using a series of perceptually similar designs that are difficult to verbally encode. The test has been found to reliably differentiate between left and right cerebral vascular accident (CVA) patients and appears to measure a construct (visually-based non-verbal memory) different from visuospatial or verbal ability in the delayed recognition recall trial (Trahan, Larrabee, & Quintana, 1990).

Although the CVMT (Trahan & Larrabee, 1988) appears to have corrected some of the major problems associated with *visual memory* testing, there are still no widely utilized tests that measure *visual learning* across trials via reproduction (i.e., drawing). The distinction between learning and memory is an important one. According to Squire (1987), learning is the process of acquiring new information, whereas memory is the persistence of learning in a state that can be revealed at a later time (cited in Delis, 1989). The clinical utility of this distinction is evident in findings that anxious clients often perform poorly on the first trial but improve on subsequent trials of learning tests (Lezak, 1983; in Delis, 1989). Also, Luria (1981) reports that frontal lobe patients tend to show a normal performance on first trials but reach a learning plateau quickly on subsequent trials (cited in Delis, 1989). A test of memory using only immediate and/or delayed recall trials may not be sensitive to these useful clinical distinctions. The only "visual learning through reproduction across trials" test widely available appears to be the Rey Visual Design Learning Test (RVDLT; Rey, 1964; in Spreen & Strauss, 1991). The RVDLT was just recently made available to English speaking people in 1991 by Spreen and Strauss who translated it from French, standardized it, and developed norms for it. However, a perusal of the literature did not reveal any published studies using this test; hence, its validity and utility are largely unknown.

Practical Utility

Recently, criticisms have emerged regarding the ecological and rehabilitative utility of neuropsychological testing (Heinrichs, 1990; Wilson, Cockburn, Baddely, & Hiorns, 1989). The fact that a patient performed at two standard deviations below the mean on a test of memory does not directly answer questions regarding placement, instructional technique, or vocational planning. The ability to return to work, drive a motor vehicle, succeed in college, live independently, or return home are also important questions addressed to neuropsychologists (Wilson et al., 1989). Indeed, the rehabilitation community anxiously awaits reliable and valid tests relevant to these issues (Heinrichs, 1990). The only standardized and commercially available direct test of these everyday learning and memory functions is the Rivermead Behavioral Memory Test (RBMT; Wilson et al.). Such tests may also be useful for quantifying the non-academic everyday memory problems of LD populations. Other measures commonly used in assessing everyday abilities dependent on memory function are questionnaires and checklists filled out by patients, staff, and family members (Malec, Zweber, & DePompolo, 1990). These measures have significant weaknesses in areas of reliability and validity, as findings using these measures are often inconsistent and have low correlations with daily functional living and working skills (Malec et al., 1990; Wilson et al., 1989). Also, little work has been done in the area of evaluating the practical utility of psychometric neurocognitive tests in assisting and predicting habilitation or rehabilitation outcome (Heinrichs, 1990; Heaton & Pendleton, 1981). Some authors (e.g., Delis et al., 1989) claim that the California Verbal Learning Test (CVLT), with its format of presenting a list of items as a grocery list, is an everyday memory task and henceforth has utility in this regard.

The proliferation of neuroradiological techniques in the past decade has created a major shift in the task of neuropsychological assessment, one where cerebral localization of lesions and brain function are only of secondary importance (Heinrichs, 1990; Loring & Papanicolaou, 1987). One trend resulting from the onset of neuroradiological advances is an applied focus on more pragmatic, applied behavioral issues in the management and treatment of persons with cerebral dysfunction

(Heinrichs, 1990; Loring & Papanicolaou, 1987). Accordingly, referral questions are increasingly more likely to center on habilitative/rehabilitative and ecological issues (Heaton & Pendleton, 1981; Heinrichs, 1990), rather than diagnosis or making a functional-organic distinction vis-a'-vis cognitive deficits. Such evaluations are helpful when addressing functional daily living and community skills, socialization, and ability to benefit from certain specific cognitive-behavioral and educational interventions. A great stride in this direction has been made with the development of the RBMT (Wilson, Cockburn, & Baddeley, 1989), which is the first memory test to go beyond rote learning/memory tasks by adding face valid components such as remembering to ask the examiner a specific pre-identified question when an alarm clock goes off ("prospective memory"). However, the RBMT does not yield indices that address how a subject succeeds or fails on any item, and it does not detect mild memory impairments; indeed, it is not intended for populations other than severe head injury and stroke survivors in rehabilitation.

Loring & Papanicolau (1987) note that an additional effect of neuroradiological advances is the integration of cognitive psychology and the analysis of cognitive components of complex tasks with clinical or research-based neuropsychological findings. As a result, a more elaborate breakdown of test performance has been promulgated. The CVLT as a measure of auditory-verbal learning and the RVDLT as a measure of visual-figural learning represent two new tests that complement each other well theoretically while simultaneously assessing the multiple components necessary to complete the task successfully. Collective use of these tests is particularly relevant to the evaluation of persons with differing subtypes of reading and arithmetic disabilities, who have been shown to possess material-specific (e.g., common use objects verses novel geometric configurations) differences in terms of their memory assets and deficits (Rourke, 1993).

The California Verbal Learning Test (CVLT)

The California Verbal Learning Test (CVLT; Delis, Kramer, Kaplan, & Ober, 1987) incorporates modern models of normal memory functioning developed in cognitive psychology as well as clinical neuropsychological observations of memory dysfunction in its design, thus breaking down and measuring the empirically validated component processes, strategies, and error types utilized in learning new verbal information. The CVLT was developed in response to years of criticisms directed at some of the most popular clinical memory tests in current use (Delis et al., 1987). It consists of two 16-word shopping lists each containing four categories (e.g., fruits, clothing, tools, and spices & herbs) of four items each, which are used in cued recall trials. Subjects are asked to immediately freely recall as many List A items as they can over the course of five learning trials. A second list (List B) is then administered for immediate recall. List B shares two semantic categories with List A ("fruits" and "herbs and spices"); this semantic similarity is used in the analysis of interference effects. Short and long-delay (20') free and cued recall of List A are then measured. The test concludes with a yes/no forced-choice recognition recall trial containing a total of 44 shopping items.

In addition to providing the more traditional measures of recognition and recall, the CVLT also provides normative data collected in a standardized fashion for a total of 22 variables, using over 250 raw scores. The CVLT is most different in that it measures not just the *amount* of information retained but *how* the information was retained or not retained (Delis et al., 1987). Conducting an analysis of the processes, strategies, and error types in learning new verbal information helps to validate and identify the processes underlying performance and to define circumscribed memory deficits and their associated neurological etiologies (Delis, Kramer, Freeland, & Kaplan, 1988).

Variables quantified on the CVLT include semantic verses serial-ordered clustering, pooled serial position recall, learning rate across trials, recall consistency across trials, proactive and retroactive interference, cued recall, long-delay recall, cue-enhanced semantic clustering, perseveration and intrusion errors, and recognition memory. Each of these measures will be operationally defined and considered in turn.

Consecutive recall of words from the same category (i.e., semantic clustering) typically results in the most effective learning strategy, as it implies an active organization of the words into semantic groupings, and has been found to decline in the normal elderly and to be deficient in amnesic patients with Korsakoff's syndrome (Craik, 1984, & Cermak & Butters, 1972, as cited in Delis et al., 1987). Conversely, recall of the words in the same order they were presented (i.e., serial clustering) is considered a less effective strategy than semantic clustering and correlates with poor performance on other CVLT measures (Delis et al., 1987).

The percentage of words correctly recalled from each of the primacy (first four words in List A), middle (middle eight words), and recency (last four words) regions constitute the three indices in pooled serial-position recall. Normal memory research indicates that subjects favor recalling words from the primacy and recency regions, and this "primacy-recency effect" was true of the CVLT normative sample; however, some amnesic subjects have been found to recall only words from the recency region, indicating a more passive recall strategy of echoing back the words just heard (Delis et al., 1987).

To quantify the rate of learning across the five trials, the slope of the least-squares regression line is calculated to fit correct response scores across the first five learning trials of List A. Thus, a slope value near zero indicates that a learning plateau was reached quickly (but the scores must be observed to rule out the possibility of a ceiling effect in highly skilled subjects), and a slope value greater than one indicates a sizable increase in free-recall verbal learning from trial to trial (Delis et al., 1987). As mentioned earlier, anxiety and structural brain pathology can affect this learning curve (Lezak, 1983; Luria, 1981; cited in Delis et al., 1987).

The ability of the subject to consistently recall the same word across repeated presentations of the list is reflected in the recall consistency across trials score, and is computed by taking the percentage of words that are recalled once that are also recalled on the next trial. Amnesics, especially those with frontal lobe pathology, are typically inconsistent in this regard and respond to each presentation as though it were a new list (Luria, 1981; cited in Delis et al., 1987).

Interference is said to occur when the learning of new material is reduced due to the learning of other similar material. Proactive interference (PI) refers to the decremental effect of prior learning on the retention of subsequently learned material, and retroactive interference (RI) refers to the decremental effect of subsequent learning on the retention of previously learned material (Postman, 1971; as cited in Delis et al., 1987). Hence, when presented with the two CVLT word lists, a high degree of PI is said to occur when having learned List A interferes with learning List B (indicated on the CVLT when the subject gives List A words after being asked to immediately recall List B words, or when List B recall is significantly lower that List A Trial 1 recall). RI is said to occur when having learned List B interferes with the subsequent recall of List A (indicated on the CVLT when the subject gives List B words after being asked to recall List A in the short and long delayed recall trials; Delis et al., 1987).

Cued recall is measured on short and long (20") delays simply by asking the subject for the words from each category, e.g., "Tell me all the fruits from the first list." Difference scores are computed between the free and the cued recall scores. As discussed above, these differences can detect encoding versus retrieval difficulties and have implications for diagnosis and treatment.

Short and long delay (20") free recall is also assessed, and a difference score is calculated using these two measures. This difference score is sometimes referred to as a "savings" score. Deficient performances in long delay free recall and the "savings" score are particularly evident in patients with cortical dementia's.

The cue-enhanced semantic clustering score is a measure of the change in semantic clustering from short delay to long delay free recall. This is possible because categorical cueing is imposed between these two measures in standardized administration of the test. Thus, the examinee may learn this as an effective strategy when recalling during the long delay trial. The results may indicate whether the examinee will benefit from cognitive rehabilitation that uses semantic clustering strategies (Delis et al., 1987).

Perseverations (repeating responses given on the same trial) and intrusions (responses given not on the target list) are tabulated; intrusions are further broken down into whether they came from shared or unshared categories on the CVLT lists. Perseverations are commonly seen in frontal lobe patients, and intrusions are commonly seen in more diffusely compromised patients, such as head-injured (Crosson et al., 1988), Alzheimer's (Kramer et al., 1988), and Korsakoff's (Butters & Cermak, 1980) patients. Intrusions may reflect problems in discriminating relevant from irrelevant responses (Fuld, Katzman, Davies, & Terry, 1982; as cited in Delis et al., 1987).

In the recognition trial subjects are asked to respond "yes" or "no" as to whether they think each word from an auditorily presented list of 44 words came from List A. All 16 of the original List A words are included in this recognition list. Twenty-eight of the words are "distracters" constituting five types: (1) List B shared category words,

(2) List B non-shared category words, (3) words from neither list but prototypical of a List A category (e.g., "hammer" for tools), (4) words from neither list but are phonemically similar to List A words (e.g., "drums" for "plums"), and (5) words from neither list that are not related in any obvious way to List A or List B words. Measures derived include number of hits, misses, false positives, and correct rejections. Discriminability (ability to distinguish target from distracter items) and response bias (tendency to favor yes or no responses regardless of stimulus type) indices are also calculated.

Numerous studies using the CVLT have demonstrated its reliability, validity, and utility in characterizing the specific learning and memory deficits of patients with a variety of diagnoses. Cognitive profiles of individuals with alcoholism (Kramer, Blusewicz, & Preston, 1989), Alzheimer's Disease (Delis, Massman, Butters, Salmon, Cermak, & Kramer, 1991; Kramer, Delis, Blusewicz, Brandt, Ober, & Strauss, 1988; Kramer, Levin, Brandt, & Delis, 1989), attention deficit disorder (Loge, Staton, & Beatty, in press), head injury (Crosson, Novack, Trenerry, & Craig, 1988; Crosson, Novack, Trenerry, & Craig, 1989; Haut & Shutty, 1992), human immunodeficiency virus (Saykin et al., in press), Huntington's disease (Delis et al., 1991; Kramer et al., 1988; Kramer et al., 1989a; Massman, Delis, Butters, Levin, & Salmon, 1990), Korsakoff's disease (Delis et al., 1991), language-impairments (Shear, Tallal, & Delis, 1992), left and right temporal lobe epilepsy (Hermann, Wyler, Richey, & Rea, 1987), major affective disorder (Dupont et al., 1990), multiple sclerosis (Kessler, Cohen, Lauer, & Kausch, 1992), memory loss associated with normal aging (Kramer et al., 1989; Pope, 1990), Parkinson's Disease (Kramer et al., 1989a; Massman et al., 1990), premenstrual syndrome (Keenan et al., in press), and schizophrenia (Authelet & Raymond, 1987; Cullum et al., 1990) have been investigated and delineated. In addition, performance differences in neurologically intact male and female adults were investigated by Kramer, Delis, & Daniel (1988). Although there were no sex differences in recognition testing or error types, women displayed consistently higher levels of immediate and delayed free recall and made greater use of semantic clustering strategies (Kramer, et al., 1988). The authors suggested that women have superior recall because of better retrieval functions which are related to their greater use of verbally mediated strategies. They also suggested reporting separate sex norms on clinical and experimental measures of learning and memory. Bolla-Wilson & Bleecker (1986) reported similar sex differences on a similar list learning test, the Rey-Auditory Verbal Learning Test (Rey, 1964; in Lezak, 1983), a test after which the CVLT was modeled (Delis et al., 1987).

Fewer studies have been conducted in the important area of rehabilitative utility or ecological validity of the CVLT. Privett & Freeland (1990) reported that CVLT scores significantly predicted head-injured patients' ability to follow through with behavioral contracts arranged with their physical, occupational, and speech-pathology therapists over a 2-week period. Kibby, Schmitter-Edgecombe, & Long (1993) found that the Total Words Recalled and Discriminability indices of the CVLT were correlated with current level of work performance and type of job held (laborer, semi-professional, etc.) in a group of 28 closed head injury survivors with an average time since injury of close to seven years. However, none of the CVLT indices or other neuropsychological measures used were significantly associated with performance in activities of daily living (ADL's). Finally, Zimbelman (1989) found that the Semantic Clustering and Total Immediate Free Recall indices significantly predicted recall of an alcoholism lecture 20 minutes after its presentation in 55 hospitalized male veterans.

Factor analysis is a statistical psychometric procedure commonly used to explore the validity of a test's constructs (Anastasi, 1988). This type of research can assess "whether certain scoring categories enhance the test's capacity to differentiate and characterize the cognitive profiles of different patient populations" (Delis, Freeland, Kramer, & Kaplan, 1988). The end product of such a procedure is the production of one or more factors that purportedly account for the majority of the variance in performance, and these factors are derived by computing the average of the relationships between the correlations. In the past, factor-analytic studies of memory tests have revealed only a single learning factor, not unexpected since the indices used in these studies were limited to total recall scores (Delis et al., 1988).

Delis, Freeland, Kramer, & Kaplan (1988) investigated the construct validity of the CVLT by administering the test to 286 neurologically-intact and 113 neurologically-impaired patients and then conducting a factor analysis using the principal components procedure on 19 CVLT indices. They wanted to find out if the multiple measures used in the CVLT add to the evaluation of learning and memory, or more specifically, "to determine whether the various CVLT indices cluster into linearly independent domains of performance consonant with experimental constructs or whether they are merely redundant measures of a single learning factor" (Delis et al.,1988; p. 124). The results revealed a six-factor solution for the neurologically intact group and for all of the subjects, whereas a five factor solution was revealed for the neurological group. The six-factor solution for the first two of these groups included General Verbal Learning, Response Discrimination, Serial Position Effect, Learning Strategy, Proactive Effect, and Acquisition Rate factors. Wilde & Boake (1993) found the same six-factor solution, which accounted for 77% of the total variance, in their study of 97 closed head injury victims. The five factors for the neurological group in the Delis et al. (1988) study were General Verbal Learning, Response Discrimination, Serial Position Effect, Learning Strategy, and the Retroactive/Short-Delay Effect factor. The authors concluded that "a number of meaningful, orthogonal factors underlie verbal memory performance on the CVLT" (Delis, et al., 1988; p. 128). Furthermore, similar to the

WAIS-R, the CVLT appears to have a factor structure applicable to normal and patient groups and separate factor structures applicable to different patient groups.

In terms of implications for test construction, results support the claim of those who have suggested that such tests should provide a multifactorial assessment of how tasks are solved or not solved, in addition to the overall level of achievement (Werner, 1937; Eysenck, 1967, 1982; cited in Kaplan, 1983). Results also endorse an approach that involves analysis of performance into component functions empirically identified in cognitive and neuropsychological research. The collective contributions of this "process approach", when standardized, and neuroimaging technology has begun to yield increasingly specific and quantifiable data regarding brain-behavior relationships.

Kramer & Delis (1991) investigated whether the CVLT was sensitive to (i.e., had construct validity for) interference effects in 270 normal adults. Interference has been found to be greatest when target and interference material are similar or in "shared categories" (Klatzky, 1980; Reitman, 1971; Wickens, 1972; in Kramer & Delis, 1991). Results from the Kramer & Delis (1991) study indicated that recall from List B relative to List A showed a significantly lower recall of shared category items (i.e., PI) and a significantly higher recall of nonshared category items (release from PI). RI effects were also found on delayed recall and recognition trials of List A (Kramer & Delis, 1991).

In examinations of the concurrent validity of the CVLT, the instrument has been found to correlate highly with other similar measures, such as scales of the WMS, WMS-R, and a modified Buschke's (1973) selective reminding procedure (Delis, Cullum, Butters, Cairns, & Prifitera, 1988; Schear & Craft, 1989). Conversely, some of the newer indices of the CVLT such as vulnerability to proactive and retroactive interference and types of recall errors do not correlate with any previously used measures of memory (Delis et al., 1988). Further, CVLT indices correlated only modestly (r = .22 to .53) with WAIS-R IQ's, suggesting that the test is not simply measuring some dimension of intellectual ability as measured by the WAIS-R (Schear & Craft, 1991).

A correlational analysis of the CVLT using other neuropsychological measures of memory, orientation, language, and executive function supported the validity of the General Verbal Learning factor; however, little evidence was found for the external validity of the other factors, indicating that more evidence for the validity of the process scores is needed (Wilde & Boake, 1993). However, it seems as though the low correlations may also be explained by the other test's insensitivity to functions other than verbal learning due to their less sophisticated design. Further confirmatory factor-analytic (Wilde & Boake, 1993) and clinical research studies are necessary to address these issues.

The one-year test-retest reliability of the CVLT in a group of 21 normals, although significant, was just .59 (Delis, Kramer, Kaplan, & Ober, 1987). However, test-retest reliability in this type of test, which measures primarily new, episodic learning rather than remote, semantic knowledge or skills, may result in significant practice effects, confounding the appropriateness of the measure (Delis et al., 1987). A better approach may be to use an alternate form of the same test.

Delis, McKee, Massman, Kramer, Kaplan, & Gettman (1991) have noted that alternate forms for neuropsychological tests are rare, although repeated assessment of patients is sometimes necessary. For example, a progressive decline in cognitive and intellectual functions must be documented in diagnosing probable Alzheimer's disease. Serial testing is also desirable in situations investigating rehabilitation and instructional efficacy. In a study investigating the development and reliability of an alternate form of the CVLT, Delis et al., 1991) found that the two CVLT forms yielded equivalent mean scores for all 19 indices analyzed, and no significant practice effects in the average eight-day test-retest interval arose regardless of order of administration. Sixteen of the 19 indices resulted in significant alternate-form reliability coefficients, ranging from $r = .31$ to $r = .84$, with 10 of the indices being .62 or higher. The three indices that did not show significant alternate-form reliability coefficients in this neurologically intact group of 41 adults were percent primacy recall, learning slope, and perseverations. The relationship between scores and age and education were almost identical for both forms (Delis et al., 1991).

The Rey Visual Design Learning Test (RVDLT)

The RVDLT is a 15-item test in which the subject is asked to draw from memory 15 simple geometric designs immediately after they are visually presented sequentially at a rate of two seconds each. Each design contains two primary configural elements. After five learning trials, recognition memory is tested by asking the subject to identify the 15 designs from an array of 30 designs. The supraspan nature of the task makes it unlikely that all designs will be freely recalled on the first trial. This test has the advantage of assessing whether the subject increasingly learns visually-presented non-verbal material on successive trials. Also, the recognition task allows the examiner to determine whether low scores are related to retrieval deficits rather than encoding or storage difficulties, as the drawing response represents "free recall" performance which may be deficient despite intact encoding and storage mechanisms.

Despite its advantages, the RVDLT has some shortcomings. A literature review failed to locate one published article using the RVDLT; hence its reliability, validity, and utility awaits empirical investigation. The designs are ostensibly relatively easy to verbally encode. For example, a subject may look at the design and say to herself "a circle and a triangle to the right of it." Problems in visual acuity may lead to poor scores, but there is no component of the test in its original design assessing visual discrimination that would allow the examiner to rule out this possibility. The test-retest reliability is low (r = .45 after one month) and practice effects are high (average gain of 12 points after one month), but a normed alternate form that may correct these deficiencies does not exist. Finally, the requirement that the subject draw from memory introduces visuoconstructional skill as a contributing factor to the final score, but a separate constructional task that could help to rule out or measure the contribution of constructional factors to the final score is not incorporated into the design of the test.

On first appearance, the RVDLT designs appear to be easily verbally encodable. However, several factors discount the severity of this criticism. Similar geometric figures (i.e., circles, squares, triangles, and straight lines) are used on no fewer than five different design cards each, with each card containing essentially two different configural elements. Since many of the configurations and their simple constituent elements bear resemblance to each other, verbal descriptions of each configuration would be similar, thereby introducing an increased likelihood of interference effects when using a verbal encoding strategy. Indeed, studies on verbal learning and retention demonstrate that item similarity correlates with increased interference effects (Postman, 1971, in Delis et al., 1987), and there is no reason to believe that this is not true for visual or spatial information. Also, the position of the configurations with relation to each other have to be recalled correctly in order to reproduce them accurately, making the spatial left-right orientation distinction important. Furthermore, these figures may not be any more verbally encodable than CVLT words are "visually encodable." For example, the word “plum” may be pictured to help remember it, indeed, even olfactory or gustatory mechanisms may be utilized as mnemonic devices to help remembering "plum." Finally, the importance of eliminating the “verbal encodability" of visual stimuli in visual learning and memory tests may be overestimated, as this may be construed as a useful or even superior strategy to employ when recalling some types of non-verbal information, analogous to the empirically documented superiority of using a semantic clustering strategy when learning verbal material (Delis et al., 1987). This type of strategy may be deficient in certain persons with learning disabilities and it has been theorized that some LD subjects are deficient in their ability to verbally encode visual information and vice-versa (Swanson, 1984, 1988). From a neuropsychological perspective, this theory can be restated as a deficiency in the ability to transfer knowledge across hemispheres. However, Clark, Deshler, Schumaker, Alley, & Warner (1984) found that both self-questioning and visualization techniques were effective in improving comprehension of written materials in a small group (N = 6) of learning disabled subjects. Additional research is needed in this area, using a greater number of subjects and more clearly defining the participants' learning disability subtypes.

Other shortcomings of the RDVLT could be mitigated by making several modifications. Adding a simple matching-to-sample visual discrimination task using some of the original designs in the RVDLT would address the issue of whether visual acuity problems were a contributing factor to poor performance in a particular case. Thus, if the subject can't match a design to a replicate of that design, then visual acuity problems can be attributed as a cause for poor performance, and visually-based learning will have to be tested at a later time if this problem can be corrected.

As indicated above, the one month test-retest reliability of the RVDLT is low ($r = .45$), presumably because practice effects are so high. That practice effects were found to be high is not surprising, since (a) the subject is exposed to each design at least six times, (b) the subjects were exposed to the designs tactually as well as visually for up to 90 seconds each trial, and (c) the test-retest interval used was only one month long. Comparatively, in a similar task gauging learning across five trials, the one-year test-retest reliability of a group of 21 normals, although significant, was only .59 (CVLT; Delis et al., 1987). A more appropriate method to address the issue of reliability with this type of test is to create an alternate form of the test and to then investigate its alternate-form reliability and test-retest reliability using the alternate form. Increasing the number of designs used in the test may improve reliability by decreasing the impact of practice effects. Increasing the number of subjects in a reliability study may also increase the reliability coefficient, if the test is indeed reliable. Finally, a longer (e.g., one year, as used in the CVLT test-retest reliability study) test-retest interval may actually result in a higher reliability in this type of test due to the effects of forgetting.

The possibility of graphomotor impairment (i.e., constructional dyspraxia) affecting RVDLT results could be investigated by having the subject copy designs similar to those used in the test before the testing begins. This would allow the examiner to assess whether a constructional dyspraxia of the magnitude necessary to affect performance on the RVDLT is evident. Collectively these modifications would result in the development of a promising psychometric instrument representing key cognitive and neuropsychological concepts while also serving as an underutilized non-verbal complement to the CVLT.

CHAPTER II

SUMMARY AND PURPOSE

The CVLT represents an integration of the most reliable and important conceptual and empirical contributions of experimental cognitive psychology and clinical neuropsychology to the assessment and treatment of clinical groups with learning and memory difficulties. A modified RVDLT could be used to make similar types of analyses of declarative learning and memory as in the CVLT by using visual presented designs rather than auditorily presented words as the stimuli to be remembered. Since the CVLT and RVDLT utilize the same repeated trials procedure to measure different types of material-specific (i.e., auditory-verbal versus visual-figural) declarative learning and memory, it would be useful to determine their relatedness in terms of correlation, validity, and utility with both normative and clinical groups, including those with learning disabilities. Although learning and memory difficulties have been well documented in dyslexic children, for example (Cermak, Goldberg, Cermak, & Drake, 1980), few individuals receiving an LD evaluation actually receive learning or memory testing. Tests of motor function, such as the Purdue Pegboard test, are also commonly underutilized in LD evaluations despite a long and sometimes controversial line of evidence that supports the comorbidity of motor inefficiency in persons with learning disabilities. Research that elaborates the relative merits of these tests and their theoretical underpinnings as they apply to students with learning disabilities of differing kinds, degrees, and etiologies is warranted, given the current trend to develop more sophisticated instruments based on the experimental cognitive and clinical neuropsychological literature. As such a database builds, their utility for assessment and treatment will continue to expand.

Although the authors of the CVLT suggest that the test can contribute to the diagnosis and treatment of memory impairments secondary to developmental learning disabilities (Delis et al., 1987), a review of the literature revealed only one published article that used the CVLT with such individuals. However, a small sample size and a now-defunct 12-item version of the CVLT was used, which is clearly not as challenging as the 16-item version. In addition, the study included children only, with an average age of eight and a half years old; thus, the possibility of developmental lag as the etiology for LD in these individuals could not be ruled out. No such published research has been conducted using the RVDLT with LD populations. Although considerable research on LD children's performance on the Purdue Pegboard test has been conducted, no published research has documented performance of LD adults on this test. Therefore, the purpose of this study was to delineate the characteristic learning patterns, error types, and intercorrelational convergence and divergence of performance indices as measured by the CVLT and the RVDLT in learning disabled adults, and to extend the body of research on Purdue Pegboard performance to include LD adults. This was accomplished through the use of a quasi-experimental two-group comparison design involving the use of the CVLT, RVDLT, and Purdue Pegboard. Subjects included learning disabled and non-learning disabled adult college students matched for age, sex, estimated WAIS-R intelligence, socioeconomic status, and educational level. The discriminative validity of the CVLT, RVDLT, and Purdue Pegboard in this LD group was subsequently assessed using a multiple one-way analysis of variance (ANOVA) statistical design.

It was hypothesized that the patterns of performance seen on the CVLT by the LD group would be similar to those found in the Schear, Tallal, & Delis (1992) group of language-impaired children. Specifically, a significantly lower number of correct responses on List A Total Recall Trials 1-5, long delay free recall, and long delay cued recall was expected, as was a higher rate of perseverative errors. It was also hypothesized that the LD group would recall fewer items by the fifth learning trial, and would forget a greater number of items in the short delay to long delay recall interval. In terms of learning style, it was hypothesized that the LD group would be more vulnerable to the effects of interference, would produce a greater number of intrusion errors, and would be less consistent in the words they typically recalled due to a less organized learning approach. Finally, it was hypothesized that the LD group would recognize fewer items at the end of the test in a forced-choice format, due to initial acquisition and consolidation problems prohibiting them from retaining all of the items over time.

On the RVDLT, it was hypothesized that the LD group would recall through reproduction fewer items over the five learning trials and would have a lower final level of attainment as measured by the Trial 5 and Long Delay Free Recall indices. It was also hypothesized that the LD group would recognize fewer items from similar-appearing distracters at the end of the test, due to initial acquisition and consolidation problems prohibiting them from retaining all of the designs over time. Finally, it was hypothesized that the LD group would make a greater number of errors of commission, reflected by reversals and rotations of the design elements and their configurations, and other incorrect reproductions.

On the Purdue Pegboard test, it was hypothesized that consistent with previous research, the LD group would be slower in their overall performance. Lastly, it was hypothesized that the correlation table constructed to compare indices from the CVLT and RVDLT would produce several modest to high intercorrelations, thereby supporting their commonality as tests of declarative learning and memory.

CHAPTER III

METHOD

Subjects

Fifty-one volunteers participated in the study. However, in order to match the two groups on age, seven subjects (five non-learning disabled, two learning disabled) whose data were initially collected were removed from the final data pool. A one-way ANOVA revealed that without removal of these subjects the LD group would have been slightly and significantly older [$\underline{M} = 29.3$ (11.04) versus $\underline{M} = 22.63$ (5.02); $\underline{F} = 8.083$; $\underline{p} = .0065$). The five non-learning disabled students whose scores were removed from the final data pool ranged in age from 18 to 19 years old, and the two learning disabled subjects removed from the final data pool were 47 and 48 years old. Statistical comparisons were conducted on the remaining 44 subjects. Family-wise alpha was set at .05 for all of the statistical comparisons. Of the 44 subjects, 21 (48%) were from West Virginia University (WVU) and 23 (52%) were from Western Michigan University (WMU). Racial composition was primarily Caucasian; three of the subjects were of Asian descent and one subject was African American. Five of the LD and three of the non-LD subjects were left-handed. Testing took place in The Psychology Clinic of Wood Hall on the campus of WMU, or at the psychological testing laboratory of Chestnut Ridge Hospital at the WVU School of Medicine. Data from all 51 subjects (26 from WVU, 25 from WMU) were used in an exploratory correlational analysis of the convergence and divergence of measures from the CVLT and RVDLT.

Demographic composition of the two groups is presented in Tables 1 and 2.

Multiple one-way ANOVA's revealed that the two groups did not significantly differ with respect to age, educational level, or estimated WAIS-R Full-Scale IQ (Table 1). Estimated WAIS-R intelligence based on the two-subtest short form developed by Silverstein (1985) was actually an average of 3.9 points higher in the LD group. However, most if not all of these LD subjects had been tested using the Wechsler intelligence tests in the past, and these non-statistically significant differences could be accounted for by practice effects alone. Further observation of the data revealed that the LD group demonstrated non-significant trends towards higher Vocabulary subtest scores and poorer performance on the Block Design subtest than the non-LD group. A non-significant trend of older age and more age variability in the LD group was also observed.

Table 1

Mean Age, Education, and Estimated IQ of the LD and Non-LD Groups

	LD (n = 22)	Non-LD (n = 22)	ANOVA
Age	27.68 (9.96)	23.45 (5.23)	$F = 3.11$; $p = .0853$
Age Range	18-46 Years	20-42 Years	
Education	15.14 (2.23)	15.27 (.7)	$F = .07$; $p = .7859$
IQ Estimate	112.95 (10.18)	109.05 (11.69)	$F = 1.4$; $p = .2436$
GPA	2.65 (.53)	3.19 (.41)	$F = 14.12$; $p = .0005$

Note. LD = Learning Disabled; IQ = Intelligence Quotient; GPA = Grade Point Average.

A 2 x 2 chi-square analysis revealed that the two groups were matched for sex, although both groups had more females than males (Table 2). A 2 x 5 chi-square analysis demonstrated no significant differences between the groups with respect to self-reported socioeconomic status (Table 2). Thus, overall, the two groups were well-matched on multiple demographic variables, including age, sex, educational level, socio-economic status, and estimated WAIS-R intelligence. An external probe supporting the existence of LD in the students identified as LD by a previous evaluator using the self-reported GPA of the subjects was assessed using a one-way ANOVA. This analysis revealed that the two groups differed significantly (F=14.12; p=.0005), with the LD group not unexpectedly demonstrating a lower GPA.

Table 2

Demographic Composition of the LD and Non-LD Groups: Sex and SES

	LD (n = 22)	Non-LD (n = 22)	Chi-Square Test
Sex	9 Male (40.91%)	4 Male (18.18%)	2 x 2 Chi-Square
	13 Female (59.09%)	18 Female (81.82%)	x^2 = 2.78; p = .1863
SES	1 LC (4.55%)	2 LC (9.09%)	2 x 5 Chi-Square
	2 LMC (9.09%)	3 LMC (13.64%)	x^2 = 1.79; p = .7741
	13 MC (59.09%)	11 MC (50%)	
	5 UMC (22.73%)	6 UMC (27.27%)	
	1 UC (4.55%)	0 UC (0%)	

Note. LD = Learning Disabled; SES = Socioeconomic Status; LC = Lower Class; LMC = Lower Middle Class; MC = Middle Class; UMC = Upper Middle Class; UC = Upper Class.

Subjects in the LD sample consisted of three general LD subtypes: language-based LD, nonverbal LD, and mixed LD. The 11 individuals with language-based LD's had deficits in linguistic processing, dyslexia, spelling, and written expression. The five individuals with documented nonverbal LD's had deficits in mathematical calculations and visuospatial reasoning. The remaining six LD subjects had mixed LD's with verbal and nonverbal factors, as well as deficits in processing speed.

Materials

Materials used included the CVLT test kit and scoring software, the RVDLT visual stimulus cards and stimulus array, the WAIS-R Block Design and Vocabulary subtests, the Reitan-Indiana Aphasia Screening Test stimulus booklet, the Purdue Pegboard Test, a stopwatch, informed consent forms for the LD and non-LD subjects, and demographic and neurological screening forms (see Appendices A and B for informed consent and screening forms). Statistical analyses were conducted using the Statview SE+ Graphics and SuperANOVA software programs developed by Abacus Concepts, Incorporated.

The Block Design and Vocabulary subtests of the WAIS-R were utilized to estimate WAIS-R intelligence as a matching variable. Silverstein (1985) developed a WAIS-R FSIQ estimation procedure using the original WAIS-R standardization sample which demonstrated adequate validity and reliability. The two-subtest short form validity was an average of .90 across age groups, with a range of .87 to .92. The average standard error of estimate was 6.64, ranging from 6.07 to 7.59 across age groups. The two-subtest short form reliability was an average of .94, with a range of .91 to .95. The standard error of measurement was an average of 3.64, ranging from 3.25 to 4.4 across age groups.

The CVLT consists of two 16-word shopping lists. The subject is asked to freely recall as many shopping items as possible over the course of five repeated learning trials immediately after they are read the list (List A, or the Monday list). Consistent with standardized instructions, the shopping items are read at the rate of one per second. Each list contains 4 words from each of 4 categories (e.g., tools, fruits, etc.). A trial is then introduced where the instructions are the same, but a different list (List B, the Tuesday list, or the "interference list") is read to the subject. The subject is then asked to freely recall as many of the List A words as possible. Short-delay category-cued recall follows, e.g., "what were the spices and herbs from the first list?" Twenty minutes after these short-delay trials, long-delay free recall, long-delay cued recall, and long-delay recognition of List A items are tested from a list of the 16 original items plus 28 non-list distracter items. The long-delay recognition trial utilizes a "yes" or "no", forced choice format, and concludes the CVLT testing. CVLT results were scored using the test's scoring software (Fridlund & Delis, 1987).

The CVLT has been found to have acceptable test-retest reliability for a learning across trials test ($\underline{r}$ = .59 for the Total Recall score after one year, with a range from .12 to .79 in the 18 indices studied, 13 of which were statistically significant; Delis et al, 1987). The alternate-form reliability coefficients, as expected, were higher ($\underline{r}$ = .84 for the Total Recall score, with a range from .05 to .84 on the 19 indices studied, 16 of which were statistically significant; Delis et al, 1991).

The validity of the CVLT has been demonstrated with multiple clinical populations through the use of factor analysis, correlational analysis, and corroboration of findings consistent with previous learning and memory characteristics of specific well-defined clinical groups known to have characteristic patterns of performance on memory tests. Factor-analytic studies have resulted in the production of five and six-factor solutions (Delis et al, 1988, Wilde & Boake, 1993). The theoretically meaningful factors consonant with experimental constructs contributing to CVLT performance in 399 CVLT standardization sample subjects were termed General Verbal Learning, Response Discrimination, Learning Strategy, Proactive Effect, Serial Position Effect, and Acquisition Rate. In a group of 113 neurological subjects, a five-factor solution was generated which resembled the non-neurological groups' performance with the exception that the Acquisition Rate factor was not produced. These multiple factors contributing to CVLT performance contrast with one general learning factor and one general attention factor as has been frequently reported with other memory batteries (e.g., the WMS and WMS-R; Delis et al, 1988), and is therefore recognized as an improvement in delineating the specific nature of learning and memory difficulties within individuals and across patient groups.

A correlational study using 52 subjects composed of 20 age-residualized WMS-R indices and 23 age-residualized CVLT indices found that 74% (341 of 460) of the resulting correlations were significant at the .01 level, with approximately five correlations expected to be significant by chance (Delis et al, 1988). As expected, CVLT indices reflecting learning style and error types manifested less robust intercorrelations, representing and consistent with clinically relevant dimensions of learning and memory not measured by the WMS-R or other memory tests (Delis et al, 1988).

The RVDLT is a visual-figural learning and memory test in which the subject is asked to draw from memory a series of 15 simple geometric configurations immediately after they are presented sequentially at the rate of two seconds each. After five learning trials, recognition memory is tested by asking the subject to identify the 15 designs from an array of 30 designs. The only appropriate data available with respect to reliability and validity for this test is produced by Spreen & Strauss (1991). They found that the RVDLT has an acceptable test-retest reliability for a learning across trials test ($\underline{r} = .45$). This low but statistically significant reliability coefficient is not unexpected when practice effects are taken into account. Indeed, the normals gained an average of 12 recalled items on the second administration. Also, performance on the recognition trial did not decrease with age as it did on the recall trials, which is consistent with other similar memory research (Kramer et al, 1989).

The Purdue Pegboard was administered as a measure of speeded distal motor coordination. This test consists of placing pegs in a board as rapidly as possible for a duration of 60 seconds, using one hand at a time. Time was recorded at the 30-second half point as well as the 60-second end point; two trials were given to elicit a subject's best performance. The best 30-second time of the four total trials was used for the database. Test-retest reliability over three trials in 60 college students was found to be acceptable (.86 and .85 for the right and left hand, respectively) by Tiffin & Asher (1948). Performance on this test has not been significantly correlated with educational level (r = .11) and is only mildly correlated with age (r = .-39; Costa, Vaughan, Levita, & Farber, 1963). Costa et al. (1963) were able to predict the presence of brain lesions with 90% accuracy using the Purdue Pegboard test, although prediction of laterality of lesion (70%) was less robust. Cross-validational studies of the ability of the Purdue Pegboard to predict the presence and laterality of lesions fell to 89% and 60%, respectively (Costa et al, 1963). However, these studies were conducted before the use of neuroradiological diagnostic techniques were available to help pinpoint the exact location of lesions. Additionally, the importance of the potential distance effects ("diaschisis") or time since onset of lesion was not reported, factors which may directly affect motor performance.

Procedure

The twenty-two college students with confirmable diagnoses of specific learning disabilities (LD) from Western Michigan University (WMU) and West Virginia University (WVU) were solicited for voluntary participation through the WMU Disabled Student Services and Resources department, the WMU Academic Skills Center, WMU and WVU classrooms, and the WVU Disability Services office. Participants were recruited via newsletter announcements, postings at the WMU

Academic Skills Center, classroom recruitment, and through direct referrals from Director's of these departments. They were paid five dollars for their participation. Confirmation of learning disability in this group was obtained by the Directors of these respective departments, after informed consent from the student was obtained. The specific subtypes of learning disability were recorded (classified as language-based, non-verbal, or mixed), but not used as selection criteria. Learning disabled students were told explicitly that this testing was not to be considered an LD evaluation.

Twenty-two non-learning disabled adult students were solicited for participation via classroom recruitment and departmental postings, through which they were able to receive extra credit. In accordance with ethical standards, these students had opportunities other than participation in this research to earn extra credit. A lottery for three cash prizes of 75, 50, and 25 dollars was drawn and awarded to 3 of the grand total of 51 participants after data collection was complete.

After informed consent was obtained (Appendix A), the CVLT, RVDLT, Vocabulary, Block Design, and Purdue Pegboard Test were individually administered sequentially in a single session. CVLT responses were tape recorded in some instances to ensure accurate and complete documentation of all the subjects responses. Otherwise, the tests were administered according to standardized instructions, with one exception: the RVDLT was administered and scored according to a modification of the standardized protocol described by Spreen & Strauss (1991). First, subjects were asked to copy (draw) the square, triangle, and cross from the Reitan-Indiana Aphasia Screening Test (1981) stimulus booklet on a piece of blank paper before the RVDLT was administered, to rule out the possibility of graphomotor/visuoconstructional impairments which could lead to spuriously poor performance on the RVDLT. Second, a separate series ("Series B") of 15 designs was presented sequentially for two seconds each after the fifth trial of the first series ("Series A"). Instructions to reproduce the Series B designs was identical to the initial ("Series A") instructions. These 15 designs were taken from the RVDLT recognition trial stimulus array. This modification is analogous to the CVLT procedure of presenting a Tuesday shopping list. Third, a short-delay free-recall trial was added after the Series B recall trial. Fourth, a 20 minute delayed free-recall trial was added, in which the subject was asked to draw as many of the designs from Series A as they could freely recall. Finally, after the recognition trial, the subject was presented three of the visual design stimulus cards one at a time and asked to point out the identical design on the stimulus array board previously used for recognition testing. This matching to sample procedure was used to ensure that the subjects had the requisite visual-perceptual form discrimination capability to perform the reproduction and recognition trials of the task adequately.

The testing was conducted either by a doctoral-level student or a trained upper-level undergraduate student who served as a research assistant. Specifically, 34 (77%) of the subjects were administered the tests by the doctoral-level student and the remaining 10 (23%) subjects were run by the research assistant. To rule out possible effects of examiner bias or drift in administration, reliability was investigated through the use of multiple videotapings of testing sessions. Three pilot subjects were administered the entire battery of tests, and the tapes were observed by a licensed psychologist practicing in neuropsychology for consistency with standardized protocol. After approval from the neuropsychologist was obtained to proceed with the study subjects, an additional six random, unannounced sessions were videotaped, three of each examiner, and the resulting videotapes were examined by the same neuropsychologist and judged to be consistent with standardized protocol. To examine the possible effects of examiner bias or drift in scoring, multiple two-tailed unpaired t-test comparisons between examiners on the 17 dependent measures obtained were conducted. None of these comparisons were found to be significant at the .05 level. It should also be noted that 10 of the 17 indices were computer-scored by the CVLT scoring software.

After all testing was completed, demographic information and a brief neurological history were taken (Appendix B). Demographic information recorded included handedness, age, sex, race/ethnicity, socioeconomic status (upper class, upper middle class, middle class, lower middle class, or lower class), years of education, major, self-reported GPA, and employment status. History of stroke, head injury/disease, loss of consciousness, seizures, and/or learning disability were recorded as a brief screen for possible competing etiologies of decreased test performance. Several portions of the demographic information (e.g., socioeconomic status) were recorded in compliance with "Minimum Standards for the Description of Participants in Learning Disabilities Research" guidelines set forth by the CLD Research Committee (CLD Research Committee, 1993). An open-ended question asking subjects to describe what strategy, if any, they utilized to help them memorize the stimuli on the CVLT and RVDLT was utilized in order to garner a qualitative analysis of the learning styles of each group. Specifically, they were asked two separate questions, one pertaining to each learning test (CVLT & RVDLT). The question posed was "What type of strategy, if any, did you use to help you remember the shopping items/designs?" The question was clarified for a few individuals who did not understand; however, most subjects gave their perception of how they learned the items quite readily. Their responses were recorded verbatim.

Data Analysis

Missing data from five of the subjects (Block Design - 3, Purdue Pegboard - 1, RVDLT Recognition Hits and False Positives - 1) were recoded by replacing the missing value with the mean score from the sample obtained for that value. A multiple one-way ANOVA statistical design was utilized to compare group performances on selected measures of the CVLT and RVDLT as well as the Purdue Pegboard test. An ANCOVA was also utilized to investigate the possible effects of speeded visuoconstructional ability on RVDLT performance, using the Block Design subtest raw score as the covariate. Separate 2 x 5 repeated-measure ANOVA's were also conducted between groups and across the five learning trials for the CVLT and the RVDLT. CVLT and RVDLT learning trials by group were also graphically depicted through the use of line charts. A qualitative analysis was conducted on subjects' verbal descriptions of their self-reported CVLT and RVDLT learning strategies by grouping their descriptions into similar categories and then conducting a frequency count of these categories. Finally, a comparative analysis of the CVLT and RVDLT was conducted by computing 252 intercorrelations using the multiple indices generated from each test and constructing a correlation table.

CHAPTER IV

RESULTS

Auditory-Verbal Learning and Memory as Measured by the CVLT

Observational analysis of the CVLT data revealed no outliers. The database with regard to CVLT indices was complete, although self-described learning strategies were not collected from 23 of the subjects due to examiner oversight. To evaluate the potential contribution of estimated general verbal intelligence as measured by the WAIS-R Vocabulary score on CVLT performance via the CVLT Total Recall score, a Pearson-Product Moment correlation was calculated and found to be non-significant ($r = .05$, $p < .75$). The influence of academic achievement on CVLT learning was ruled out by running a Pearson Product-Moment correlation between GPA and the CVLT Total Recall score. The correlation obtained was not significant ($r = .071$, $p = .62$).

A series of one-way ANOVA's was then conducted on 10 selected CVLT indices hypothesized to demonstrate differences in LD populations (Trial #1-5 Total Recall, Trial #5 Recall, list B recall verses list A Trial #1 recall, recall consistency index, number of perseverations, number of intrusions, long delay free recall, long delay cued recall, long delay free recall compared to short delay recall/"savings", and recognition hits). Due to the number of comparisons (10) performed, a corrected .005 level of significance (.05/10) was used for a family-wise alpha of .05. The results of these analyses are presented in Table 3. The LD group demonstrated considerable inefficiency on the recall consistency index and committed more intrusion errors. An unexpected trend was also observed in which the LD subjects were less affected by the potential interference effects of List A on List B recall, as measured by the numerical percentage of change in recall from Trial 1 of List A to List B recall.

Table 3

Mean CVLT Performances on Selected Indices in LD and Non-LD Populations

	LD (n = 22)	Non-LD (n = 22)	ANOVA
Trials 1-5	55.27 (8.65)	57.05 (7.73)	$F = .51$; $p = .4774$
Trial #5	12.64 (2.26)	13.41 (2.17)	$F = 1.34$; $p = .2542$
Consistency (%)	52 (40.14)	85.27 (7.34)	$F = 15.01$; $p = .0004$
LDFR	12 (1.88)	12.73 (2.85)	$F = 1$; $p = .323$
LDCR	12.86 (1.73)	13.27 (2.14)	$F = .49$; $p = .4894$
#Perseverations	5 (3.32)	4.55 (4.35)	$F = .15$; $p = .6989$
#Intrusions	3.73 (3.18)	1.32 (2.01)	$F = 9.02$; $p = .0045$
Recognition Hits	14.82 (1.14)	15.41 (.96)	$F = 3.46$; $p = .0698$
B v. A1 (%)	10.25 (24.91)	-12.13 (26.52)	$F = 8.324$; $p = .0062$
Savings (%)	.4 (12.07)	4.75 (10.37)	$F = 1.64$; $p = .2068$

Note. LD = Learning Disabled; LDFR = Long Delay Free Recall; LDCR = Long Delay Cued Recall; B v. A1 (%) = percent change in the number of items recalled from Trial 1 of List A to List B; Savings = percent of SDFR items recalled on LDFR.

A 2 x 5 repeated-measures ANOVA across the five learning trials of List A did not show a significant main effect for group [F (1, 42) = .443, p = .51], but did show a main effect for learning across trials [F (4, 42) = 127.35, p = .0001]. The group by trial interaction was not significant [F (4,42) = 1.167, p = .33]. Therefore, multiple comparison analyses using the Scheffe's F-test procedure for both groups collapsed into one analysis were conducted. Results indicated that learning across trials began to reach asymptote around Trial 4. Specifically, significant differences ($p < .05$) were found in recall performance between Trial 1 and each of Trials 2-5 (F = 10.01, 17.43, 23.17, respectively) and between Trial 2 and each of Trials 3-5 (F =3.1, 9.216, 8.493, respectively). Although significant differences were seen between Trial 3 and Trial 5 (F = 2.71), significant differences in recall were not found between Trial 3 and Trial 4 (F = 1.03) or between Trial 4 and Trial 5 (F = .4), indicating that the subjects benefited much less from the fourth and fifth learning trials than from the first three trials.

The mean CVLT score for each of the five learning trials was calculated separately for the LD and control groups and is graphically depicted in Figure 1. Visual analysis indicated that the groups appeared to produce a similar learning curve on the CVLT, especially across Trials 1-3. The LD group appeared to reach the asymptote at the fourth trial while the control group appeared to continue to show a learning curve; however, additional trials would be necessary to confirm this interpretation due to non-definitive visual evidence that either of the groups had plateaud in their respective learning curves. Statistical analysis via multiple comparisons as explained above did suggest, however, that the groups had plateaud in their collective learning curve and that no statistically significant differences existed between the groups by learning trials.

Self-described strategies/mnemonics that subjects' used to assist learning and memory on the CVLT were recorded from 21 of the subjects, twelve of whom were from the LD group. Qualitative analysis involved grouping descriptions of learning strategies into conceptually similar sets and tabulating their frequencies. Some of the subjects listed more than one approach. A total of nine different strategies were described, and two individuals, both LD, indicated they did not use a strategy (Table 4). Interestingly, of all the strategies espoused, the most frequent was semantic clustering, which is a standard index included in the CVLT scoring system. All other strategies employed were reported relatively infrequently, often by only one or two subjects.

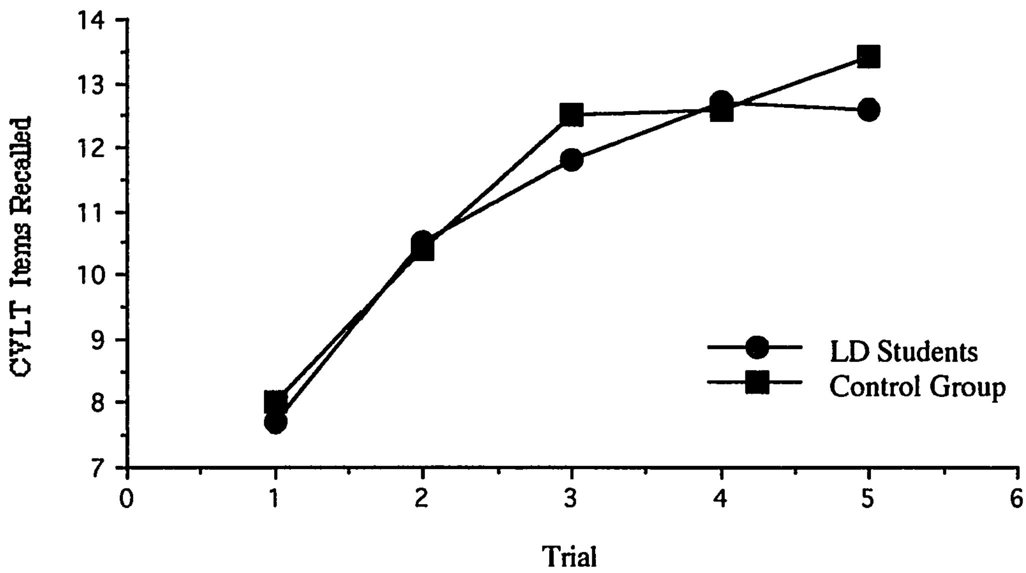

Figure 1. Trial 1-5 CVLT Performance by Group.

Visual-Figural Learning and Memory as Measured by the RVDLT

Observational analysis of the RVDLT measures revealed no outliers. None of the LD or control subjects were deficient in their performance on the matching-to-sample screen of visual perceptual ability. Since this screen used actual RVDLT stimulus material, it was concluded that any differences found in RVDLT recall performance between the groups could not be accounted for on the basis of visual-perceptual disturbance. Likewise, none of the subjects in either group were impaired on the copying task of the Reitan-Indiana Aphasia Screening Test. This provided some evidence supporting the notion that visuoconstructional deficits could not account for impaired RVDLT "recall through reconstruction" performances in either group. To double-check this interpretation, a simple correlational analysis was calculated to investigate the possible relation between speeded non-verbal visuoconstructional ability (WAIS-R Block Design subtest raw score) and non-verbal visual-figural learning via

Table 4

Frequency of Self-Described CVLT Learning Strategies

Description	LD (n = 12)	NLD (n = 9)
1. Targeted shopping items not formerly recalled	1	0
2. Counted the number of shopping items	1	0
3. Grouped by category (Semantic clustering)	4	7
4. Created visual images of shopping items	1	0
5. Silently rehearsed shopping items	1	1
6. Tried to recall in order presented	1	1
7. Wrote first letter of shopping item with finger	1	0
8. Pictured shopping items in store aisles	0	1
9. Pictured items in visual quadrants	0	1
10. No strategy used/reported	2	0

Note. LD = Learning Disabled; NLD = Non-Learning Disabled.

reconstruction (RVDLT Total Recall score). Results indicated that the two indices were significantly correlated (r =.395, p = .008), with Block Design scores accounting for 15.6% of the variance in the RVDLT Total Recall scores. To assess whether the LD and control groups were differentially affected by their respective speeded non-verbal visuoconstructional abilities on their RVDLT performances, a one-way ANCOVA between groups with WAIS-R Block Design as the covariate was conducted on the RVDLT Total Recall score. No main effect for between group differences was found

[F (1, 40) = .23, p = .64]; however, the expected main effect for Block Design scores was significant [F (1, 40) = 6.63, p = .01], once again suggesting that speeded non-verbal visual-motor ability contributed to the RVDLT learning scores. No interaction between experimental group and WAIS-R Block Design scores was demonstrated [F (1, 40) = .04, p = .85], suggesting that the groups were equally influenced by their speeded non-verbal visual-motor ability in their RVDLT Total Recall performance. Therefore, the remaining analyses were conducted without the use of WAIS-R Block Design scores as a covariate. Finally, the influence of academic achievement on RVDLT learning was ruled out by running a Pearson Product-Moment correlation between GPA and the RVDLT Total Recall score. The correlation obtained was not significant (r = .009, p = .95).

Multiple one-way ANOVA's were conducted on several selected RVDLT measures that represented significant constructs in LD analysis and figural learning/memory research and theory (Trial #5, long-delay free recall, reversals/rotations, total errors and intrusions reproduced across trials, recognition hits). The results are presented in Table 5. Due to the number of comparisons (5) performed, a corrected .01 level of significance (.05/5) was used for a family-wise alpha of .05. Two of the comparisons were significant at the .01 level. Individuals in the LD group produced significantly less correct responses by the fifth trial of the RVDLT, and also produced fewer correct responses on the long-delay free recall trial. They also showed a strong trend towards producing significantly more total errors in their reconstructions than the non-LD group, including a greater number of reversals and rotations.

A 2 x 5 repeated-measures ANOVA across the five RVDLT learning trials revealed a trend towards a significant main effect for group [F (1, 42) = 3.27,

p = .078] and a significant main effect for trials [F (4, 42) = 138.1, p = .0001]. The group by trial interaction was significant [F (4, 42) = 3.585, p = .008]. Graphical representation of the separate groups performances is depicted in Figure 2. The two groups appeared to show similar learning curves, although the control groups' recall was slightly higher across the learning trials.

Table 5

Mean RVDLT Performances on Selected Indices in LD and Non-LD Populations

	LD (n = 22)	Non-LD (n = 22)	ANOVA
Trial #5	10.23 (2.74)	12.05 (1.73)	F = 6.92; p = .01
LDFR	9.5 (2.69)	11.41 (2.25)	F = 6.93; p = .01
Recognition Hits	13 (1.51)	13.62 (1.28)	F = 2.09; p = .15
Reversals/Rotations	11.32 (8.64)	7 (5.77)	F = 3.8; p = .05
Total Errors	23.68 (12.31)	15.86 (9.54)	F = 5.54; p = .02

Note. LD = Learning Disabled; LDFR = Long Delay Free Recall.

To evaluate the significant learning effect across trials, the RVDLT scores from both groups were calculated separately and multiple comparison analyses using the Scheffe's F-test procedure were conducted. As with the CVLT, the asymptote was approached at Trial 4 of the RVDLT. Significant differences (p < .05) in the LD groups' recall performance were revealed between Trial 1 and each of Trials 2-5 (F = 6.523, 17.224, 32.413, and 35.513, respectively), Trial 2 and each of Trials 3-5 (F = 2.548, 9.855, and 11.596, respectively), and Trial 3 and Trial 5 (F = 3.273). Differences between Trial 3 and Trial 4 (F = 2.381) or between Trials 4 and 5

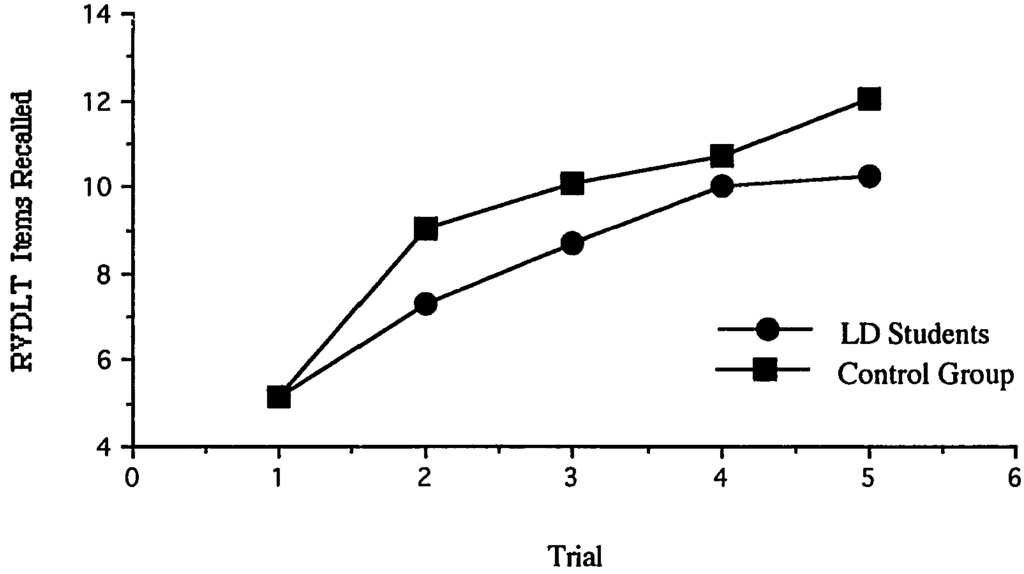

Figure 2. Trial 1-5 RVDLT Performance by Group.

(F = .071) were not significant at the .05 level. In the control group, significant differences at the .05 level were revealed between Trial 1 and each of Trials 2-5 (F = 28.056, 44.458, 56.853, and 88.539, respectively), Trial 2 and each of Trials 4-5 (F = 5.033 and 16.915), Trial 3 and Trial 5 (F = 7.518) and Trial 4 and Trial 5 (F = 3.495). Significant differences were not found between Trial 2 and Trial 3 (F = 1.879) or Trial 3 and Trial 4 (F = .761). Thus, the control subjects continued to learn with the presentation of the fifth learning trial, whereas the LD subjects learning curve began to flatten by the fifth learning trial.

The self-described strategies/mnemonics that subjects' used to assist learning and memory on the RVDLT were recorded in 21 of the subjects, twelve of whom were LD. Qualitative analysis involved grouping descriptions of learning strategies into conceptually similar sets and tabulating their frequencies. Some of the subjects listed more than one approach. A total of seven different strategies were described, and two individuals, both LD, indicated they did not use a strategy (Table 6). Interestingly, of all the strategies espoused, the most frequent was similar to the semantic clustering strategy often used with verbal material. Eight subjects reported that they clustered or grouped the designs by figurally similar geometric elements, e.g., all of the designs that contained a line, all of the designs that contained a circle, etc. Also common was the use of pictorial-verbal labels, whereby subjects recalled the designs by describing what they looked like, e.g., a house, a hat, a pyramid, an eye, etc. All other strategies employed were reported relatively infrequently, often by only one or two subjects.

Table 6

Frequency of Self-Described RVDLT Learning Strategies

Description	LD (n = 12)	NLD (n = 9)
1. Targeted designs not formerly recalled	1	1
2. Counted the number of designs	1	0
3. Grouped by figurally similar elements (lines, etc.)	4	4
4. Visualized the designs	1	0
5. Assigned pictorial-verbal labels	3	2
6. Verbally described configuration	0	1
7. Tried to recall in order presented	1	0
8. No strategy used/reported	2	0

Note. LD = Learning Disabled; NLD = Non-Learning Disabled.

Intercorrelational Analysis of the CVLT and RVDLT

To investigate the convergent and divergent properties of auditory-verbal versus visual-figural learning and memory as measured by the CVLT and RVDLT respectively, a correlational analysis using data from all 51 subjects was conducted using 21 CVLT indices (List A total recall, List A Trial 1 Recall, List A Trial 5 recall, recall consistency, semantic clustering index, serial clustering index, List B recall, short delay free recall, long delay free recall, learning slope, short delay cued recall, long delay cued recall, total number of perseverations, total number of intrusions, recognition hits, recognition discriminability, false positives, List B recall vs. List A Trial 1 recall, short delay free recall vs. Trial 5 recall, and recognition hits compared to long delay free recall) and 12 indices from the RVDLT (Trials 1, 5, and total recall across the five trials of Series A, recall of Series B, Series A short delay recall, Series A long delay recall, recognition hits, false positives, number of reversals/rotations, number of confabulations, number of intrusions, and total number of errors). Due to the large number of comparisons performed (252), a two-tailed .02 significance level was used. At this level, approximately five correlations would be expected to be significant by chance (252 x .02 = 5.04).

The correlation table for CVLT and RVDLT indices is presented in Table 7. A total of 32 (13%) of the correlations were significant at the .02 level. Virtually all of the significant correlations were low to moderate (range = -.327 - .463). The highest correlation was between the CVLT and the RVDLT long-delay free recall scores ($\underline{r}$ =.463). These long-delay free recall scores also produced a higher number of significant intercorrelations than any of the measures used on either test. Eight CVLT indices correlated significantly with the RVDLT long delay recall measure, and six of the RVDLT measures correlated significantly with the long delay free recall measure of the CVLT. The total recall trials 1-5 score for both tests also produced a relatively high number of correlations, resulting in five significant correlations on the RVDLT and four significant correlations on the CVLT. Unexpectedly, the CVLT short delay cued recall score significantly correlated with seven of the RVDLT variables.

Table 7

Intercorrelations Between Selected CVLT and RVDLT Variables

RVDLT Variables	CVLT Variables						
	Trial 1	Trial 5	Total Recall	List B	SDFR	SDCR	False Positives
Trial 1	.097	.305	.329*	.079	.297	.328*	.011
Trial 5	.279	.257	.265	-.004	.302	.401*	.125
Total Recall	.239	.291	.347*	-.008	.345*	.405*	.073
Series B	.26	.202	.324	-.16	.284	.34*	.108
SDFR	.203	.247	.218	-.207	.266	.296	.295
LDFR	.291	.341*	.327*	-.116	.368*	.457*	-.223
Recognition	.239	.389*	.382*	.02	.382*	.417*	.025
False Positives	-.019	-.162	-.111	.021	-.194	-.356*	.062
Rotations	-.228	-.222	-.095	-.011	-.191	-.256	.169
Confabulations	.134	-.012	-.017	.232	-.078	-.048	.022
Intrusions	.227	0	.153	.179	-.074	-.062	.131
Total Errors	-.035	-.152	-.062	.169	-.184	-.203	.134

Table 7 - Continued

RVDLT Variables	CVLT Variables						
	LDFR	LDCR	Slope	Perseverations	Intrusions	Recognition	Discrim.
Trial 1	.265	.291	.219	.156	.021	.189	.102
Trial 5	.344*	.305	.14	.232	.106	.054	.128
Total Recall	.353*	.33*	.152	.23	.105	.162	.148
List B	.347*	.365*	.002	.204	.085	.134	.157
SDFR	.308	.188	.166	-.062	.035	.093	.275
LDFR	.463*	.362	.201	.145	.055	.147	.26
Recognition	.384*	.341*	.21	-.022	-.098	.253	.151
False Positives	-.25	-.152	-.156	.031	.018	.088	.011
Rotations	-.327*	-.217	-.099	-.124	.029	.007	-.125
Confabulations	-.038	.004	-.206	-.059	.054	-.042	-.04
Intrusions	-.122	.017	-.19	.213	.127	.043	-.075
Total Errors	-.247	-.136	-.223	-.105	.066	-.021	-.144

Table 7 - Continued

RVDLT Variables	CVLT Variables						
	B - A1	Savings	Semantic	Serial	Consistency	SD - A5	Hits - LD
Trial 1	-.014	-.04	.337*	-.158	-.039	-.065	-.215
Trial 5	-.389*	.067	.03	-.149	.029	-.021	-.316
Total Recall	-.307	.014	.205	-.151	.053	-.002	-.295
List B	-.3	.077	.251	-.242	.053	.143	-.283
SDFR	-.445*	.106	.012	-.098	.205	-.069	-.265
LDFR	-.463*	.167	.111	-.165	.17	-.04	-.415*
Recognition	-.295	-.031	.208	-.208	.057	-.008	-.259
False Positives	.196	-.082	-.165	.106	-.093	-.011	.288
Rotations	.225	-.267	-.136	.193	.121	.07	.345*
Confabulations	.24	.048	.076	-.145	.018	-.054	.017
Intrusions	-.006	-.115	.065	.116	-.252	-.1	.146
Total Errors	.313	-.147	-.029	.031	.071	-.208	.245

Note. CVLT = California Verbal Learning Test; RVDLT = Rey Visual Design Learning Test; SDFR = Short Delay Free Recall; SDCR = Short Delay Cued Recall; LDFR = Long Delay Free Recall; LDCR = Long Delay Cued Recall; Discrim. = Recognition Discriminability; B - A1 = % change from Trial 1 List A to List B; SD - A5 = % change from Trial 5 List A to SDFR; Hits - LD = % change from LDFR to Recognition.

* $p < .02$

Of the 32 significant correlations, 29 were related to the correct number of items recalled on both tests, while only three were related to error type. Of these three, two were negative correlations between error type on the RVDLT and number of correctly recalled items on the CVLT. The remaining correlation was a positive correlation between number of reversals/rotations on the RVDLT and percent improvement from long delay free recall to recognition hits on the CVLT.

Speeded Unilateral Distal Motor Coordination

A pair of one-way ANOVA's was conducted to compare the Purdue Pegboard - Dominant Hand and Purdue Pegboard - Non-dominant Hand performance between groups. Observational analysis revealed no significant outliers. Results revealed a significant difference between groups on the unilateral dominant hand performance, with the non-LD control group (M = 17.86, SD = 1.32) outperforming the LD group (M = 16.54, SD = 1.87) on this measure (F = 7.2, p =.0105). Non-dominant hand performance approached significance (F = 3.27, p=.0778), with the non-LD group showing a trend towards more speeded performance (M = 16.41, SD = 1.26) compared to the LD group (M = 15.59, SD = 1.71).

CHAPTER V

DISCUSSION

The results of this study suggest that the CVLT, RVDLT, and the Purdue Pegboard are sensitive measures to the presence of LD in college student populations. Specifically, the LD group committed more intrusion errors and had poorer recall consistency on the CVLT, recalled fewer designs by the fifth trial and long delay recall trial while committing more errors of commission on the RVDLT, and were significantly slower on the Purdue Pegboard task. The findings are considered robust in light of the modest sample size used, the number of comparisons conducted which resulted in stringent alpha levels of statistical significance, and the use of well matched controls. In addition, the sample of LD adults used in this study were decidedly high-level LD subjects, not only by virtue of the fact they were attending college but that they were succeeding, with an average GPA of 2.65 after an average of three years of college. It could therefore be argued that this LD group represented the "cream of the crop" from an academic standpoint of those individuals with LD, and that additional significant findings as well as stronger effect sizes may be found in a non-college adult LD sample.

Unexpectedly, the differences in CVLT performance by the LD group did not take the form of decreased learning and memory through recall performance; indeed, the two groups performed similarly on measures of long-delay free and cued recall, as well as recognition memory. It appears that at this level of educational achievement, these students were able to overcome their learning difficulties to achieve adequate performance on the CVLT. However, significant inefficiencies were seen in their learning styles. Specifically, the LD group exhibited a less well maintained learning strategy resulting in a lower consistency of recalling the same items from one trial to the next, and generated more intrusion (non-list) errors than their non-learning disabled counterparts. This finding provides validational evidence for a process approach to neuropsychological assessment, as the differences found in the LD group may not have been detected if only the traditional end-product (i.e., recall) measures typically collected were reported.

That percent recall consistency was much lower in the LD group was not surprising given the common theoretical position (Torgesen, 1980; as cited in Sattler, 1988) that the major inefficiency in persons with learning disabilities is a decreased ability to analyze tasks in such a way that will lead to the best performance strategy. Delis et al (1987) state that the recall consistency measure reflects a haphazard or disorganized style of learning suggestive of difficulty formulating or maintaining a learning plan. Similarly, Luria (1981; as cited in Delis et al., 1987) speculated that recall inconsistency was attributable to "an inability to retain the plan of memorizing" (p. 20).

Torgesen (1980, as cited in Sattler, 1988) posited three possible explanations derived from an information processing perspective for the inefficient use of active strategies in LD individuals: (1) verbal language processing difficulties which limit the speed and capacity for processing linguistic information, (2) the development of strategy use in these individuals is slower, and (3) LD children come to school unprepared to assume the role of an active, organized learner. A general linguistic processing deficit may have played a role in the deficient recall consistency found in this study, and also fits well with the finding of a higher number of intrusion errors, which reflects problems in discriminating relevant from irrelevant responses in their semantic store. The second possibility cited by Torgensen is a less likely explanation for the current findings if inferred to represent a developmental-lag hypothesis, as the average age of the LD group was 27 years old. However, if taken to mean an inherent or constitutional limitation whereby the LD student is slow in developing and employing a strategy on each new occasion in which it is appropriate to do so, the delayed strategy use hypothesis fits the recall inconsistency finding well. Despite the repeated opportunities to formulate and employ a consistent learning strategy on the CVLT, the LD group failed to do so. The educational history of the subjects used in this study would appear to provide enough reason to rule out the latter possibility, since all subjects were college students who continued to have learning difficulties despite receiving instructional study skills assistance through their respective University departments that service LD students. Once again, however, Torgensen's third explanatory offering may simply represent a reiteration of the more general neurological limitation in LD individuals.

Total number of intrusion errors of non-list items was also greater for the LD group. A high number of intrusion errors is probable in individuals who posses adequate speech and verbal output capabilities but have limited capacity to learn new information beyond their span of apprehension, especially when required to retrieve such information after a delay. These mistakes in learning are common in Alzheimer's and Korsakoff's patients (Delis et al, 1987), and Luria (1981) found this problem to be prominent in his amnestic, especially those with frontal lobe pathology, patients. All of these diagnostic groups demonstrate cortical rather than subcortical based deficits, which is consistent with cortical abnormalities found in dyslexic adults (Bigler, 1992). However, from a neuropsychological standpoint, aberrant subcortical connections to frontal structures may also mimic "frontal" or executive-level dysfunction. Keeping this point in mind, the two CVLT indices in which the LD group performed most poorly may represent executive-level dysfunction. Decreased organizational activity resulting in recall inconsistency and poor response discrimination (manifested by intrusion errors) are common findings in patients with executive level dysfunction.

An equally feasible neuropsychological explanation would support a left-hemisphere semantic processing deficit, which is also an obviously necessary component to efficient verbal learning. Given that cytoarchitectronic abnormalities as well as abnormalities discovered on neuroimaging have been consistently found in the peri-Sylvian regions of the left hemisphere in dyslexic individuals (Bigler, 1992), this latter hypothesis appears to have greater neuroanatomical support. One half of the college students in this LD group had a verbally-based LD, and further subtype-specific research would help to clarify this issue.

The findings obtained in this study did not replicate the findings described in the only previous study using the CVLT (a 12-item children's version) in LD populations, which found significantly lower List A Total Recall Trials 1-5 scores, significantly fewer items recalled on the Short and Long Delayed Cued Recall trials, and higher perseverative (self-repetition) errors in language-impaired children when compared to normal controls. Several factors may account for this lack of index-specific cross-validation. Perhaps most important, Schear et al (1992) exclusively used subjects with "language impairment", or verbally based LD's, rather than an LD group heterogeneous with respect to subtype. The language impairment certainly contributed to decreased verbal recall in these subjects and is consistent with a body of literature documenting the effects of dyslexia on verbal learning and memory (e.g., Fletcher, 1985). For this reason, the heterogeneity of the current sample which included five students with non-verbal learning disabilities as well as six students with mixed learning disabilities likely resulted in fewer significant findings with respect to verbal learning and memory. Also, Schear et al used children with an average age of eight and a half years in their study; thus developmental delays may have been a factor in their performance. On the other hand, the current study used subjects that were primarily in their mid-20's, well past the age considered for completion of language development. As with other clinical entities, learning disabilities exist along a continuum of severity, and the current sample consisted of college students, an endeavor not pursued by a large portion of LD individuals due to the severity of their academic limitations.

Unexpectedly, the control group actually showed a trend towards a greater degree of proactive interference from the effects of learning List A on their List B recall performance. This finding was significant at the .006 level and was a strong noteworthy trend despite not meeting the Bonferroni-adjusted .005 level of significance. Observation of the means between the groups on this measure revealed a clinically significant discrepancy, as the LD group recalled an average of 10% more words on the List B recall than on List A Trial 1 recall, compared to the control group who recalled an average of 12% fewer items on List B than their List A Trial 1 recall. This finding may best be considered in the context of a greater number of intrusions and decreased recall consistency in the LD group. It is likely that the interference effect was not seen in the LD group because they used a less active, more haphazard strategy (if any at all, which was the case with two of these subjects) with which to be "interfered"; that is, the interference effect did not occur because there was less organizational information to be interfered with in the LD group. The control group showed a mild interference effect, which is generally expected in normal individuals, and suggests that the more active learning strategy and its accompanying demand on processing capacity represented a cognitive process disrupted by the presentation of a new list. Unfortunately, the CVLT developers did not report norms for this measure.

Qualitative analysis of self-described learning strategies on the CVLT supported the efforts of experimental cognitive psychology research and the inclusion of a semantic clustering index on the CVLT, while providing little support for measurement of other learning strategies due to their low frequencies. However, there are several caveats in the interpretation of these self-reported strategies. The use of cued recall conditions in the CVLT, which results in the provision of semantic clusters or category descriptions, may have affected subjects' perceptions of how they initially learned the list. In addition, subjects may have differed in their ability to articulate their learning strategies, and some may have been unaware of the nuances of their own learning processes, perhaps due to the "automaticity" of the process. The LD group also described a greater number of active CVLT and RVDLT learning strategies than the control group, likely the result of increased awareness of a need for efficient and novel learning strategies.

Because the CVLT demonstrated sensitivity to LD in this study, and has demonstrated its validity with multiple other clinical groups, including LD children (Schear et al , 1992), it appears the CVLT is a useful instrument in the assessment of adults with learning disabilities as well. Furthermore, the CVLT can provide useful information for individualized instruction by delineating each individuals learning style and error types. The multiple measures derived from the CVLT should be useful when describing a students strengths and weaknesses in learning and retaining new verbal information across time, and suggestions for improving learning styles, the formation of active learning strategies, and most effective teaching styles for these students can be made based on CVLT patterns of performance.

The RVDLT demonstrated greater sensitivity to actual recall performance than did the CVLT in this heterogeneous LD group. This was true despite having a larger number of verbally-based than non-verbally based LD individuals in the group, and could not be attributed to differences in visuoconstructional ability. The LD students produced significantly fewer configurations by the fifth learning trial of the RVDLT and freely recalled significantly fewer configurations after the 20 minute delay. Thus, while this LD group could compensate for their learning inefficiencies on the CVLT and deliver an adequate performance, they were unable to do so on the RVDLT. Clearly, the CVLT is much closer to the everyday verbal memorization necessary to succeed in college, whereby the RVDLT represents a more novel task. This novelty requires that the examinee formulate and employ a new or less common, less rehearsed mnemonic strategy, tapping a more "fluid" learning ability, again supporting the theoretical rationale of ineffective learning strategy use as a common denominator for LD individuals.

The LD group also showed a strong trend towards producing significantly more erroneous reproductions of the RVDLT configurations across the learning and delayed recall trials. This finding appeared to be a visual-figural analog to the finding of increased intrusion errors in the LD group on the CVLT. A sizable portion of these erroneous reproductions were manifested by reversals of the configurations and rotations of the individual geometric shapes comprising the configurations. This finding is not inconsistent with the manifestation of letter and word reversals dyslexic individuals commonly exhibit. Poor spatial relations is also a prominent feature of non-verbal learning disabilities. Overall the RVDLT demonstrated adequate sensitivity to non-verbal visual-figural learning problems in this group of college students with LD and appears to be a welcome tool to the neuropsychological testing armamentarium.

The CVLT and RVDLT, with their ostensibly similar task instruction, task demand, and learning through repeated presentations procedure, essentially differing only in content or type of information to be remembered, produced several statistically significant intercorrelations. The significant intercorrelations produced were modest, likely reflecting the degree to which the samples were matched and resulting restriction of range on these multiple measures. Although 32 of the correlations were significant, 220 were not, representing a greater than expected degree of divergence. The two tests appeared to have a similar underlying factor responsible for the 32 intercorrelations produced, most likely representing a general declarative learning factor that has been found through factor-analytic studies of the CVLT and other learning and memory instruments. However, the fact that the vast majority of the intercorrelations were not significant suggests that the tests differ in some important way, which may include auditory versus visual learning ability, verbal versus figural learning ability, linguistic versus spatial processing capacity, or a combination thereof. Clearly, differing functional learning abilities are necessary to perform these separate tasks and the dissociation between auditory-verbal and visual-figural learning/memory appears to be valid. Therefore, these tests be should be used in conjunction with each other as complementary tests of declarative learning ability rather than be considered redundant measures of general learning ability.

The LD group performed significantly slower with their dominant hand on the Purdue Pegboard test, a test of manual dexterity and speeded distal motor coordination. A trend reflecting the same pattern was also observed when the groups were compared on their non-dominant hand performances. Although statistically significant differences were seen in unilateral speeded distal motor coordination with the dominant hand, observation of the data revealed that the variance exhibited by both groups coupled with the small effect size of approximately one peg per 30 seconds render this finding of little use in terms of clinical utility. However, it is consistent with a body of evidence suggesting fine-motor inefficiencies in children with learning disabilities (e.g., Kane & Gill, 1972). The theoretical implications surrounding this comorbidity are particularly relevant when considering etiological factors and localization of cerebral dysfunction in LD individuals.

Perhaps not surprisingly, the LD group had a lower self-reported GPA than the non-LD group. This finding was true despite between-group equivalence in prorated

WAIS-R intelligence and demographic similarity. Since individuals with psychiatric and neurologic histories were excluded, GPA differences between the groups cannot be accounted for on the basis of these factors. Motivational factors could theoretically result in GPA differences; however, this is a difficult construct to operationalize and measure and there is little reason to believe that the groups differed in their motivation to succeed academically. That the LD individuals attempted college despite a likely greater history of scholastic failure in the past suggests they may have had even greater motivation than the non-LD group. To clarify this issue, obtaining a measure of hours studied per week may be useful in future LD research using control subjects. The most likely interpretation is that the lower GPA reflects the academic inefficiencies typically experienced by LD individuals. Further, it provides some indirect support for the federal intelligence-achievement discrepancy definition of LD; it is also likely a reflection of the federal definition.

Due to the small number of specific LD subtypes, it was felt that comparisons between subtypes were not appropriate from a statistical standpoint. The logical next step in the evolution of validation of these instruments with regard to LD is to characterize well-defined subgroup performances and evaluate the efficacy of these instruments to reliably discriminate between LD subtypes. Practical utility of the CVLT and RVDLT in terms of their ability to contribute to individually tailored teaching approaches would be an especially worthy research avenue pertaining to "social validity" in an age where cost-effectiveness and consumer satisfaction are paramount. These results await cross-validation with a larger sample size, and future research should focus on analysis of CVLT and RVDLT performance in groups of individuals with specific LD subtypes.

Using this homogeneous population with respect to age, sex, educational level, socio-economic status, and estimated WAIS-R intelligence decreased the possibility that these factors influenced results and allowed for greater precision in interpretations, but may also be a limiting factor in making generalizations to other populations. Therefore the results obtained are most applicable to demographically similar populations, and the consistency of these findings as they apply to other groups await empirical verification. Extending this validational research to other demographic groups is therefore suggested.

Precise academic profiles of the subjects were not used to characterize the sample in this study. In particular, specific student achievement information was not collected from either the experimental or control group. However, the subjects LD subtypes and self-reported GPA's were recorded, thereby providing a greater amount of subject information than typically found in LD research (CLD Research Committee, 1993). Nevertheless, WRAT-3 (Wide Ranging Achievement Test, 3rd edition) scores may be helpful in similar research investigations in the future. Although all of the LD subjects indicated that they received psychometric testing as part of their LD evaluation, the specific type of discrepancy model or severity criterion used could not be confirmed and would have been helpful information, as these models vary by state and school district.

In closing, it is important to note that as our understanding of the nature of learning and memory in individuals with LD progresses, we are obligated to employ such knowledge for the betterment of policies, schools, and effective individualized education in general. To quote Thomas Jefferson (1743-1826), "Laws and institutions must go hand in hand with the progress of the human mind" (as cited in Peter, 1977). The same can be said for the progress of scientific knowledge.

Appendix A

Consent to Participate in Research

WESTERN MICHIGAN UNIVERSITY

DEPARTMENT OF PSYCHOLOGY

CONSENT TO PARTICIPATE IN RESEARCH

Principal Investigator: M. Michele Burnette, Ph.D.
Student Investigator: Robert K. Eckert, M.S.

I have been invited to participate in a research project designed to examine the processes measured in two recently developed tests of learning and memory. The study and what the participation will mean to me has been explained to me in language I understand. I further understand that this project is Robert K. Eckert's dissertation project.

My consent to participate in this project indicates that I will be asked to attend one two-hour individual testing session with Robert K. Eckert. I will be asked to meet Robert K. Eckert for this session at the Clinical Research Laboratory (Room 285) of Wood Hall on the campus of Western Michigan University. The session will involve answering questions concerning my medical history and I will also provide general information about myself such as my age, level of education, socioeconomic status, major, GPA, and employment status. The remainder of the session will involve taking tests of verbal and non-verbal learning and memory developed for the assessment of everyday memory function and dysfunction. This will require spoken responses to recall verbal and visual information I have been asked to remember.

As in all research, there may be unforeseen risks to the participant. If an accidental injury occurs, appropriate emergency measures will be taken; however, no compensation or treatment will be made available to me except as otherwise stated in this consent form. The known risks are no greater than the discomforts generally experienced during test-taking activities in everyday life.

I understand that my participation in the study does not guarantee any beneficial results. I also understand that others who experience learning and memory difficulties may benefit from the knowledge that is gained from this research. My name may be drawn from the list of all 60 participants for a cash prize of $50.00, $25.00, or $10.00.

I understand that all the information collected from me is anonymous. If I have been diagnosed with a learning disability in the past, I authorize Robert K. Eckert to examine my file that documents this diagnosis, and to use this information in reporting results of this research. However, my name will not appear on any papers on which this information is recorded. The test forms will all be coded with a subject number, and the only form in which my name will appear will be on the sign-up sheet, which will be destroyed after all subjects have been contacted and the lottery drawing completed. All other forms will be retained for three years in a locked file in the principal investigator's laboratory. I understand that the results may be presented at professional meetings or published in professional journals, but no names or individual data will be used.

APPENDIX A (Continued)

I understand that I may refuse to participate or quit at any time during the study without prejudice or penalty. If I have any questions or concerns about this study, I may contact either Robert K. Eckert or M. Michele Burnette, Psychology Department, Western Michigan University, Kalamazoo, Michigan, 49008, (616) 387-4489. I may also contact the Chair of Human Subjects Institutional Review Board at 387-8293 or the Vice President for Research at 387-8298 with any concerns that I have. My signature below indicates that I understand the purpose and requirements of the study and that I agree to participate.

Signature	Date
Witness	Date

Appendix B

Demographic Information and Neurological History Form

WESTERN MICHIGAN UNIVERSITY

DEPARTMENT OF PSYCHOLOGY

DEMOGRAPHIC INFORMATION AND NEUROLOGICAL HISTORY

Demographic Information: Subject Number_____

DATE TESTED: EXAMINER:
AGE: SEX:
RACE: EDUCATION:
MAJOR: GPA:
HANDEDNESS:
LEFT-HANDED RELATIVES:
BIRTH ORDER:
EMPLOYMENT:
SOCIOECONOMIC STATUS: HIGH MEDIUM LOW

Neurological History

Check for history of:
STROKE______HEAD INJURY______SEIZURES________
BRAIN DISEASE (encephalitis, tumor, etc.)________

LEARNING DISABILITY________ TYPE:____________________
METHOD USED TO DIAGNOSE:________________________________
FSIQ: VIQ: PIQ:

BLOCK DESIGN SCALED SCORE:
VOCABULARY SCALED SCORE:

Appendix C

WMU Human Subjects Institutional Review Board Approval

Human Subjects Institutional Review Board

Kalamazoo, Michigan 49008-3899
616 387-8293

78

WESTERN MICHIGAN UNIVERSITY

Date: March 22, 1994

To: Robert Eckert

From: M. Michele Burnette, Chair M. Michele Burnette

Re: HSIRB Project Number 94-03-12

This letter will serve as confirmation that your research project entitled "The California Verbal Learning Test (CVLT) and Rey-Visual Design learning Test (RVDLT): An analysis of the auditory-verbal and visual-figural learning patterns of learning disabled and non-learning disabled college students" has been approved under the full category of review by the Human Subjects Institutional Review Board. The conditions and duration of this approval are specified in the Policies of Western Michigan University. You may now begin to implement the research as described in the application.

You must seek reapproval for any changes in this design. You must also seek reapproval if the project extends beyond the termination date.

The Board wishes you success in the pursuit of your research goals.

Approval Termination: March 22, 1995

xc: Burnette, Psychology

Appendix D

WVU Human Subjects Institutional Review Board
Approval

DATE: October 21, 1994

NOTICE OF APPROVAL FOR PROTOCOL # 13044

TO: Robert Eckert/Marc Haut

PROJECT TITLE: The California Verbal Learning Test (CVLT) and Rey Visual Design Learning Test (RVDLT): An Analysis of the Auditory-Verbal and Visual-Figural Learning Patterns of College Students with Learning Disabilities

*SPONSORING AGENCY:
Western Mich. Univ. Graduate Student Research Fund

The Institutional Review Board for the Protection of Human Research Subjects (IRB) has approved the project described above. Approval was based on the descriptive material and procedures you submitted for review. Should any changes in your protocol/consent form be necessary, **prior approval must be obtained from the IRB.** Any deviations from the approved protocol, as well as any new risks, reactions, injuries or deaths of research subjects must be reported to the Board immediately.

A consent form* X is required of each subject.
___ is not required of each subject.

An assent form ___ is required of each subject.
X is not required of each subject.

A recruitment ad has X has not ___ been approved.

** Only copies of the consent and/or assent form with the IRB's approval stamp may be used with human subject research. It is the responsibility of the investigator to submit a revised consent form for the IRB's approval should funding be obtained. This stamped consent form must then be used for subjects enrolled.* A copy of each subject's signed Consent/Assent Form must be retained by the investigator and accessible to federal regulatory authorities for at least three years after the study is completed.

This protocol was first approved on 10/21/94. This research will be monitored for re-approval every 6 months.

Marian J. Turner
IRB/ACUC Administrator

304 293-7073 = FAX 304 293-7435 = 617 N. Spruce Street = MORGANTOWN WV 26506-6845
Equal Opportunity / Affirmative Action Institution

BIBLIOGRAPHY

Alessi, G. (1981). The paradox of specific learning disabilities. Michigan Association of School Psychologists Newsletter, 10(2), 3.

Anastasi, A. (1988). Psychological Testing (6th ed.). New York: MacMillan.

Aram, D.M., & Nation, J.E. (1980). Preschool language disorders and subsequent language and academic difficulties. Journal of Communication Disorders, 13, 159-170.

Authelet, A.M., & Raymond, P.M. (1987, February). Schizophrenic performance on the California Verbal Learning Test: A problem beyond attention. Paper presented at the meeting of the International Neuropsychological Society, Washington, D.C.

Beers, S.R., Goldstein, G, & Katz, L.J. (1994, November). Diferential neuropsychological effects of learning disability and mild head injury in college students. Paper presented at the National Academy of Neuropsychology convention, Orlando, FL.

Benton, A. (1974). Benton Visual Retention Test. Iowa City, Iowa: AJA Associates.

Berkelhammer, L. (1996). The specificity of phonological decoding deficits in children with dyslexia. Unpublished doctoral dissertation, University of Georgia..

Bigler, E.D. (1992). The neurobiology and neuropsychology of adult learning disorderes. Journal of Learning Disabilities, 25(8), 488-506.

Bolla-Wilson, K., & Bleeker, M.L. (1986). Influence of verbal intelligence, sex, age, and education on the Rey Auditory Verbal Learning Test. Developmental Neuropsychology, 2(3), 203-211.

Buschke, H. (1973). Selective reminding for analysis of memory and behavior. Journal of Verbal Learning and Verbal Behavior, 12, 543-550.

Butters, N. (1984). The clinical aspects of memory disorders: Contributions from experimental studies of amnesia and dementia. Journal of Clinical Neuropsychology, 6, 17-36.

Butters, N., & Cermak, L.S. (1980). Alcoholic Korsakoff's Syndrome. New York: Academic Press.

Cermak, L.S., Goldberg, J., Cermak, S., & Drake, C. (1980). The short term memory ability in children with learning disabilities. Journal of Learning Disabilities, 13, 25-29.

Chelune, G.J., & Bornstein, R.A. (1988). WMS-R patterns among patients with unilateral brain lesions. The Clinical Neuropsychologist, 2, 121-132.

Clark, F.L., Deshler, D.D., Schumker, J.B., Alley, G.R., & Warner, M.M. (1984). Visual imagery and self-questioning: Strategies to improve comprehension of written material. Journal of Learning Disabilities, 17, 145-149.

Costa, L.D., Vaughan,, H.G., Jr., Levita, E., & Farber, N. (1963). Purdue Pegboard as a predictor of the presennce and laterality of brain lesions. Journal of Consulting Psychology, 27, 133-137.

Coughlan, A., & Hollows, S. (1984). Use of memory tests in differentiating organic disorder from depression. British Journal of Psychiatry, 145, 164-167.

Council on Learning Disabilities Research Committee (1993). Minimum Standards for the Description of Participants in Learning Disabilities Research. Journal of Learning Disabilities, 26(4), 210-213.

Council on Scientific Affairs (1989). Dyslexia. Journal of the American Medical Association, 261, 2236-2239.

Crosson, B., Novack, T.A., Trenerry, M.R., & Craig, P.L. (1988). California Verbal Learning Test (CVLT) performance in severely head-injured and neurologically normal adult males. Journal of Clinical and Experimental Neuropsychology, 10(6), 754-768.

Crosson, B., Novack, T.A., Trenerry, M.R., & Craig, P.L. (1989). Differentiation of verbal memory deficits in blunt head injury using the recognition trial of the California Verbal Learning Test: An exploratory study. The Clinical Neuropsychologist, 3(1), 29-44.

Cullum, C.M., Kuck, J., Delis, D.C., Heaton, R.K., Zisook, S., & Grant, I. (1990, February). Verbal learning characteristics in schizophrenia. Paper presented at the meeting of the International Neuropsychological Society, Orlando, FL.

Delis, D.C. (1989). Neuropsychological assessment of learning and memory. In F. Boller & J. Grafman (Eds.). Handbook of Neuropsychology (Vol. 3). (pp. 3-33). San Diego: Elsevier Science Publishers.

Delis, D.C., Cullum, C.M., Butters, N., Cairns, P., & Prifitera, A. (1988). Wechsler Memory Scale-Revised and California Verbal Learning Test: Convergence and Divergence. The Clinical Neuropsychologist, 2(2), 188-196.

Delis, D.C., Freeland, J., Kramer, J., & Kaplan, E. (1988). Integrating clinical assessment with cognitive neuroscience: Construct validation of the California Verbal Learning Test. Journal of Consulting and Clinical Psychology, 56(1), 123-130.

Delis, D.C., Kramer, J., Kaplan, E., & Ober, B. (1987). California Verbal Learning Test: Research Edition. New York: The Psychological Corporation.

Delis, D.C., Masman, P.J., Butters, N., Salmon, D.P., Cermak, L.S., & Kramer, J.H. (1991). Profiles of demented and amnesic patients on the California Verbal Learning Test: Implications for the Assessment of Memory Disorders. Psychological Assessment, 3(1), 19-26.

Delis, D.C., McKee, R., Massman, P.J., Kramer, J.H., Kaplan, E., & Gettman, D. (1991). Alternate form of the California Verbal Learning Test: Development and reliability. The Clinical Neuropsychologist, 5(2), 154-162.

Duara, R., Kushch, A., Gross-Glenn, K., Barker, W.W., Jallad, B., Pascal, S., Loewenstein, D.A., Sheldon, J., Rabin, M., Levin, B., & Lubs, H. (1990). Neuroanatomic references between dyslexic and normal readers on magnetic resonance imaging scans. Archives of Neurology, 48, 410-416.

Duffy, F.H., & McAnulty, G. (1990). Neuropsychological heterogeneity and the definition of dyslexia: Preliminary evidence for plasticity. Neuropsychologia, 28, 555-571.

Dupont, R.M., Jernigan, T.L., Butters, N., Delis, D.C., Hesselink, J., Heindel, W.C., & Gillin, J.C. (1990). Subcortical abnormalities detected in bipolar affective disorder using magnetic resonance imaging: Clinical neuropsychological significance. Archives of General Psychiatry, 47, 55-59.

Epps, S., Ysseldyke, J.E., & Mcgue, B. (1984). Impact of different definitions of learning disabilities on the number of students identified. Journal of Psychoeducational Assessment, 1, 341-352.

Erickson, R.C. & Scott M.L. (1977). Clinical memory testing: A review. Psychological Bulletin, 84, 1130-1149.

Fletcher, J.M. (1985). Memory for verbal and non-verbal stimuli in learning disability subgroups: Analysis by selective reminding. Journal of Experimental Child Psychology, 40, 244-259.

Fletcher, J.M. (1992). The validity of distinguishing children with language and learning disabilities according to discrepancies with IQ: Introduction to the special series. Journal of Learning Disabilities, 25(9), 546 -548.

Fridlund, A.J., & Delis, D. (1987). The California Verbal Learning Test - Administration and Scoring System, v.1.2. San Antonio: The Psychological Corporation.

Galaburda, A.M., Sherman, G.F., Rosen, G.D., Aboitiz, F., & Geschwind, N. (1985). Developmental dyslexia: Four consecutive patients with cortical anomalies. Annals of Neurology, 18, 222-233.

Geschwind, N. & Galaburda, A.M. (1985). Cerebral lateralization: Biological mechanisms, associations, and pathology: I. A hypothesis and a program for research. Archives of Neurology, 42, 428-459.

Golden, C.J. (1981). A standardized version of Luria's neuropsychological tests. In S. Filskov & T.J. Boll. Handbook of Cinical Neuropsychology. New York: Wiley-Interscience.

Hammil, D.D., Bryant, B.R., Brown, L., Dunn, C., & Marten, A, (1989). How replicable is current research? A follow-up to the CLD Research Committee's recommendations. Learning Disability Quarterly, 12 (3), 174 - 179.

Haut, M.W., & Shutty, M.S. (1992). Patterns of verbal learning after closed head injury. Neuropsychology, 6(1), 51-58.

Heaton, R.K., & Pendleton, M.G. (1981). Use of neuropsychological tests to predict adult patient's everyday functioning. Journal of Consulting and Clinical Psychology, 49, 807-821.

Heinrichs, R.W. (1990). Current and emergent applications of neuropsychological assessment: Problems of validity and utility. Professional Psychology: Research and Practice, 21(3), 171-176.

Hermann, B.P., Wyler, A.R., Richey, E.T., & Rea, J.M. (1987). Memory function and verbal learning ability in patients with complex partial seizures of temporal lobe origin. Epilepsia, 28, 547-554.

Jernigan, T.L., Hesselink, J.R., Sowell, E., & Tallal, P.A. (1991). Cerebral structure on magnetic resonance imaging in language- and learning-impaired children. Archives of Neurology, 48, 539-545.

Kane, J., & Gill, R.P. (1972). Implications of the Purdue Pegboard as a screening device. Journal of Learning Disabilities, 547, 36-40.

Kaplan, E. (1988). A process approach to neuropsychological assessment. In T. Boll & B.K. Bryant (Eds.). Clinical neuropsychology and brain function: Research, measurement, and practice. Washington, D.C.: American Psychological Association.

Keenan, P.A., Stern, R.A., Janowsky, D.S., & Pederson, C.A. (in press). Cognition, memory, and mood state in premenstrual syndrome. Psychoneuroendocrinology.

Keogh, B.K. (1983). Classification, compliance, and confusion. Journal of Learning Disabilities, 16(1), 25.

Keogh, B.K. (1990). Definitional assumptions and research issues. In H.L. Swanson & B.K. Keogh (Eds.). Learning Disabilities: Theoretical and Research Issues. (pp. 13 - 19). Hillsdale, New Jersey: Lawrence Earlbaum Associates.

Kessler, H.R., Cohen, R.A., Lauer, K., & Kausch, D.F. (1992). The relationship between disability and memory dysfunction in multiple sclerosis. International Journal of Neuroscience, 62, 17-34.

Kibby, M.K., Schmitter-Edgecombe, M.E., & Long, C.E. (1993). The relationship between cognitive neuropsychological measures and activities of daily living. Paper presented at the 1993 National Academy of Neuropsychology convention in Phoenix, Arizona.

Kolb, B., & Whishaw, I.Q. (1991). Fundamentals of neuropsychology (3rd ed.). New York: W.H. Freeman.

Kramer, J.H., Blusewicz, M.J., & Preston, K.A. (1989). The premature aging hypothesis: Old before its time? Journal of Consulting and Clinical Psychology, 57(2), 257-262.

Kramer, J.H., & Delis, D. (1991). Interference effects on the California Verbal Learning Test: A construct validation study. Psychological Assessment, 3(2), 299-302.

Kramer, J.H., Delis, D., Blusewicz, M.J., Brandt, J., Ober, B.A., Strauss, M. (1988). Verbal memory errors in Alzheimer's and Huntington's dementias. Developmental Neuropsychology, 4(1), 1-15.

Kramer, J.H., Delis, D.C., & Daniel, M. (1988). Sex differences in verbal learning. Journal of Clinical Psychology, 44(6), 907-915.

Kramer, J.H., Levin, B.E., Brandt, J., & Delis, D. (1989). Differentiation of Alzheimer's, Huntington's, and Parkinson's disease patients on the basis of verbal learning characteristics. Neuropsychology, 3, 11-20.

Larabee, G.J., Kane, R.L., Schuck, J.R., & Francis, D.J. (1985). Construct validity of various memory testing procedures. Journal of Clinical and Experimental Neuropsychology, 7, 239-250.

Larsen, J.P., Hoien, T., Lundberg, I., & Odegaard, S. (1990). MRI evaluation of the size and symmetry of the planum temporale in adolescents with developmental dyslexia. Brain and Langauge, 39, 289-301.

Leslie, S.C., Davidson, R.J., & Batey, O.B. (1985). Purdue Pegboard performance of disabled and normal readers: Unimanual versus bimanual differences. Brain and Language, 24, 359-369.

Lezak, M. (1983). Neuropsychological Assessment (2nd ed.). New York: Oxford University Press.

Loring, D.W. (1989). The Wechsler Memory Scale-Revised, or the Wechsler Memory Scale-Revisited. The Clinical Neuropsychologist, 3, 59-69.

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

Malec, J.F., Fox, B., & DePompolo, R.W. (1988). Validity of the Rivermead Behavioral Memory Test. Archives of Physical Medicine and Rehabilitation, 69, 767. Abstract.

Malec, J.F., Ivnik, R.J., & Hinkeldey, N.S. (1991). Visual Spatial Learning Test. Psychological Assessment, 3, 82-88.

Malec, J., Zweber, B., & DePompolo, R. (1990). The Rivermead Behavioral Memory Test, laboratory neurocognitive measures, and everyday functioning. Journal of Head Trauma Rehabilitation, 5(3), 60-68.

Mangrum, C.T., & Strichart, S.S. (1988). College and the learning disabled student: Program development, implementation, and selection. Philedelphia: Grune & Stratton.

Massman, P.J., Delis, D.C., Butters, N., Levin, B.E., & Salmon, D.P. (1990). Are all subcortical dementia's alike?: Verbal memory in Parkinson's and Huntington's disease patients. Journal of Clinical and Experimental Neuropsychology, 12, 729-744.

National Joint Comittee on Learning Disabilities (NJCLD). (1989, September 18). Letter from NJCLD to member organizatioins. (Topic: Modifications to the NJCLD definition of learning disabilities).

O'Donnell, B.F. , Drachman, D.A., Lew, R.A., & Swearer, J.M. (1988). Measuring dementia: Assessment of multiple deficit domains. Journal of Clincal Psychology, 44(6), 916-923.

Orton, S. (1928). Specific reading disability: Strephosymbolia. Journal of the American Medical Association, 90, 1095-1099.

Pennington, B.F. (1991). Diagnosing Learning Disorders: A Neuropsychological Framework. New York: The Guilford Press.

Peter, L.J. (1977). Peter's Quotations: Ideas For Our Time. New York: Bantam Books.

Pope, D.M. (1990). The California Verbal Learning Test: Preliminary investigation of its usefulness with older adults. Dissertation Abstracts International, Ann Arbor, Michigan.

Privett, K., & Freeland, J. (1989). Prediction of memory performance in chronic severe closed head-injury survivors. Journal of Clinical and Experimental Neuropsychology, 11(57), Abstract.

Reitan, R.M. (1981). Reitan-Indiana Aphasia Screening Test. Reitan Neuropsychology Laboratory, Tucson, Arizona.

Roth, D.L., Conboy T.J., Reeder, K.P., & Boll, T.J. (1990). Confirmatory factor analysis of the Wechsler Memory Scale-Revised. Journal of Clinical and Experimental Neuropsychology, 12, 834-842.

Rourke, B.P. (1987). Syndrome of nonverbal learning disabilities: The final common pathway of white matter disease/dysfunction? The Clinical Neuropsychologist, 1, 209-234.

Rourke, B.P. (1988). The syndrome of nonverbal learning disabilities: Developmental manifestations in neurological disease, disorder, and dysfunction. The Clinical Neuropsychologist, 2, 293-330.

Rourke, B.P. (1993). Arithmetic disabilities, specific and otherwise: A Neuropsychological Perspective. Journal of Learning Disabilities, 26 (4), 214-226.

Rourke, B.P. (1995). Nonverbal learning disabilties: The syndrome and the model. New York: Guilford Press.

Russell, E.W. (1975). A multiple scoring method for the assessment of complex memory functions. Journal of Consulting and Clinical Psychology, 43, 800-809.

Sattler, J.M. (1988). Assessment of Children (3rd ed.). San Diego, CA: Sattler.

Saykin, A.J., Janssen, R.S., Sprehn, G.C., Kaplan, J.E., Spira, T.J., & Weller, P. (in press). Neuropsychological dysfunction in HIV-infection: Characterization in a lymphadenopathy cohort. International Journal of Clinical Neuropsychology.

Schear, J.M., & Craft, R.B. (1989). Examination of the concurrent validity of the California Verbal Learning Test. The Clinical Neuropsychologist, 3(2), 162-168.

Schear, J.M., Tallal, P., & Delis, D. (1992). Verbal learning and memory in language impaired children. Neuropsychologia, 30(5), 451-458.

Silverstein, A.B. (1985). Two- and four-subtest short forms of the WAIS-R: A closer look at validity and reliability. Journal of Clinical Psychology, 41(1), 95-97.

Spreen, O., & Strauss, E. (1991). A Compendium of Neuropsychological Tests. New York: Oxford University Press.

Squire, L.R. (1987). Memory and Brain. New York: Oxford University Press.

Stanley, D.A., Clark, K.H., D'Amato, R.C., & Maricle, D.E. (1994, November). Evaluating the construct specificity of intelligence and achievement with African-American and Caucasian learning disabled students. Paper presented at the meeting of the National Academy of Neuropsychology, Orlando, FL.

Swanson, H.L. (1984). Semantic and visual memory codes in learning disabled readers. Journal of Experimental Child Psychology, 37(1), 124-140.

Swanson, H.L. (1988). Toward a metatheory of learning disabilities. Journal of Learning Disabilities, 21, 196-209.

Terryberry-Spohr, L., Wands, K., Rohling, M.L., & Cole, J.K. (1993, November). The distinction between verbal and nonverbal memory in older adults. Poster session presented at the meeting of the National Academy of Neuropsychology, Pittsburgh, PA.

Tiffin, J., & Asher, E.J. (1948). The Purdue Pegboard: Norms and studies of reliability and validity. Journal of Applied Psychology, 32, 234-247.

Trahan, D.E. & Larabee, G.J. (1988). Continuous Visual Memory Test. Odessa, FL: Psychological Assessment Resources.

Trahan, D.E., Larabee, G.J., & Quintana, J.W. (1990). Visual recognitioon memory in normal adults and patients with unilateral vascular lesions. Journal of Clinical and Experimental Neuropsychology, 12, 857-872.

Wechsler, D. (1945). A standardized memory scale for clinical use. Journal of Psychology, 19, 87-95.

Wechsler, D. (1981). Wechsler Adult Intelligence Scale-Revised manual. New York: The Psychological Corporation.

Wechsler, D. (1987). Wechsler Memory Scale-Revised manual. San Antonio, TX: The Psychological Corporation.

Wilde, M.C., & Boake, C. (1993). Factorial validity of the California Verbal Learning Test in head injury. Paper presented at the 1993 National Academy of Neuropsychology convention in Phoenix, Arizona.

Williams, J.M. (1991). Memory Assessment Scales professional manual. Odessa, FL: Psychological Assessment Resources.

Wilson, B.K. (1987). Rehabilitation of Memory. New York: Guilford Press.

Wilson, B.K., Cockburn, J., Baddely, A., & Hiorns, R. (1989). The development and validation of a test battery for detecting and monitoring everyday memory problems. Journal of Clinical and Experimental Psychology, 11, 855-870.

Zielinski, J.J. (1993). A comparison of the Wechsler Memory Scale-Revised and the Memory Assessment Scales: Administrative, clinical, and interpretive issues. Professional Psychology: Research and Practice, 24(3), 353-359.

Zimbelman, K. (1988). The California Verbal Learning Test as a predictor of alcoholics' performance on an ecologically relevant learning task. Dissertation Abstracts International, Ann Arbor, Michigan.