A study of the effect of interactive language in the stimulation of cognitive functioning for students with learning disabilities

Kathleen Ricards Hopkins
College of William & Mary - School of Education

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A STUDY OF THE EFFECT OF INTERACTIVE LANGUAGE IN THE STIMULATION OF COGNITIVE FUNCTIONING FOR STUDENTS WITH LEARNING DISABILITIES

A Dissertation Presented to

The Faculty of the School of Education

The College of William & Mary in Virginia

In Partial Fulfillment of the Requirements

for the Degree Doctor of Education

by

Kathleen Ricards Hopkins

May 1996
A STUDY OF THE EFFECT OF INTERACTIVE LANGUAGE IN THE
STIMULATION OF COGNITIVE FUNCTIONING FOR STUDENTS WITH
LEARNING DISABILITIES

Approved April 1996 by

[Signatures]

by

Kathleen Ricards Hopkins

May 1996

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To Deborah Zimmerman
and Grace Mutzabaugh,
NILD pioneers,
who had the courage
to believe
it is better to build children
than to repair men.
Acknowledgments

• To my husband, Ralph, whose steadfast confidence inspired and motivated me and whose patience was a continual source of joy in the journey.

• To my daughters, Sue and Kristin, who believe in me.

• To Chriss Walther-Thomas, my committee chair, who held me to a high standard and provided direction, insight and unfailing good humor through the tedious process.

• To Brenda Williams, special educator, whose passion for excellence inspired me to reach higher.

• To Tom Ward, statistician, who guided me through complexity to understanding.

• To Nancy Patrick, educational psychologist, whose vision for the study gave initial impetus and direction.

• To NILD program coordinators, Carole Adams, Sue Hutchison, Tony Ryff, Gail Collins, Kathy Keafer, Ann Hayden, Vesta Gillette, and Jane Clark, who provided program data and demonstrated support and enthusiasm along the way.

• To Carolyn Penner, who shared her knowledge of the neuropsychology of learning.

• To Dan Jessen, Nancy Akins, Milt Uecker, and Earlene Willis, who read the manuscript and provided wise counsel and encouragement.

• To Carolyn McBride, whose computer skills and patient revisions shaped the final product.

• To Debbie Garrick, who designed the graphics, enhancing the impact of the data.

• To Beth Trebon, who assisted with the statistical analysis.

• To all NILD educational therapists who have walked alongside me and provided notes and calls of encouragement.

• To the Master Teacher, without whom the impossible could never have been realized.

• And, finally, to the children whose cries for help must drive our quest for answers.
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Abstract

Much can be gained by applying knowledge and insight gleaned from the field of neuropsychology to the field of education. Diagnosis and treatment of learning disabilities (LD) could be enhanced through an increased understanding of neurolinguistic functioning. The present study examined the effect of five instructional techniques aimed at stimulating the cognitive functioning of students with diagnosed learning disabilities. The defining characteristic of each of the five techniques is the use of interactive dialogue to stimulate oral language production leading to greater cognitive efficiency. Evidence is presented for the need for interhemispheric collaboration in complex linguistic tasks such as reading, writing, spelling, and arithmetic. Students with learning disabilities could be viewed as having a breakdown in dynamic functioning impacting neurological systems.

The intervention model developed by the National Institute for Learning Disabilities (NILD) assessed in the present study is based upon the theoretical foundations of Feuerstein (1980), Luria (1981), Piaget (1959), and Vygotsky (1962/1975). The interrelatedness of thought and language, the creation of the zone of proximal development, the recognition of the plasticity of intelligence and the belief in the importance of a human mediator in the learning process, each contributes to the design of techniques used in the NILD program.
The statistical analysis showed significant group-by-time interaction effects in the areas of general and verbal cognitive functioning for the experimental group (n=47), as assessed by the Detroit Tests of Learning Aptitude - Second Edition (DTLA-2) when compared to the control group (n=25). Significant gains over time were evidenced by the experimental group in reading, spelling, and arithmetic scores as measured by the Wide Range Achievement Test - Revised (WRAT-R), and in nonverbal cognitive functioning as measured by the DTLA-2.

Overall results indicated that students with diagnosed learning disabilities benefited from an intensive individualized program over a three-year period in a modified pull-out approach involving 160 minutes of instruction per week. Specifically, the interactive effects of five core instructional techniques appeared to significantly impact neurolinguistic functioning for the experimental group.
Chapter I

Introduction

Historically, researchers have attempted to identify a unified condition and a single, encompassing definition of learning disabilities (LD). Each has been elusive due to the dynamic complexity of both the problems and the applied solutions. Thus, critics have challenged both the conceptualizations and operational definitions that have guided research and practice in the field of learning disabilities over the past 20 years (Adelman, 1994; Lyon & Moats, 1993).

The diversity of perspectives and range of indicators presented by individuals with learning disabilities both plague and enhance the field of learning disabilities. Controversy surrounding the appropriate treatment for these students continues to abound.

In recent years, a prevailing philosophy has encouraged the position that much of the difficulty of individuals with learning disabilities lies within the educational environment (e.g., inappropriate instruction or materials), rather than within the student (Adelman, 1994). This perspective brings into question the need to be concerned about an inherent physiological basis for LD. Emerging evidence seems to indicate a distinct anatomy of learning disabilities related to brain structure and functioning. Semrud-Clikeman and Hynd (1994) cited recent research on the beginning efforts to relate brain structure to neurolinguistic
functioning. Their data suggest a relationship between anomalies in brain structure and deficits in reading skills. These findings point to the interactive effect of systems within the brain needed to perform highly complex functions such as reading and writing.

Educational, psychological, and biomedical approaches to LD have often been parallel rather than integrated (Swanson & Keogh, 1990). Because the field of LD has lacked clear definition, specific disciplines have grappled with various aspects of the condition. For example, research funded by the Department of Education has been directed primarily at organizational and policy concerns. Psychological research has focused mainly upon identification and classification issues (Swanson & Keogh, 1990), whereas biomedical research has investigated the physiology of LD (Duane & Gray, 1991).

In the past 10 years, considerable advances in research have produced technologies that allow educators a glimpse into the inner workings of the human brain. Rapidly growing knowledge of brain anatomy confirms that the brain is an organized structure containing consistent, discrete areas interconnected by fiber pathways (Galaburda, 1991). A clearer understanding of the dynamic complexity of the human brain appears to be a key factor in both the diagnosis and treatment of learning disabilities (Restak, 1994; Semrud-Clikeman & Hynd, 1994).
Further, current theory in the field of neurology suggests that complex behaviors such as reading and writing arise from the interaction of functional systems with the brain (Golden, 1991; Restak, 1994). For example, recent research utilizing neuroimaging techniques such as positron emission tomography (PET), magnetic resonance imaging (MRI), and computerized axial tomography (CAT) scans indicates that connections between systems in individuals with learning disabilities may be inefficient (Semrud-Clikeman & Hynd, 1994). Further, studies of post-mortem brains are beginning to yield distinct characteristics in those diagnosed LD (Duane & Gray, 1991).

Educators are beginning to take note of the developing science of neuropsychology, that is, the assigning of functions to specific areas of the brain. As a result, articles on brain functioning are appearing in educational journals. In the case of special education, the field is beginning to link this research with early findings relative to the physiology of learning (Branch, Cohen, & Hynd, 1995; Caine & Caine, 1991; Das, Mishra, & Pool, 1995).

To date, research in the LD field has consisted primarily of "single-shot" investigations (Lyon & Moats, 1993), comparing students achieving normally with students with learning disabilities on one or more dependent variables at one point in time. It appears that educators have attempted to oversimplify the difficulties encountered by students with learning disabilities. Thus, research focused upon
only one aspect of learning such as attention, perception or memory does not seem to take into account the dynamic functioning of inter-dependent neurological systems (Luria, 1981).

Perhaps the time has come for LD to be viewed as a set of related but partially independent conditions with a number of possible causes (Keogh, 1990). Such a perspective would allow the educator to deal with a diversity of symptoms and confirm the legitimacy of variation within and between students. To that end, educators must complete two critical tasks. First, we must impose a certain order on the variation of student learning needs. Second, we must develop and test effective interventions. It is time to expand and enlarge upon the understandings in the field of learning disabilities reached to date. Potentially, increased collaboration between education and neuropsychology will yield new insights and effective treatment programs for learning disabilities.

**Justification for the Study**

Although the number of students with LD who receive diplomas has increased (Seventeenth Annual Report to Congress, 1995), most interventions for students with learning disabilities have yielded disappointing results (Adelman, 1994). For example, in a review of both recent and earlier studies of interventions for LD, Spreen (1988) found only one study that showed positive results. Some evidence suggests that most interventions have lacked intensity, have adapted a
one-dimensional or watered-down educational approach, or have attempted to
"fix" specific modalities of inefficient functioning (Keogh, 1990; Kronick, 1988;
Martin, 1993). Brain-behavior studies seem to support the position that cognitive
functioning can be enhanced through effective instruction (Bakker, Licht, &
Kappers, 1995; Caine & Caine, 1991; Feuerstein, Hoffman, Egozi, & Shachar-
Segev, 1994). For example, it appears that structured verbal interchanges between
teachers and students can effectively direct and enhance cognitive development

The current study will approach the field of learning disabilities from the
standpoint that learning disabilities are a result of physiological or neurological
dysfunction. This position is based upon the following assumptions:

1. Learning is an intrinsic, active process influenced by both interactive and
inner (unspoken) language (Das et al., 1995; Luria, 1966, 1973; Vygotsky,

2. Students with LD need intensive stimulation of interactive cognitive
systems in order to improve mental processing (Bakker et al., 1995;
Feuerstein, 1994; Kronick, 1988; Luria, 1966, 1973; Presseisen & Kozulin,

3. Both distal (hereditary) and proximal (environmental) etiological factors in
LD can be negated through dynamic mediation, the verbal interaction
between teacher and student (Feuerstein et al., 1994; Preseisen & Kozulin, 1994).

4. Interhemispheric collaboration, or the effective communication across the brain's hemispheres, is essential for efficient cognitive processing (Bakker et al., 1995; Levy, 1985; Semrud-Clikeman & Hynd, 1994).

**Statement of the Problem**

This study will investigate the effects of five core instructional techniques that require the use of precise and accurate verbalization by students with learning disabilities as a means of improving cognitive functioning. Specifically, it is hypothesized that a direct and focused intervention incorporating interactive dialogue between educational therapists and students working in individualized settings will stimulate improvements in reading, spelling and arithmetic skills. Additionally, it is hypothesized that intensive intervention will lead to improvements in verbal, nonverbal, and general cognitive functioning.

**Research Questions**

This study will investigate and test the validity of an intervention program for students with LD. Specifically, the interactive effects of five core instructional techniques that incorporate precise and accurate oral language production will be examined. The proposed integrative model will be measured through test score differences on pre- and posttest measures.
Students with LD in an experimental group completed a three-year program of intensive stimulation of cognitive functioning through the interactive effect of five core techniques designed and developed by the National Institute for Learning Disabilities (NILD). Control group students with LD did not participate in the intervention.

The following general hypotheses are offered. It is hypothesized that the experimental group of students will demonstrate significant improvement in: (a) reading words in isolation as measured by a standardized reading test; (b) spelling as measured by a standardized spelling test; (c) arithmetic as measured by a standardized arithmetic test; (d) general cognitive functioning as measured by a standardized test of general intelligence; (e) verbal cognitive functioning as measured by a standardized test of verbal intelligence; and (f) nonverbal cognitive functioning as measured by a standardized test of nonverbal intelligence.


**General Design**

This three-year longitudinal study will utilize a quasi-experimental, nonequivalent control-group design. Students were not assigned randomly to the experimental or control groups based upon a prior diagnosis of a learning
disability. All students in the study (N=72) had learning disabilities identified through a battery of psychological and educational tests. All students were recommended to receive educational therapy intervention through NILD. The control group (n=25) consisted of those students whose parents declined the intervention program. Students who received the intervention comprised the experimental group (n=47).

**Limitations of the Study**

Although this study was conducted in a relatively controlled setting, used a control group, and employed a longitudinal design, some limitations need to be considered. One such limitation is the continued controversy that surrounds the definition of learning disabilities. There is no consensus in the field on defining parameters of LD; however, the students included in the study fulfilled the most widely accepted definition in that those diagnosed with LD exhibited significant ability-achievement discrepancies and scored within the average to superior IQ range, which should approximate other students placed in similar settings.

A second limitation is the lack of random assignment to treatment groups due to prior designation of a learning disability. However, the use of a control group strengthens the study and specific treatment was withheld from students only by parental choice.
A third limitation involves the possibility of variation in teacher (educational therapist) effectiveness. Although participating educational therapists were trained in a standardized approach, it is impossible to account for individual differences in technique implementation. However, the fact that each educational therapist in the study held NILD certification assumes a certain level of experience and proficiency.

A fourth limitation involves the issue of individualization of instruction. Were the results due to the individual attention given to the students or to the intensive stimulation of academic functioning? Comparison studies of one-to-one tutoring sessions generally do not reflect lasting gains in achievement. Follow-up studies would be important indicators of the benefits of specific cognitive stimulation.

A fifth limitation involves the specific tests used in measuring the results. Since the WRAT-R measures academic performance rather than higher level cognitive functioning, its application is limited. However, the DTLA-2, an additional test used in this study, provides some measure of cognitive processing. Viewed together the two instruments present a more comprehensive picture.

Finally, a sixth limitation is the question of generalizability of findings to a public setting. To the extent that LD students in private settings approximate their peers in demographic data, the results of this investigation should generalize.
Definitions of Terms

Educational therapist: An individual trained in the NILD approach to stimulate academic functioning through interactive dialogue.

Educational therapy: The process of intensive intervention delivered in a clinical, individualized setting utilizing interactive dialogue to stimulate academic functioning.

Hemispheric dominance: A relative status in the contributions of the two hemispheres of the brain in mediating a particular cognitive task.

Human modifiability: The ability to have the basic structures of one’s thinking changed.

Inner language: Abbreviated inner speech, language that is thought, not spoken, which becomes the basis of cognitive growth and development.

Interactive speech: The dialogue that is facilitated by a mediator using a process of guided questioning to develop the child’s basic thought processes.

Interhemispheric collaboration: The interchange of information across and between the left and right hemispheres of the brain, which promotes efficient learning.

Students with learning disabilities: Students with average to superior intellectual ability who exhibit some form of neurological dysfunction as evidenced
by an ability/achievement discrepancy measured by standardized testing and classroom performance.

Mediation: The influence of a human mediator who facilitates student learning through interactive dialogue by interpreting the environment and thereby creating focus and strategic thinking.

Neural plasticity: The property of the brain to reorganize itself based upon the presence of stimulation within the environment.

Stimulation of cognitive functioning: Intensive intervention procedures that require information to be processed across both hemispheres of the brain designed to create new neural pathways.

Verbal syncretism: Students’ tendency to jump from premises to conclusions without developing specific steps of deduction. That is, students think they understand a concept and do not ask for assistance based upon their assumption.

Zone of proximal development: The distance between a child’s actual developmental level and the level of potential development, that which a child can attain with assistance.

Purpose of the Study

The purpose of the present study is to determine if statistically significant differences exist between groups of students who have learning disabilities and
have received two distinctly different treatment programs. The experimental group received educational therapy along with a regular education program. The control group received a regular education program without educational therapy. Thus, the study was undertaken to determine whether or not students with LD benefit from receiving educational therapy in addition to their regular education programs.

The dependent variables in this study are academic achievement and cognitive ability levels. The instrument used to measure academic achievement is the Wide Range Achievement Test - Revised (WRAT-R) (1984) and the instrument used to measure cognitive ability levels is the Detroit Tests of Learning Aptitude - Second Edition (DTLA-2) (1985).

The hypotheses under investigation are:

1. \( H_0: \) There will be no statistically significant difference in means between the pretest and posttest standard scores for reading for the experimental and control groups.

   \( H_1: \) not \( H_0. \)

2. \( H_0: \) There will be no statistically significant difference in means between the pretest and posttest standard scores for spelling for the experimental and control groups.

   \( H_2: \) not \( H_0. \)
3. $H_0$: There will be no statistically significant difference in means between the pretest and posttest standard scores for arithmetic for the experimental and control groups.

$H_3$: not $H_0$.

4. $H_0$: There will be no statistically significant difference in means between the pretest and posttest standard scores for general cognitive functioning between the experimental and control groups.

$H_4$: not $H_0$.

5. $H_0$: There will be no statistically significant difference in means between the pretest and posttest standard scores for verbal cognitive functioning between the experimental and control groups.

$H_5$: not $H_0$.

6. $H_0$: There will be no statistically significant difference in means between the pretest and posttest standard scores for nonverbal cognitive functioning between the experimental and control groups.

$H_6$: not $H_0$. 

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Chapter II

Review of Literature

The literature review traces the historical and theoretical foundations of the field of learning disabilities highlighting the neurological implications of learning.

Learning Disabilities

Historical frameworks. Diagnostic and research guidelines established by early researchers of LD almost 100 years ago can still be found in contemporary theory, research, and practice (Farnham-Diggory, 1992). Thus, the leading pioneers, Hinshelwood (1917), Orton (1925), Strauss and Lehtinen (1947), and Werner (1961), each contributed specific insight and knowledge to current understanding of the specific neurological dysfunction underlying learning disabilities. Each began his scientific inquiry with the intuitive sense that the brains of students struggling to learn were not operating at optimal efficiency and each probed the physiological bases of dysfunction. Their contributions encouraged research into subtle forms of brain injury and unsuspected causal mechanisms.

Neurological foundations. Hinshelwood (1917), a Scottish ophthalmologist with an interest in neurology, began publishing in 1895 about a mysterious affliction known as “acquired word blindness,” a sudden loss of the ability to read. Hinshelwood’s theory was that there must be separate places in the brain for visual memory of the everyday type and specific visual word memory.
Through extensive clinical testing, he discovered that word blindness was usually defined in cases where general memory remained intact, thereby implying a subsystem of memory function. In time, Hinshelwood developed a complex theory of different kinds of reading disability, each with a specific location in the brain. This theory is receiving new support from contemporary neuropsychologists (Ellis & Young, 1988). Hinshelwood's studies gave rise to an important scientific notion that was beginning to appear in the medical literature, that is, learning disabilities may be present in some people from birth.

Another early researcher, Orton, an American physician specializing in neurology, became particularly interested in the phenomenon of hemispheric imbalance (Orton, 1925). It had been recognized for some time that the left hemisphere was responsible for the storage and production of language (Farnham-Diggory, 1992). Less was known about right hemisphere functions, but Orton believed they mirrored the activities of the left. Thus, according to Orton, damage to the left hemisphere produced word blindness. If the left hemisphere was unable to suppress images coming from the right, confusions and delays in motor output would result.

Strauss and Werner, both refugees from Nazi Germany, laid the foundations for neurological implications of learning dysfunction. Strauss and Lehtinen (1947) identified a category of student who demonstrated exogenous
brain dysfunction. In other words, something external to the genetic development was responsible for the damage. So called “exogenous children” were described as emotionally unstable, perceptually disordered, impulsive, distractible and repetitive. The condition became known as the “Strauss syndrome” (Farnham-Diggory, 1992).

Werner (1961), a Gestalt psychologist, was particularly interested in the complementary biological processes of differentiation and integration as they involved brain function. Specifically, he believed in the equipotentiality of the mind, that is, the likelihood that one part of the brain can substitute for another (Werner, 1961). Thus, he postulated that gradually specific capabilities differentiated out of the mental mass. Once formed, these capabilities needed to be integrated. For example, number concepts began with counting fingers, then became visually discernible and finally automatized. Werner shared a conviction with other Gestalt theorists that learning and development produced a restructuring of the mind. His interest in perception had a strong influence on Strauss and, subsequently, on the field of learning disabilities (Farnham-Diggory, 1992).

Wiederholt (1974) identified phases within the historical development of the field of learning disabilities. From the foundation phase just described, Wiederholt recognized an emergent transitional phase characterized by the entry of
many new groups into the field. These included educators, psychologists, parents, and policymakers who wrestled the field away from its medical foundations. It could be this detachment from its scientific roots that has contributed to confusion in definition and causality in the LD field today (Farnham-Diggory, 1992).

Current Terminology, Technology, and Practices

The term “learning disabilities” was adopted in 1963 following a lecture by Dr. Sam Kirk, a professor at the University of Illinois. Chords of disharmony were struck among Kirk’s colleagues at the 1963 meeting because Kirk had not explained the scientific contributions of Strauss and Werner. Parents and professionals were delighted to hear him say that children and adolescents had “learning disabilities” instead of “retardation” and a special, rather elitist, category of dysfunction was born (Farnham-Diggory, 1992). According to Cruikshank (1989) “learning disability” was:

- a functional term but without precedents to guide those who attempted to define it, and without research or common usage which would assist in its appropriate formulation as a functional term. At that date, more than forty terms were used in English to describe the same child. (p. 1)

Emerging sciences. Recent advances in research have produced new technologies that allow educators a glimpse into the inner workings of the human brain (Duane & Gray, 1991). Current brain-imaging technology focuses on three
elements of the organization and operation of the brain, (a) chemical composition of cells and neurotransmitters, (b) electrical transmission of information along neuronal fibers and accompanying magnetic fields, and (c) the distribution of blood through the brain as it replenishes energy used in electrochemical activity. These three elements can be studied through the use of computerized axial tomography (CAT) scans, electroencephalogram (EEG), and positron emission tomography (PET) scans, respectively (Duane & Gray, 1991).

Both psychology and neurology were infant sciences in 1963. Discoveries that confirmed the assumptions of Werner and Strauss, such as the CAT and MRI scans, were unknown to the early pioneers. Cruikshank (1989) pointed out that everything that was known about students with learning disabilities originated from research conducted on students with mental retardation. Thus, it was inaccurate to speak of learning disabilities as being restricted to children or youth of average or above average intellectual ability. “It is positively accurate to state that the issues of learning disabilities are respectors of no single intellectual level, but are found in all levels of the intellectual spectrum” (Cruikshank, 1989, p. 4).

Emerging practices. During the 1960s an attempt was made to merge widely scattered information into comprehensive diagnostic-remedial practices. Since Kirk had no scientific basis for postulating a new type of learning disorder, a number of “magic cures” for this newly defined malady appeared in the 1960s and
1970s. For example, process training approaches developed by Delacato (1966), Kephart (1971), and Frostig and Maslow (1973) isolated particular skills and mental functions and attempted to remediate them. For the most part, these approaches were based upon incorrect theories of brain function and scientific research did not confirm their effectiveness (Doris, 1993; Farnham-Diggory, 1992; Lerner, 1993). Consequently, it was assumed that an educational focus on one element of learning, such a perception, would generalize to academic skills such as reading and spelling. However, this approach failed to recognize the brain as a functional system with interdependent components.

The period from 1963 on was termed by Wiederholt (1974) as the integration phase, that is, the merging of information into comprehensive diagnostic-remedial practices. During this phase the number of professionals in the field grew quickly with a concurrent rapid escalation of basic and applied research.

Common Assumptions

Tracing the historical development of the field of learning disabilities (LD) produced some common assumptions that have remained relatively consistent over the past 50 years. First, it had been assumed that a learning disability was of neurological origin. The idea of minimal brain dysfunction (Clements, 1966; McIntosh & Dunn, 1973; Strauss & Lehtinen, 1947) received major impetus from the work of Strauss, Kephart, Lehtinen and Cruikshank (Doris, 1986; Lerner,
1993; Swanson & Keogh, 1990). This idea has been expanded and developed by
work in the neurosciences and neuropsychology with the recent identification of
anatomical differences in brain structure in students with LD (Galaburda, 1991;
Semrud-Clikeman & Hynd, 1994).

A second commonly held assumption was that individuals with learning
disabilities do not function at levels consistent with their intellectual ability (Cone
& Wilson, 1981; Keogh, 1990; Reynolds, 1985). That is, they evidence a
measured discrepancy between intellectual capacity, as indicated by a standardized
psychological test such as the Wechsler Intelligence Scale for Children - Revised
(WISC-R) (1974), and achievement as measured by an educational battery of tests.
The aptitude-achievement discrepancy has been analyzed, supported, and criticized
in terms of specific formulae (Ysseldyke, Algozzini, Richey, & Graden, 1982).
Thus, a number of investigations have described inconsistencies in decision-making
related to the method of assessment or statistics applied as well as what and how
much constitutes a meaningful discrepancy. A major problem with discrepancy
formulas was seen to be the requirement that students fail in academic areas before
they can be identified (Fletcher, Francis, Rourke, Shaywitz, & Shaywitz, 1993).
The aptitude-achievement discrepancy, however, continues to be one of the
primary indicators differentiating students with LD from learners with limited
cognitive abilities.
A third assumption related to specificity (Stanovich, 1986). Individuals with learning disabilities exhibited unexpected failures or depressed performance in certain, but not all, educational tasks (such as reading, spelling, or mathematics). This failure was unexpected based upon the student's cognitive level as measured on an IQ test. A number of causal hypotheses have been proposed to explain the specific failure, most inferring links between neural or cognitive functions, and the demands of particular academic tasks (Keogh, 1990). For example, a specific deficit in short-term memory would present difficulties in certain types of tasks (e.g., oral arithmetic), but not in others (e.g., history facts). Researchers have uncovered a plethora of deficits that suggested widespread cognitive dysfunction rather than that which was highly localized (Brainerd, Kingma, & Howe 1986; Stanovich, 1986).

If, as many have implied (e.g., Healy, 1990; Kronick, 1988), the process of learning involves the dynamic complexity of whole-brain functioning, then an understanding of brain function is imperative for educators. Indeed, a new psychology of learning disabilities may be emerging. Knowledge of the plasticity of intelligence and the malleability of the human brain should redirect efforts toward the enhancement of cognitive functioning (Feuerstein, 1993). If it is possible for the brain to rewire itself around areas of injury, should it not also be possible to restructure deficient thinking processes?
Creative solutions will necessitate the collaboration of a number of professionals and disciplines (Lyon & Moats, 1993; Tallal, 1994). Educators, psychologists, neuroscientists and neuropsychologists will benefit greatly from increased dialogue and a spirit of interactive inquiry (Presseisen & Kozulin, 1994; Vygotsky, 1978). It is this very spirit of interactive inquiry that should become the basis of sound instructional practices (Lipman, 1991).

Decade of the Brain

Return to scientific roots. The United States Congress has designated the 1990s as the “Decade of the Brain” (Conte, 1991). As a result, the field of learning disabilities was beginning to take note of research developments in the field of neuropsychology, thereby signaling a return to its scientific roots. Also, a spirit of collaboration has been developing between the medical and educational fields.

Research conducted by Galaburda (1991), Geschwind and Galaburda (1985), and Wood, Felton, Flowers, and Naylor (1991) has confirmed the biological bases of learning disabilities leading to more comprehensive etiology. The work by De Fries, Olson, Pennington, and Smith (1991) in the field of genetics underscored that the biological determinants of reading disability included heritable familial factors that by linkage analysis could be associated with at least two distinct chromosomes, namely 6 and 15.
There is mounting evidence that learning disabilities may be the result of a wide variety of etiological factors, each of which may have impact on the developing central nervous system. These may occur at prenatal, perinatal or postnatal periods of development. According to Cruikshank (1989):

It would appear, however, in terms of the present knowledge, that most processing deficits are coincident with prenatal and perinatal etiological factors. Thus, definitionally, it is possible to state that the central nervous system impairment with its subsequent processing deficits and learning disabilities may be related to almost any etiological factor. (p. 8)

**Anatomical differences.** Actual studies of post-mortem brains have revealed anatomical differences in the structures of the brains of individuals with diagnosed learning disabilities. Galaburda (1991) shed further light upon the anatomy of learning disabilities:

The two main findings in the brains of individuals (with LD) are the presence of symmetry of an important language area of the cerebral cortex and focal areas of cortical malformation that sometimes, but not always, affect the classical language areas. (pp. 128-129)

This symmetry may contribute to the inefficiency of neurological functioning as will be explained later.
Learning disabilities - a clinical entity. In order to understand learning disabilities as a clinical entity, researchers (Cruikshank, 1989; Farnham-Diggory, 1992; Kronick, 1988) have provided some important parameters: (a) Learning disabilities are the end result of many complex factors, (b) learning disabilities are the result of perceptual processing deficits of an extremely diverse nature, and (c) perception is neurological and is an inherent function of the neurology of an organism. That is, perception is the direct reflection of the neurological system’s capacity to receive and transform stimuli into higher forms of intellectual functioning.

Although still a relatively new field, learning disabilities has been researched more carefully and comprehensively than most other fields. A major impetus for research growth was the passage of Public Law 94-142 - the Education of All Handicapped Children Act in 1975 (now known as Individuals with Disabilities Education Act [IDEA]). The scientific basis for developing a classification system for learning disabilities, however, has not progressed to the point that research scientists can be certain that the samples they study are comparable. As a result of definitional difficulties, treatment continues to vary widely from school district to school district. Duane and Gray (1991) summarized the need for the National Institute of Child Health and Human Development (NICHHD) to learn more about the nature of LD:
The implications of an improved understanding of learning disabilities for the future are that with better classification systems, more homogeneous groups of individuals with LD can be studied for biological and behavioral markers. These indicators of a learning disorder could be used as risk factors for establishing early medical and behavioral interventions specifically designed to effectively ameliorate the disabilities of the children at risk for poor academic performance. (p. xv)

Heterogeneity has been a vexing problem for the LD field. Differences between LD and normally achieving comparison groups have not coalesced into a unified conceptualization of LD. Subtype research has tried to divide heterogeneous LD samples into homogeneous subgroups based upon performance patterns obtained through multivariate classification techniques with limited success (Kavale, 1990). There seems to be converging evidence from research laboratories around the world, however, that 80% of students who struggle with specific reading disabilities form a single subgroup characterized by deficits at the phonological level (Tallal, 1994). Renewed optimism is emerging that categories of specific disability may correspond to particular areas of neurological dysfunction (Duane & Gray, 1991).

A new era. Learning disabilities research now commands the attention of mainstream researchers and benefits from the latest theories and empirical results.
to come out of developmental and experimental psychology. However, it is important to discriminate between the accumulated sludge of the past and the nuggets of wisdom laboriously uncovered by individuals who toiled in the field long before its current popularity (Adelman, 1994; Lerner, 1993; Lyon & Moats, 1993). According to Stanovich (1986),

Perhaps the bad old days are over. Perhaps a new era in the study of learning disabilities has really begun. Maybe the days are past when a few clinical observations could be turned into a full-fledged theory that then worked its way into the textbooks and subsequently into classrooms.

(p. 229)

Neurological Functioning

Theoretical foundations. It is important to examine the building blocks of cognition and neurological functioning in the light of theories posited by Piaget (1959), Luria (1961, 1966, 1973, 1976, 1980), and Vygotsky (1962/1975, 1978). Their combined contributions to the field of cognitive developmental psychology provided the essential framework for the present study. Specifically, the interrelatedness of thought and language and the contributions of these concepts to cognitive development will be explored.

Piaget, considered by many to be the father of cognitive developmental psychology, laid the foundation for the egocentrism of children's thinking in his
seminal work, *The Language and Thought of the Child* (1959). In describing the differences between egocentric and socialized thought, Piaget stated, "It is non-discursive, and goes straight from premises to conclusion in a single intuitive act, without any of the intervening steps of deduction" (p. 127).

From this theory of egocentrism, Piaget developed the important concept of verbal syncretism. Stated simply, children often think they understand and jump quickly to conclusions without any request for assistance. For example, children hear the remarks of adults and instead of asking for clarification, they instantly imagine that they understand. Thus, they develop their own schemas based upon faulty perceptions and are resistant to explore other possibilities.

Piaget contended that childish egocentrism predominates up to the age of seven or eight when social thought begins to be formed. After this age, the egocentrism does not disappear, but "remained crystallized in the most abstract and inaccessible part of the mind... the realm of purely verbal thought" (p. 128). To Piaget, a child's thinking could be directed and structured through verbal interchange. As the adult requested clarification of a concept, the child's mental processes could be taken through specific steps of deduction.

Vygotsky reaffirmed the notion that human learning presupposed a specific social nature. He contended that egocentric speech played an important role, in fact, that the development of thought was determined by language. As a result,
Vygotsky viewed verbal interaction with adults as prerequisite for the development of conceptual thinking within the child (Vygotsky, 1962/1975).

In his classic work, *Thought and Language*, Vygotsky (1962/1975) traced the child's development of speech and thought. He maintained that these skills did not stem from one root, rather, initially thought was nonverbal, speech was nonintellectual. Eventually, the lines met and became essentially linked. Both Piaget (1959) and Vygotsky (1962/1975) noted the importance of inner speech. Vygotsky stated, "Inner speech develops through a slow accumulation of functional and structural changes... and finally the speech structures mastered by the child become the basic structures of his thinking" (pp. 50-51). Vygotsky (1978) refuted Binet's (1909) assumption that development was always a prerequisite for learning. He believed that the developmental process lagged behind the learning process, and that social development gave rise to new functional systems within the mind.

Vygotsky (1962/1975) is perhaps best known for his theoretical position regarding the "zone of proximal development." In essence, this is the distance between a child's actual developmental level and the level of potential development (that which a child can attain with assistance). The role of interactive speech was viewed as crucial in the creation of this zone of proximal development. To Vygotsky (1978), learning was more than the acquisition of the ability to think. It
was the acquisition of many specialized abilities for thinking about a variety of things. In other words, he conceived of learning as a dynamic process involving social contact, verbal interchange, and active learner involvement.

Building upon the philosophies of both Piaget and Vygotsky, Luria (1973) affirmed that mental activities were conditioned by social relations. Concurring that new functional systems were developed in the child as a result of adult interaction, Luria confirmed that egocentric language did not disappear, but became abbreviated internal language, an essential component of thought processing.

**Influence of language on learning.** In investigating the influence of language upon learning, Luria (1961) conducted an experiment in which he gave young children (aged 12-30 months) two boxes, an empty green one and a red one filled with sweets. It proved difficult for the children to remember which box contained the sweets. When language was introduced to the experiment, however, (i.e., when the colors of the boxes were named), the children were able to identify correct choices more quickly. Luria concluded that language substantially modified the children’s perception and permitted them to work out a system of stable associations.

Mounting evidence suggests some students with learning disabilities have significant problems using language functionally (Bryan, Donahue, & Pearl, 1981).
Further, in ambiguous or socially complex situations, students with LD have great difficulty asking questions, disagreeing or supporting an argument (Vellutino, 1987). Language development appears to alter the relative strength of stimuli acting upon a child. Thus, Luria discovered that speaking to a child could reshape perception of a compound stimulus and enable weaker perceptual components to predominate. For example, when the backgrounds were verbally described in a visual stimulus, children attended to them in preference to the stronger foreground stimulus. To Luria, this cognitive restructuring signaled the rise of new functional systems.

These important discoveries paved the way for Feuerstein’s theory of cognitive modifiability (1980). Feuerstein studied under Piaget and built upon the theories of Vygotsky and Luria. Although Piaget, Vygotsky and Luria all recognized the importance of social interaction in the development of cognition, in particular, interactive speech, it was left to Feuerstein to define the role of the mediator, the facilitator of learning, in the learning process.

In their comprehensive examination of Feuerstein’s empirical research, Savell, Twohig, and Rachford (1994) cited two issues: the nature of the effects and the investment required to produce them. They reported that significant gains were commonly found in nonverbal measures of intelligence through Feuerstein’s techniques and that measurable gains in verbal areas were directly related to the
amount of instructor training in the mediation processes. It was evident that one of the weaknesses in Feuerstein's programs was the training of competent mediators who were skilled in guided questioning.

**Influence of mediator.** According to Feuerstein (Presseisen & Kozulin, 1994), a key component in the learning process was the dynamic involvement of learners in the construction of their own knowledge. This construction, facilitated by mediators, enabled students to transition from a state of passive dependence to active autonomy. Thus, mediators enabled students to frame, filter and define stimuli rather than be ruled by them, thereby enlarging the static view of behaviorists. It was Feuerstein who claimed that reflective, intelligent behavior could be enhanced and that instruction should go beyond given information. Vygotsky's zone of proximal development took on new meaning as Feuerstein (1980) affirmed the propensity for change within all learners. The view that intelligence was malleable gave new impetus to the importance of socialization and the power of interactive language.

Behavioral treatment interventions have proliferated in recent years with 90% of special educators reporting using them (Bender, 1992). These treatments, such as positive reinforcement, token economies, and behavioral contracts provide external controls and a structuring of the environment necessary for student learning. Feuerstein (1980), in contrast, proposed internal structural changes. He
postulated that mediators (i.e., teachers) in the learning process have the
opportunity to create an environment that gives learners the propensity to change.
A stimulating environment, according to Feuerstein, could overcome and even
negate distal (hereditary) and proximal (environmental) etiological factors
contributing to learning disabilities.

Alteration of the environment alone, however, does not modify the
individual. To Feuerstein, humans are not modified merely by stimulation. It is the
mediator who creates order, focus and meaning from the stimuli and by so doing,
is able to create a new orientation or disposition in the learner. Mediation, as
defined by Feuerstein, is not a teaching process, rather, a quality of interaction
producing both behavioral and cognitive change within the student (1993).

Reflecting upon the contemporaries, Piaget and Vygotsky, Kozulin (1993),
a modern Russian psychologist, cited overlapping elements in their work:
(a) children were not to be viewed as miniature adults; (b) a child’s mind was
structurally organized; it did not develop in a continuous, quantitative way; and
(c) language was a powerful psychological tool and played a dramatic role in a
child’s mental development.

Cognitive revolution. Kozulin (1993) spoke of a cognitive revolution in
process, which moved the learning environment beyond stimulus/response
behaviorism into dynamic unpredictability. Egocentrism, verbal syncretism,
interaction of thought and language, the zone of proximal development, mediation, and cognitive modifiability, each provided the building blocks of a new psychology in the understanding and treatment of learning disabilities (Kozulin, 1993).

**Neurological Implications of Learning**

**Human modifiability.** What lies behind the failure to learn? Educators often cite the presence or absence of an entity called “intelligence” as a crucial factor in school success. At one extreme, Jensen (1969) held that mental ability is largely determined by genetics and, therefore, inaccessible to substantial modification. He proposed that we accept the “limits” imposed by heredity and adjust educational goals downward for those with low intelligence.

Another view was that poor academic performance could be traced to unreasonable demands imposed by an insensitive school system. This theory implied that merely altering the student’s learning environment would eliminate poor performance. Both positions appear to be oversimplifications and fail to recognize that deficient cognitive functioning is neither culture bound nor limited to the classroom but occurs in all life situations (Link, 1986).

**Theories of intelligence.** When intelligence was conceptualized in quantitative terms as a fixed product of ability that was constant through life, passive acceptance of the present condition was the outcome. Binet, author of the intelligence scale, wrote in 1909 (as cited in Campioni, 1989):
I have always believed that intelligence can, to some extent, be taught, can be improved in every child, and I deplore the pessimism that this question often evokes. There is a frequent prejudice against the educability of intelligence. The familiar proverb which says, "When we are stupid, it is for a long time," seems to be taken for granted by unscrupulous teachers. They are indifferent to children [seemingly] lacking intelligence, they don't have any sympathy for them... [they] assert that intelligence is a fixed quantity, a quantity which cannot be increased. We must protest and react against this brutal pessimism and show that it has no foundation. If it were not possible to change intelligence, why measure it in the first place?

(p. 155)

Evidence appears to be mounting that the human mind is open to modification at all ages and stages of development (Feuerstein et al., 1994; Link, 1986; Swanson & Keogh, 1990). This evidence seems to be largely ignored by current practice in special education, which attempts to set "realistic limits" upon students based upon their current levels of intellectual functioning. Thus, students' cognitive structures are considered an immutable entity and any attempts to elicit change are kept within this presumed capacity. In other words, the mind is perceived as a rigid container with predetermined limits as to how much it can contain (Link, 1986).
The issue then becomes: What should be modified, the learner or the material to be learned? Rationales have been developed to support both positions. In modifying the material to be learned, there was a basic acceptance of learner limitations, the recognition of a need for multimodal instruction, flexibility in service delivery options, and the desire to alleviate pressure on the student (Lerner, 1993). In modifying the learner, there was the consideration of the creation of the zone of proximal development, the malleability of the brain and cognitive processes, the educability of intelligence, and the power of mediation upon student learning (Feuerstein, 1980; Feuerstein et al., 1994; Vygotsky, 1962/1975).

At the heart of the matter is the issue of whether the mind is an open or a closed system (Link, 1986). When intelligence is conceptualized in quantitative terms as a fixed entity, constant through life, passive acceptance of the present condition is the outcome. As a result, attempts to modify an individual’s development are regarded as futile, even unfair, because they demand the impossible. When students are labeled and classified in a particular category based upon diagnostic testing, a self-fulfilling prophesy holds devastating implications for the ultimate destiny of the student. According to Carnine (1992), “As long as educators believe that a learning disability makes a student incapable of higher order thinking, they will not search out and implement effective interventions” (p. 2).
Educational research appears to be rediscovering the works of Vygotsky (Kozulin, 1990; Lipman, 1991; Moll, 1992; Wertsch, 1985) and Feuerstein (Jones & Pierce, 1992; Lidz, 1987; Presseisen & Kozulin, 1994; Sharron, 1987). Emerging from the research is the concept of the enhancement of student autonomy and the need to explicitly teach students how to think. Both Vygotsky and Feuerstein took a strong sociological approach to the development of intelligence and cognition. They both viewed development as a dynamic process (Sternberg, 1990; Tharp & Gallimore, 1991). A rich literature on cognitive modifiability confirms that thinking and problem-solving can actually be taught to all children, even those with LD (Bransford & Vye, 1989; Haller, Child, & Walberg, 1988).

**Structural cognitive modifiability.** At the heart of Feuerstein’s theory of structural cognitive modifiability is the notion that modifiability is a departure from a predicted form of development and creates within the learner a propensity for change. Simple cognitive modifiability can be defined as an additive process (i.e., modification of a behavior or repertoire of skills). When an individual is modified structurally, however, the whole course of cognitive development is open to alteration. Furthermore, modifiability is not limited to cognition, but as a holistic phenomenon with intersystemic effects, it also impacts behavior. “Suddenly, a new way of thinking, acting, and aspiring appears and a new type of existence emerges.
modifying the trajectory of your life" (Feuerstein, 1993). Structural modifiability was seen to be present when the effect of a certain trend continued beyond the point of intervention by a human mediator. If the change had been structural, rather than additive, the learning continued to become enhanced and ever more efficient over time.

According to Feuerstein (1993) human beings have the option of being modified. Not all are equally open or available to change. Also, modifiability can be bidirectional, either toward improvement or deterioration. Human behavior is seen to be in a continual state of dynamic unpredictability. As a result, the mediator’s role is to lead students to greater understanding depending upon their responses.

**Plasticity.** The evidence is abundant from a neurological perspective that functional plasticity is a general property of the brain (Restak, 1994; Witelson, 1985). Functional plasticity or equipotentiality was seen as the restitution of function after brain damage. Neural plasticity, on the other hand, referred to the hypothesized neurobiological changes underlying the recovery of function. Bakker (1992) found evidence that stimulation of left-hemisphere functioning improved reading skill in students with LD. Das et al. (1995) found that cognitive training improved decoding deficits. Further, Tallal, Miller, and Fitch (1993) found evidence that dysfunction of higher level language processing was the result of
basic sensory processing weaknesses and that these processing deficits were reversible.

In light of these neurobiological constructs educators may well ask, "Can a particular intervention induce structural changes within the brain?" Some leading neurologists assume that intensive educational intervention may actually change the structure of the brain, not just alter its function (Wood et al., 1991). Alternately, lack of effective cognitive stimulation may inhibit neuronal growth (Healy, 1990).

The brain appears to reorganize itself on the basis of experience (Restak, 1994). Thus, neurologists now believe that the brain is not organized hierarchically as was once assumed, but is arranged according to a distributed system composed of large numbers of modular elements linked together. This means that information that flows through such a system "may follow a number of different pathways and the dominance of one path or another is a dynamic and changing property of the system" (Restak, 1994, p. 35).

In many ways the environment affects the true expression of the brain's genetic potential or plasticity. Plasticity has been defined as a property of the brain during development and that development lasts a lifetime (Galaburda, 1993). The influence of a human mediator in the learning process appears to play an important role in the shaping of thought patterns.
Reid (1988) cited the years between 1970 and 1980 as ushering in a new approach to the study of learning. Prior to that decade, the vast majority of research was based on the premise that humans were essentially passive organisms responding to environmental influences. Gradually, however, researchers began to view children as active learners bringing four basic sets of characteristics to the learning negotiation: strategies, knowledge of the world, metacognition, and capacity (Reid, 1988).

Instruction in the field of LD has sought to keep pace with the active learning paradigm (Lerner, 1993). For example, Palinscar, Brown, and Campione (1991) developed a model of reciprocal teaching and Ellis, Deshler, Lenz, Schumaker, and Clark (1991) developed a process of formal instruction in learning strategies. These approaches and others were designed to capitalize on active learner involvement in a task. The fact that a stimulating learning environment might enhance inherent neurological functioning has long been a distinct possibility.

**Stimulation of Deficient Functioning Rationale**

Schilder (1964) proposed that training stimulates maturation. In an early experiment, Silver, Hagin, and Hersch (1967) confirmed that the stimulation of deficient perceptual areas led to improved reading ability. They cited Itard (1962) as the innovator in the educational application of theories of perceptual stimulation.
in his attempts to educate the wild boy who had been found in the woods near
Aveyron. Itard regarded human inequalities as due solely to differences in
education and experience and demonstrated that modalities differed in response to
training. Summarizing the results of their experiment, Silver et al. (1967) stated:

In short, in each child the stimulation of the deficient perceptual areas in
the manner described resulted in generally improved perception in those
areas. It is as though a function left behind in successive waves of
maturation may be stimulated to a level more appropriate to the child’s
total development. The results so far suggest that where perceptual defects
are first trained out, reading instruction at intermodal and verbal levels will
have a better chance of success. (p. 751)

Later studies have confirmed the results of these early experiments.
Identification of core deficits in reading, spelling and mathematics has led to a
series of experiments providing a direct attack on the specific areas of deficient
functioning. For example, Wade and Kass (1987) identified component deficits
that are characteristic of learning disabilities and found that direct stimulation of
these deficits resulted in increased academic functioning. Lovett et al. (1994)
discovered clear evidence for transfer of learning after treatment of core reading
deficits. The direct attack upon deficits must be systematic, focused and intensive,
a consistent finding across studies. Bakker (1989) proposed a neurological perspective of deficient cognitive functioning:

In the same manner in which a river responds to rain and drought our nervous system responds to psychological rain and drought, i.e., to the presence and absence of stimulation from the environment. Sufficiently powerful stimulation causes the nerve cells to fire whereas a sufficient drop of stimulation causes a “cease-fire.” (p. 173)

According to Bakker (1989), the very structure of the brain, that is, its anatomy, chemistry and physiology may change upon psychosocial stimulation. Hemisphere specific stimulation of students with specific reading disabilities served to “boost” the brains of students with LD to function more efficiently.

Although more research is needed to confirm the effects of selective neurological stimulation, preliminary studies seem to indicate that deficient cognitive functioning may be stimulated through a direct attack upon specific perceptual and cognitive impairments. Bakker (1989) concluded that neuropsychological stimulation is not able to change the concrete aspects of the brain. It does, however, have the capability of altering the tuning of the brain by changing the size of the neuronal cell bodies, the length and branchings of dendrites, the number and quality of synapses, and the amount of various neurotransmitters.
Thus, it appears that when a selective part of the brain was stimulated, as Bakker demonstrated in a study on left- and right-hemisphere reading skills, the altered performance is a result of stimulation-induced anatomical and/or physiological alterations (Bakker et al., 1995). The brain appears to be an ecological entity, that is, environmental manipulations affect an alteration in neural parameters. Given the plasticity of the human brain, it is instructive to examine the role of the two hemispheres and the corpus callosum, the connecting bundle of nerve fibers, in the learning process.

**Development of Hemispheric Specialization**

Healy (1987) aptly stated “children are whole brain learners and the brain prefers cooperation to conflict” (p. 125). From infancy, the left hemisphere has a tendency to act as “boss,” and this dominance continues with the development of language comprehension and speech.

A summary of findings follows:

1. Hemispheric specialization is present from birth. Development of the brain is influenced by early auditory and verbal stimulation, which increases left-hemisphere capabilities. Children with hearing disabilities, for example, show a pattern of hemispheric organization that is different from that of hearing children (Best & Gladstone, 1985; Healy, 1987).
2. Individuals vary in their ability to activate the appropriate hemisphere for different demands. Such flexibility, or lack thereof, may be a major factor in intellectual ability (Healy, 1987; Kronick, 1988; Restak, 1994).

3. The hemispheres communicate by way of the corpus callosum. There is evidence that this bundle of nerve fibers holds the key to mental efficiency by activating and suppressing hemispheric control. For example, in reading, both visual and verbal abilities are used, but if the language hemisphere does not take control accuracy, fluency and comprehension suffer (Healy, 1987; Hynd et al., 1995; Walsh, 1978).

4. Dominance denotes asymmetry in hemispheric function, that is, the hemispheres subserve particular functions to an unequal degree. Each side of the brain is able to perform and chooses to perform a certain set of cognitive tasks which the other side finds difficult, distasteful or both. The right hemisphere synthesizes over space and the left hemisphere analyzes over time (Best & Gladstone, 1985; Restak, 1994; Walsh, 1978).

**Neurophysiological explanation.** Orton (1989) was the first to develop a neurophysiological explanation for learning disabilities. He believed that confusion arose in the thinking processes of individuals when clear-cut hemispheric dominance failed to be established. Recently, findings of Galaburda (1993)
revealed the presence of anatomical symmetry in the brains of those with LD providing support for Orton's thesis of confusion and cerebral dominance.

The most elaborate neuropsychological model of reading disability was presented by Satz and Sparrow (1970) who defined developmental reading disability as a failure “to acquire normal reading proficiency despite conventional instruction, socio-cultural opportunity, average intelligence, and freedom from gross sensory, emotional or neurological handicap” (p. 17). Failure to attain normal reading proficiency was explained as a functional delay of left-hemisphere specialization.

Masland (1975) formulated a different theory of reading disability that stressed left-hemisphere dysfunctioning, arguing that connections within hemispheres seemed to be more easily affected than connections between hemispheres. He explained that overdevelopment of the right hemisphere impeded the functional development of the left.

Bakker (1983) posited that proficient reading was correlated with right-hemispheric speech control at an early age and left-hemispheric speech control at later ages. This hypothesis was tested in a later experiment in which Bakker et al. (1995) identified P and L type dyslexics. P-type dyslexia had its roots in the functional overdevelopment of the right hemisphere and/or underdevelopment of the left. This student relied upon spatial, perceptual cues, reading slowly and
laboriously. The L-type dyslexic, on the other hand, was related to the functional excess of the left hemisphere and/or weakness of the right hemisphere. Because initial reading requires close attention to the perceptual features of the text, L-type dyslexics made many substantive (perceptual) errors.

Best and Gladstone (1985) argued that hemispheric specialization does not change throughout a person's lifetime, but cognition does. As cognitive skills emerge over time they tap different types of processing skills lateralized in the two hemispheres. To Witelson (1985), hemispheric specialization in a healthy brain implied a relative status in the contribution of the two hemispheres in mediating a particular cognitive process. She wrote:

The essence of hemispheric specialization is only that each hemisphere is more involved and possibly more efficient than the other in mediating some cognitive tasks. Hemispheric specialization does not imply a quantitative dimension, namely, that more cognition is mediated by one hemisphere than the other, nor a qualitative aspect, namely that information processing of one hemisphere is at a higher level than that of the other. Unfortunately, hemisphere specialization is often implicitly assumed to include such attributes. (p. 38)

Role of the corpus callosum. The role of the corpus callosum in interhemispheric communication has been well documented (Witelson & Kigar,
The corpus callosum is important for the functional integration of the two cerebral hemispheres as well as for the manifestation of hemisphere functional specialization. Recent studies have determined that the corpus callosum is significantly smaller in students with disabilities (Hynd et al., 1995). It was found that subtle neurodevelopmental variation in the morphology of the corpus callosum may be associated with the difficulty that dyslexic children experience in reading and on tasks involving interhemispheric transfer. In light of theories of cognitive stimulation, these structural abnormalities may be alterable given the role of interactive speech and the dynamic involvement of a mediator in the learning process.

**Role of Mediator in Learning Process**

Believing that it is the learner, rather than the material to be learned that can and should be modified, Feuerstein (1980) advanced his theory of mediated learning. In Feuerstein’s conceptual framework, children from economically and psychologically impoverished homes perform poorly on intelligence tests and function at a generally low level because they have been denied appropriate mediated learning experiences. Specifically, this type of deprivation was explained as the absence of adults in a child’s life who could effectively focus attention and interpret to the child the significance of objects, events and ideas. In Feuerstein’s view, the cognitive development of the child is not solely the outcome of the
process of maturation, but the child’s interaction with his or her culture and environment guided by a mediator. This concept of mediated learning experience provides the theoretical foundation for the “reversibility of deficient cognitive processes under specified conditions of intervention” (p. 17).

Luria (1961) highlighted the role of speech in the formation of mental processes. He asserted that children’s mental activities are conditioned from the beginning of their development by their social relationships with adults. Vygotsky (1962/1975) recognized the mother as the primary facilitator in the development of new functional systems within the child that eventually formed the essence of all higher mental activity. Interactive dialogue between mother (mediator) and child led to the development of inner speech, which became the basis of cognitive growth and development.

As mentioned, Piaget (1959) traced the child’s development from egocentric to socialized thought. Children’s mental development underwent a gradual change of character from undirected or autistic thought to directed or intelligent thought. “Directed thought” was defined as conscious and aware, pursuing a specific aim, whereas “intelligent thought” referred to the ability to adapt to and influence reality as well as the ability to communicate through oral language. In contrast, “autistic thought” was defined as being subconscious, not adapted to reality, remaining strictly individual and incommunicable.
A mediator's role, therefore, was to enable the child to give verbal expression to inner language, thus influencing the structure and development of logical, directed thought. Piaget (1959) described the development of a syncretism of understanding:

This is more or less how things happen. When the child hears people talk, he makes an effort, not so much to adapt himself and share the point of view of the other person as to assimilate everything he hears to his own point of view... perception and understanding are thus syncretized because they are unanalyzed and unadapted. (p. 154)

Clearly, a facilitator or mediator is needed to bring a child into what Vygotsky called “the zone of proximal development.” This coaching of the thinking process has been supported by recent theorists and research both in the field of education (Caine & Caine, 1991; Debray, 1994; Healy, 1990; Kronick, 1988; Scruggs, Mastropieri, & Sullivan, 1994) and in neuropsychology (Bakker et al., 1995; Donahue, 1986). Guided questioning has been found to be instrumental in fostering metacognitive thinking (Kronick, 1988). For example, students coached in relational thinking statistically outperformed those in a control condition (Scruggs et al., 1994). A summary of studies indicated that elaborative interrogation techniques significantly impacted student performance.
**Nature of thought.** New findings relative to the brain's organization for language have prompted new ideas about the nature of thought. Through the use of technology it has been determined that each individual has a unique brain pattern underlying language ability. Components of language were found to be stored in several discrete brain areas. Scientists have discovered what are called "convergence zones", in which clusters of neurons that store knowledge of the attributes of a given word (for example, "cup") are activated and project their information (i.e., size, color, function, etc.) to a common convergence zone (Restak, 1994). "Cognitive abilities such as language are the result of the concerted activity of many simple processing mechanisms distributed in many different regions of the brain" (p. 66).

It is this new understanding of brain function that must illuminate our educational practice. Contemporary methods in special education have tended to emphasize direct teaching of skills and content (Bos & Vaughn, 1988; Carnine & Silbert, 1979; Mastropieri & Scruggs, 1991). These methods involve explicit teacher provision and practice of specific information and have been validated through a number of studies.

Indirect teaching methods aimed at the development of inquiry and inferential thinking have been less frequently used with deficient learners. In a recent study, Scruggs, Mastropieri and Sullivan (1994) found that students...
coached in relational thinking statistically outperformed those who received direct instruction or teacher provided information. The role of the mediator in a process of dynamic interaction appears to facilitate language development and enable the student to move beyond rote responses.

In another recent study, Leshowitz, Jenkens, Heaton, and Bough (1993) found that students with learning disabilities could be taught critical thinking skills exceeding those of a control group in regular education. A key component in their study was the element of interactive dialogue between teacher and student. Guided questioning provided the scaffolding, which took students to higher levels of reasoning and conceptualizing.

Nature of the learner. Kronick (1988) defined a learning disability as a breakdown in dynamic functioning. Luria (1976) found that the difference between educated and uneducated persons was the ability to think abstractly and to generalize. Despite education, concretely thinking individuals with learning disabilities still failed to master the transition to abstract and generalized thought, which Ong (1982) cited as a quality of written language thinkers.

The process of direct instruction (DI) grew out of the principles of behavioral psychology (Lerner, 1993). Significant characteristics of this method include teacher direction and control, carefully structured materials, continuous monitoring, review, and consistent feedback. Teacher-directed instruction is not
to be equated with effective mediation. In fact, teacher-directed instruction may
"promote passivity, lack of commitment and static thought" (Kronick, 1988, p. vii)
in the learner. If, as has been posited, students with learning disabilities are
capable of higher level abstract reasoning, the role of the mediator is critical. The
interaction of thought and language provided the tools for cognitive restructuring
(Bakker, 1989; Berk & Winsler, 1995).

Cognitive Dysfunction and Restructuring

Two models advanced by Kershner (1988) attempted to explain learning
disabilities in the light of brain functioning. The neurological model (NM), based
upon a social network metaphor, described the brain as a unified and differentiated
community where tasks competed for functional brain space. In this model,
resources were shared by the two hemispheres, which were asymmetrically
activated. Interference between tasks occurred both within and between
hemispheres when tasks encroached upon the same conceptual space. Problem-
free learning took place when neurons could function unimpeded by neighboring
neurons. In this model, similarity of tasks produced the greatest confusion for
learners.

A second model, the resource model (RM), was based upon a
microeconomic metaphor in which the brain was conceptualized as a two-vaulted
repository of different valued currencies paid out to tasks in a competitive
marketplace where resources were in short supply. Problem-free learning occurred as long as tasks did not exceed resource demands. The educational priority of this model was to make tasks easier.

Kershner’s models underscore the position that manifestations of learning disabilities involve many different perceptual and cognitive processes (Hynd et al., 1995). Studies have supported the position that students with LD have difficulty accessing and coordinating a number of mental activities (Swanson & Keogh, 1990). Spreen (1988) suggested that the problem of higher order processing deficits was pervasive over time. Indirect evidence has shown that individuals with learning disabilities use qualitatively different mental operations rendering them "actively inefficient" learners (Swanson, 1990). Specific cognitive deficiencies include: lack of precision, poor organizational strategies, difficulty perceiving and extracting relevant information, difficulty forming hypotheses, imprecise language, difficulty coordinating perception with memory and attention, difficulty with discrimination as well as lack of available strategies with which to check the correctness of a solution (Brown & Campione, 1986).

Given the complexity of potential dysfunction within the brains of individuals with learning disabilities, it is not surprising that educators have been reluctant to provide a direct and focused attack upon the deficits. Clearly, an understanding of brain functioning has provided the rationale if not the tools for
direct and intensive intervention. Preliminary research seems to support the potential for cognitive restructuring. The time has come for an increased collaboration between educators and neuropsychologists.

A Meeting of the Minds - Neuropsychologists Meet Educators

Modern theorists have begun to question historical assumptions relative to brain functioning. Specifically, Gall's theory of localization (Krech, 1962) suggested that each area of the brain had a specific, discrete function that was exercised in isolation from skills in the rest of the brain. Later, Flourens (Luria, 1980) developed assumptions, which led to the emergence of the equipotential theory of brain function. That is, all brain tissue was viewed as equivalent in terms of what it could and could not do. Both of these theories have dominated American psychology and education leading to the classic description of the "brain-damaged child," which included attention deficits, emotional lability, coordination difficulties and poor academic functioning.

However, a growing realization of the inadequacies of both theories has led to the postulation of alternatives. Perhaps the most well-known alternative was given by Luria (1973, 1980), who initiated the concept of the brain as a functional system. Specifically, Luria proposed that each area of the brain could operate only in conjunction with other areas of the brain to produce a behavior. No one area of the brain was seen to be solely responsible for any voluntary human behavior.
(Luria, 1973, 1980). Further, Luria postulated that the specific areas involved in a behavior depended upon how the behavior had been taught. For example, the person who learned a phonetic approach to reading would not use the same functional systems as a sight reader. As a consequence, when overt behaviors were seen to be similar (i.e., reading), it should never be assumed that the underlying functional systems were the same.

Within this context, consider textbook definitions of learning disabilities, which have stressed the specificity of impairment. A child was thought to possess a single level of intelligence that permeated all of his or her abilities. Ceci (1990) proposed a modular rather than a singular view of cognitive function. That is, students with learning disabilities may not differ from other youngsters in the number of mental processes they possess or in the mental steps they take during cognitive processing. Rather, more of their processes may be located at the low end of the efficiency continuum (because of biological disposition and/or lack of informational elaboratedness) than their higher functioning peers.

Neurologists have deplored the simplistic view held by educators who are caught in the right- and left-brain dichotomy (Harris, 1988). Champions of specific left- or right-brain training have ignored the neuropsychological evidence. One of the most pervasive errors has been the characterization of highly complex, multidimensional cognitive processes as simple and unidimensional, thereby
supposing that they can be localized "in toto" in either the left or the right brain. Despite an absence of neurological evidence that any cognitive task involves only one hemisphere, the educational myth seems to perpetuate. Harris concluded:

What should neuropsychologists tell educators and the general public about the brain and about lateral specialization? We should present the basic research in appropriate detail with the qualifications and cautions always necessary in a developing science... Perhaps some day... we shall have learned to tailor learning environments to individual cognitive-cerebral organization and to improve individual performance on specific tasks through controlled shifts in cerebral balance. But..., we have not yet reached that point. (p. 229)

Is the future so distant? Or do we, as educators, have enough evidence from the scientific world to justify the stimulation of cognitive processing which we know to be modular and dynamic rather than singular and static? Another look at the importance of the role of language in dynamic discourse was instructive.

Dynamic Interaction Between Teachers and Students

According to Restak (1994), "Above all, the brain is a dynamic organ, so dynamic in fact that as I write that word 'dynamic' I am aware that the word doesn't adequately express the true state of affairs" (p. 4). The pioneering
neurophysiologist, Sir Charles Sherrington, in a frequently quoted passage, came as close as anyone to describing the dynamism of the human brain:

- It is as if the Milky Way entered upon some cosmic dance. Swiftly the brain becomes an enchanted loom where millions of flashing shuttles weave a dissolving pattern, always a meaningful pattern though never an abiding one; a shifting harmony of subpatterns. (Restak, 1994, pp. 4-5)

Typically, students with learning disabilities have demonstrated difficulties across areas of functioning (Kronick, 1988). For example, children who were poor at organizing their belongings did no better at organizing use of time or spoken or written language. In order to assess breakdowns in dynamic functioning, it is important to outline specific competencies (see Kronick, 1988, for a complete description).

The development of spoken language is an important construct. French (1985) reflected current thinking when he proposed that children’s cognitive development is best characterized as a process of gradual decontextualization. That is, children become increasingly able to generalize learning to a variety of contexts, thus moving beyond egocentrism. Children progress from the use of language as a “toy” to the complexity of communication involving the ability to distance themselves from language and reflect upon meaning.
The move to increased complexity does not occur in the absence of social contact. In fact, Vygotsky (1962/1975) described the role of the teacher as provoking occasions of discovery through a kind of alert, inspired facilitation and stimulation of children's dialogue, co-action and co-construction of knowledge. Vygotsky regarded the discourse of schooling as qualitatively different from everyday interaction. Children could be taught to appreciate language as a system and use it as a tool for thought.

In a recent study involving reciprocal teaching (Palinscar, Brown, & Campione, 1993) strategies conveyed to students through dialogues scaffolded by an adult expert led to impressive gains in the students' higher mental functions. According to Vygotsky (1978), behavior must first be regulated through dialogue with a more capable individual surrounding challenging tasks, then by the self-directed utterances of the learner. Inner speech then would go underground and become more rapid, abbreviated and silent as new skills became automated.

This phenomenon has been observed in teachers as well as students (Berk & Winsler, 1995). When teachers were asked to describe their inner speech upon learning a new approach to this instructional dialogue, they reported thinking to themselves in ways quite different than before. For example, in a guided questioning format supporting the child’s zone of proximal development, teachers had to learn to tailor each new question in order to extend students’ skills and
knowledge. “As a result, the experience of teaching became more serendipitous and cognitively demanding, but also more experimental, stimulating and gratifying” (Berk & Winsler, 1995, p. 123).

In a program consistent with Vygotsky’s framework, the Reggio Emilia program in Italy, teachers learned to “catch the ball that children throw at us and toss it back in a way that makes children want to continue... developing other games as we go along” (Berk & Winsler, 1995, p. 113). The teacher served not just as a skilled moderator of dialogue, but also as the designer of a highly literate environment in which children used oral and written language to construct meaning.

Moll and Whitmore (as cited in Berk & Winsler, 1995) summarized the variety of roles the teacher (mediator) assumed when engaging in interactive dialogue. First, the teacher acted as a guide and supporter helping students to organize their questions and ideas, ensuring that each child experienced academic success. Second, the teacher became an active participant in learning, exploring, experimenting, and collaborating with children. In addition, the teacher became a facilitator, structuring the environment and selecting materials that fostered purposeful use of language and learning strategies. Finally, the teacher assumed the role of an evaluator monitoring individual development, and continually reformulating learning experiences to fit the students’ changing needs.
In Piaget’s view, children were not capable of truly harmonious, cooperative interaction with agemates until they overcame their egocentrism (Piaget, 1959). Vygotsky, on the other hand, saw peer interactions as facilitators of cognitive development. In other words, children’s capacity to collaborate needed to be cultivated by adult interaction (Berk & Winsler, 1995).

Dynamic interaction between teachers and students appears to produce higher cognitive function in both (Berk & Winsler, 1995). Thus, structured dialogue, guided questioning, and verbal stimulation have been found to play an important role in the brain’s physiological growth and development (Healy, 1990).

Implications for students diagnosed with learning disabilities surface. Could deficient cognitive functioning be successfully stimulated? The plasticity of intelligence and recent research developments suggested that it could. A closer look at some components of interactive learning theory provides the framework for an emergent model of intervention.

**Interactive Learning Theory Components**

**Metacognition.** In 1964, Lewin and Festinger created a dynamic model of individuals acting upon their constructs, or thinking about thinking (cited in Kronick, 1988). The theory of metacognition, or reflection, allows us to explain why different learners, despite similar knowledge bases, made different choices. It described the continuous process whereby individuals mediated and adjusted
meanings and monitored their own and others' productions. Most importantly, the
notion of metacognition embraced the mind as it acted on events, so that teachers
could move beyond the training of mental processes that were removed from
behavior and context (Swanson, 1993).

Despite the enthusiasm that the concept of metacognition has generated in
the LD field, it appears that children below fifth grade are unskilled in evaluating
their knowledge or memory capacity (Moynihan, 1973; Tenney, 1975). However,
Meichenbaum and Goodman (1971) found that kindergarten-aged children
mediated tasks verbally and Luria (1981) reported that children aged three to three
and a half years were able to mediate their behavior linguistically. Bruner (1983)
noted that by the second year of life, infants' self-awareness and evaluative
standards were already in place.

These findings have encouraged those who saw promise in the active
monitoring of learning as a means of inculcating organized, reflective thought in
students with learning disabilities. Metacognition has also been embraced as
possibly providing a solution for the insidious passivity (learned helplessness) that
has consistently been observed in a large number of students with learning
disabilities (Kronick, 1988).

Because of the excitement these findings generated in the LD field, hope
arose that inefficient learners could be taught systematic methods. Thus, the
cognitive behavioral approach to remediation was conceived (Brown & Alford, 1984; Hallahan & Sapona, 1983). However, the teaching of rote strategies, out of context, with the conviction that such training would generalize proved disappointing (Kronick, 1988).

Metacognitive strategies originate with the learner, whereas cognitive behavioral strategies are imposed upon the learner. The underlying assumption of imposed strategies is that all individuals mediate tasks in a similar way. Kronick (1988) elaborated:

We have every reason to believe that no two people interpret or select priorities for tasks or events in the same manner, and we know that similar tasks invariably are modified in relation to momentary context. It is impossible to create functional people by teaching them rote strategies to use in relationship to tasks or in response to events because it is impossible to anticipate the context they will encounter in life. (p. 17)

The dynamic of metacognition extends beyond the limits of cognitive behaviorism. The process of comparing one’s own productions with those of others was viewed as an individual, lifelong endeavor. Students with learning disabilities, in their particular areas of deficit, are not able on their own to critique their own productions, use problem-solving to identify alternatives, or add facets
of others’ productions to their own repertoire (Harris & Pressley, 1991; Kronick, 1988).

Behavioral and cognitive psychologists have commented on the difficulties in facilitating transfer of learning in students with intellectual or cognitive disabilities (Scruggs & Mastropieri, 1984). It had been assumed that metacognition played a significant role in the transfer and that it may be foundational in learning how to learn. In a recent experiment (1995), Lucangeli, Galderisi, and Cornoldi found that “programs devoted to teaching how to learn sometimes run the risk of being overly structured, rigid and demanding, thus blocking the flexible use of sufficient cognitive resources in children” (p. 17). Results of the experiment did show, however, that some learning activities could produce transfer abilities that enabled the child to extend learned strategies and abilities to new situations thus emphasizing the potential causal role of metacognition. By modifying the metacognitive level, performance was enhanced. This suggested that the development of mental abilities and knowledge about them were interconnected and mutually influenced.

Increasing evidence has revealed the role of environmental influences on metacognitive development (Moely et al., 1992). For example, bidirectional interactions between adults and children have been found to enhance the acquisition of metacognitive knowledge. Questions such as “Tell me what you are
thinking” or “How did you get that answer?” provided opportunities for reflection and the transfer of inner speech to verbal expression. A skilled mediator could draw cognition from the child in the form of oral language, possibly stimulating the brain to make interhemispheric connections.

Kershner (1988) cited the importance of metacognitive supervision in interhemispheric processing. Students with learning disabilities may have poorer control over the allocation of both left-hemisphere and bi-hemispheric resources. In students with processing weaknesses, there appeared to be what Kershner referred to as “metacognitive mismanagement.” A look at the component of cognitive processing offers further insight.

**Processing.** The human brain was viewed as having the capacity to do many things at one time (Restak, 1994). Thus, good teaching “orchestrated” the learning experience so that thoughts, emotions, imagination, and predispositions operated simultaneously and interacted with the specific modalities of information processing (Caine & Caine, 1991). In a way, the brain could be conceived as both artist and scientist, attempting to understand and discern patterns as they occurred. Caine and Caine (1991) noted that the brain resisted having meaningless patterns imposed upon it, that is, isolated pieces of information unrelated to that which made sense to a student. Feuerstein (1980) spoke of the “episodic grasp of reality” (p. 102), which characterized many deficient learners. There seemed to be
an inability to connect learning to any previous concept resulting in a series of unrelated episodes.

Lack of efficiency in learning may be totally unrelated to the individual's capacity to grasp and elaborate a particular problem (Feuerstein, 1980). Kronick (1988) postulated a breakdown in dynamic functioning as a possible explanation for learning difficulties. That is, the world should be perceived as rhythmical and patterned, and these patterns or schemata mutually negotiated within interactions seemed to have broken down. Thus, individuals with learning disabilities who were unaware of their patterns or rhythms lacked focus, which impacted both memory and predictability. To Kronick, focus could be achieved by coordinating goals with a mediator, leading to the establishment of priorities and mental organization.

The breakdown in learning negotiated language and its template, inner language, had impact on the ability to achieve flexible thought and the realization that there may be alternative strategies and explanations. Moreover, the boundaries between inner language and spoken language were perhaps poorly conceptualized so that students with LD were seen as uncertain when to imagine speaking or behaving and what to edit from their language or behavior (Kronick, 1988).
In investigating the neurobiological basis of speech, Tallal et al. (1993) found that dysfunction of higher level speech processing may have resulted from difficulties in the processing of basic sensory information entering the nervous system in rapid succession. These authors presented evidence to suggest that the inability to integrate this sensory information affected processing in multiple sensory modalities leading to a cascade of effects impacting the ability to speak and read normally.

Merzenich (cited in Tallal et al., 1993) theorized that a lack of critical experience in early development could bias the nervous system, rendering it unable to process rapidly presented information. Further, because the brain had to ensure that it kept the external world in sync, processing in all modalities would have to adjust to the slowest processing rate of any single modality.

A growing interest in the concept of executive function and its role in cognitive processing has been expressed (Welsh, 1994; Welsh, Pennington & Grossier, 1991). Rather than holding to traditional discrete categories of cognition, such as attention, memory, language, and so forth, executive function was defined as an overarching concept that regulates, integrates and coordinates the various cognitive processes toward goal-directed behavior. These cognitive functions were ascribed to the frontal cortex of the brain and included such skills
as planning, organized search, flexibility of strategies, impulse control and self-monitoring.

The child’s deficiencies in these areas will require that external cues, structure and scaffolds be provided by the teacher, parent, and educational therapist. The working assumption is that the intervention system must bolster the weak frontal cortical system of the child. (Welsh, 1994, p. 38)

**Functional Systems**

Luria assigned specific functions to each of the areas of the brain and divided the brain into three basic units (see Figure 1, p. 68); Unit I: Arousal and attention processes, or the Reticular Activating System (RAS), Unit II: Sensory reception and integration, and Unit III: Motor execution, planning and evaluation (Golden, 1991). Each of these units was seen to be involved in all behavior, without exception, though the relative contribution of each unit varied with the behavior. Within the second and third units were located primary, secondary and tertiary areas. The auditory primary area was found in the temporal lobe, the visual primary area in the occipital lobe and the tactile/kinesthetic in the parietal lobe. The secondary areas analyzed and integrated the information received in the primary areas.

According to Luria (see Golden, 1991), it was the tertiary levels of the parietal and frontal lobes that played the greatest role in cross-modal integration.
and simultaneous analysis of input from the sensory modalities. In particular, the tertiary parietal areas played a major role in efficient cognitive functioning on academic tasks. Auditory-visual integration was necessary for reading and auditory-tactile integration was necessary for writing. Additionally, there was increasing hemispheric differentiation of tasks at the tertiary level in the second unit. Any breakdown in functioning in the primary or secondary levels would impact the development of tertiary level skills.

The tertiary level of the third unit, called the “prefrontal lobes”, represented the highest functioning of the human brain. Major tasks of this area were planning, decision-making, evaluation, temporal continuity, focus of attention, creativity, and flexibility (Luria, 1980). As the prefrontal lobes developed, they assumed dominance over the first unit of the brain (RAS). Students with LD were found to have difficulty with highly integrative tasks located in the tertiary areas (Kronick, 1988; Swanson & Keogh, 1990).

Processing, then, must not be viewed in terms of specific, discrete categories of function that are defined in isolation. Rather, the brain’s complexity demands that we understand interhemispheric connectedness and design appropriate interventions based upon that knowledge.
Figure 1. Functional systems

Unit I
Arousal
Attention Processes

Unit II
Sensory Reception
and Integration

Unit III
Motor Execution,
Planning and
Evaluation

Tactile/Kinesthetic primary area

Frontal

Parietal

Occipital

Temporal

Visual primary area

Auditory primary area

Luria (see Golden, 1991)
Intensive Intervention

How important is intensity in the process of intervention? As has already been documented, stimulation of neurological functioning appears to be able to affect changes in brain morphology. This stimulation or activation of processes requires intense concentration and hard work on the part of the teacher/mediator. Bakker (1989) found that a certain subtle pressure had to be placed on the student so that thought processes were activated. Intensity of the instructional climate implied concentrated effort, a sense of direction, and a high level of interaction between the student and the teacher.

Recent studies have confirmed that a systematic, focused attack upon core areas of deficit produces significant reading gains and transfer of learning effects (Lovett et al., 1994). For example, programs that attempted to use the reader’s relative strength in whole-word learning suggested that given a choice, the child with a reading disability avoided word analysis and remained at a level of functioning that did not challenge the areas of greatest deficit.

The Lovett study emphasizes that success in the training process depends upon intensive intervention in a specific phonological approach to reading. “An intensive and focused phonologically-based training program appears essential: Segmentation training must be explicit - to the point of exaggeration” (Lovett et al., 1994, p. 820). The core deficits that contributed to reading failure, deficient
phonological awareness and lack of metacognitive decoding strategies, were identified as vehicles for addressing the failures of transfer of learning.

According to Feuerstein (1980), deficient cognitive functions should not be considered as elements that are missing from a cognitive repertoire; rather, they should be seen as elements that are weak and vulnerable. These functions did not appear spontaneously, regularly or predictively in the cognitive behavior of the individual with LD. The result of successful intensive intervention was the “elimination of deficient functioning directed squarely at the individual rather than at factors external to his condition” (Feuerstein, 1980, p. 69). Intensive intervention, then, as opposed to compensatory instructional procedures, appeared to affect changes in academic performance.

**Individualized Instruction**

Recent findings seem to suggest that one curriculum may not be best for all children and that it may be possible to match a program to the child's individual needs (Mills, Dale, Cole, & Jenkins, 1995). Given a presumed breakdown in the dynamic functioning of children with learning disabilities, a variety of approaches may be necessary to meet the diversity of individual needs. This may be difficult to do in an exclusive whole class environment (Berk & Winsler, 1995).

Whole-class instruction seems to work poorly to achieve the negotiation of shared meaning necessary to guide children into their zones of proximal
development (Berk & Winsler, 1995). When children were granted no more than a reactive voice in classroom dialogues, they may have had little opportunity to experiment with strategies under the watchful eye of an adult mediator and to indicate the kind of assistance they needed to achieve meaningful understanding.

Kronick (1988) commented on the limitations of focusing exclusively on the mechanical aspects of what needs to be learned in an individualized educational plan (IEP). This attempt to individualize instruction for the student with learning disabilities pays little attention to the interactive component and denies the elements of innovation and creativity in the learning process. Thus, individualization has become largely rhetorical according to Farnham-Diggory (1992). At best, it refers to the speed at which a child is permitted to advance through a fixed curriculum.

Students with learning disabilities have traditionally had significant difficulty progressing through a fixed curriculum. Research in neuropsychology suggests a variety of possible etiologies impacting deficient neurological functioning. Additionally, it has been postulated that a mediator engaging a student in interactive speech could provide stimulation of cognition. In order to effectively assess and address particular deficits, the intervention must be both individual and intense. (See Figure 2, p. 72, for Foundations and Emergent Theory.)
Figure 2. Foundations and emergent theory
An Emergent Model

In the late 1960s, Deborah Zimmerman, an educator with a medical background, began working with Drs. Silver and Hagin at Bellevue Medical Center in New York City to classify students with learning disabilities. Specific techniques were being developed to stimulate cognitive functioning and address hemispheric specialization for language.

As Zimmerman enhanced and refined these techniques, she shared them with a group of educators in Virginia led by Grace Mutzabaugh, also a nurse, educator. Over the next 20 years, the program became standardized as the National Institute for Learning Disabilities (NILD) and became established within hundreds of private, parochial schools throughout the United States.

The merging of educational and medical perspectives provided a unique backdrop for the development of an intervention program whose defining characteristic was the stimulation of cognitive functioning through interactive language. NILD's model of intervention is based upon the theoretical foundations established by Piaget, Vygotsky, Luria and Feuerstein. The interrelatedness of thought and language, the creation of the zone of proximal development, the belief in the plasticity of intelligence, and the recognized importance of a human mediator of learning all contribute to the design of techniques used in the NILD program. Additionally, insights from neuropsychology generated by research of Galaburda
(1991), Duane and Gray (1991), and Bakker et al. (1995) seemed to confirm the
importance of interhemispheric transfer and cognitive stimulation in the learning
process.

Kronick (1988) suggested that a breakdown in dynamic functioning
involving the rhythms and patterns of interactions was responsible for deficient
academic functioning in students with learning disabilities. Returning to the
premise that the processing of language is critical to a child’s neurological
development (Vygotsky, 1962/1975), consideration is given to the role of the
mediator in the stimulation of interactive dialogue in an intensive, individualized
setting. An overview of five core techniques of the NILD program follows based
upon the literature review.

Rhythmic writing. Evidence suggests that a sense of rhythm and patterning
is essential in the development of language and cognition (Feuerstein, 1980;
Kronick, 1988). Students with learning disabilities are often unaware of their
patterns or rhythms and this could affect focus, memory, and predictability.
Language itself is rhythmic and patterned, as is mediated thought. Thus, each
language form, spoken or written, has its own rhythm and pace, and its own
specific rules of organization.

A breakdown in dynamic functioning in individuals with learning disabilities
may have at its root an inability to discern the rhythms of language (Kronick,
1988). For instance, we learn how carefully we must listen to teachers because we have observed how frequently they repeat points, review, and punctuate specific content. Awareness of the salient junctures and punctuations within schema enables us to attend to more than one activity at a time, such as watching television and talking on the telephone while making a shopping list. The general rule for spoken language is that it should be focused and sufficiently explicit to be understood. Clearly, the breakdown in learning negotiated language and its template, inner language, has impact on the ability to think flexibly. A mediator can direct a child’s cognitive development through a process of rhythmic interchange.

Rhythmic Writing is a multimodal activity involving interactive language, inner speech, rhythmic patterning, and mediated learning. As a direct and focused attack upon deficient neurological functioning, it promotes interhemispheric collaboration through motoric exercises designed to engage and stimulate functioning of the corpus callosum by crossing the midline of the body (Best & Gladstone, 1985). Metacognition, auditory and visual processing, and the dynamic interaction of mediator and student through specific language stimulation are essential features.

The technique incorporates the theory behind Vygotsky’s zone of proximal development in that students are taken beyond their current levels of functioning.
by the assistance of an adult mediator. The technique assumes neural plasticity and
the interactive properties of thought and language. Specifically, Rhythmic Writing
addresses the limbic system (Luria’s Unit I) of the brain (see Figure 1, p. 68),
which calls for neurotransmitters, chemical changes and exchanges that make
learning possible. Since the limbic system responds to balance and crossing the
midline of the body, the technique of Rhythmic Writing should produce a chemical
continuity (Kandel & Hawkins, 1993). It stimulates through the vestibular,
proprioceptive system influencing balance, eye and limb movements and promotes
integration with the frontal lobe (Morrison, 1986). Long-term changes in learning
require the activation of genes, the expression of new proteins and the growth of
new neural connections (Kandel & Hawkins, 1993). (See Figure 3, p. 77, for an
overview of the proposed impact of Rhythmic Writing upon neurological
function.)
PARIETAL TERTIARY

cross-modal integration
- crossing midline, activating corpus callosum
- integrating right brain (tracing) and left brain (math computation) activities at the same time

simultaneous analysis
- hearing and solving math questions while maintaining spoken direction of left and right

hemispheric differentiation
- recognizing associations between letters and motifs

FRONTAL TERTIARY

temporal continuity
(central flow of thoughts between left and right hemispheres)
- crossing midline while solving math problems
- maintaining quality of motifs across midline

focus
- staying on line, maintaining direction, solving math problems
- remembering specific problems while solving them
- remembering motifs for each letter

planning and evaluation
- choosing strategy and knowing it is correct

flexibility
- choosing different math strategies for problem-solving

LIMBIC SYSTEM

chemical continuity
- balancing and crossing midline of body through excitement of the limbic system
- integrating simultaneous right brain (tracing) and left brain (math computation) activities
- calling for appropriate neurotransmitter

stimulation of vestibular, proprioceptive system
- coordinating eye-hand movements
- promoting integration especially with frontal lobe

Figure 3. Proposed impact on neurological functioning through the technique of Rhythmic Writing

Luria (see Golden, 1991)
Blue book. The Blue Book technique (Dwyer, 1993) employs an associative key-word approach to the learning of phonemes. Developed by Gillingham and Stillman (1977), this approach has been found effective for students with specific reading disabilities. Research has confirmed that phonemic awareness is an essential skill in learning to read (Das et al., 1995; Stanovich, 1988). The awareness that the building blocks of language, sounds that can be used to make words, can be segmented and used repeatedly is basic to reading and spelling success. In keeping with the dynamic functioning principle, however, some evidence suggests that reciprocal relationships between reading and other cognitive skills such as vocabulary development may have generalized effects that underlie a broader range of tasks and skills than just reading. A “Matthew effect” (Stanovich, 1986) implies that students with enriched educational experiences get better and better, whereas students with poor mediated learning environments grow weaker in a broad range of skills required for reading.

In the early stages of reading acquisition, poor readers have difficulty identifying words. When word recognition is used as the primary measure of reading achievement, researchers have found strong relationships between skills such as rhyming, phoneme segmentation, phoneme manipulation, and linguistic awareness (Johnson, 1995). Without efficient mechanisms of word identification,
reading becomes laborious and frustrating, leading to a downward spiral that could culminate in a learned helplessness and lack of motivation.

Reading is more difficult than speech. Thus, reading always follows speech production and often takes several years to master placing stress on the cognitive-linguistic system. In a recent study, Shaywitz et al., (1991) determined that students with learning disabilities exhibited general processing deficits across cognitive domains. Further, areas of weakness in phonologic awareness and verbal short-term memory greatly impacted reading skills.

Chall (1994) noted that merely matching modality strengths to methods used to teach reading has not fulfilled optimistic expectations. For example, using a sight approach with students who are strong in visual perception failed to improve their learning. Therefore, a more potent form of treatment utilizing a specific focus on direct teaching seemed to be warranted.

The Blue Book provides opportunity for direct instruction in the area of sound/symbol associations while stimulating verbal short-term memory. It provides a framework for an adult mediator to create focus within the child leading to the development of strategic thinking. Application of phonemes becomes decontextualized as associative patterning within new words is practiced. (See Figure 4, p. 80, for specific units of the brain impacted by this technique.)
Figure 4. Proposed impact on neurological functioning through the technique of Blue Book

Luria (see Golden, 1991)
**Buzzer.** The Buzzer technique incorporates the interaction of both auditory and visual stimuli and requires successive processing, phonological coding, and articulation. A Morse Code card containing a pattern of dots and dashes for each letter provides the stimulus in this technique. Students hear a series of letter patterns buzzed one letter at a time and must both analyze and synthesize the components, thereby gradually building a word. They must then define the word and use it to generate a complete sentence. The interactive dialogue and guided questioning of the mediator provide intense language stimulation.

Das and colleagues (1994) identified successive processing, that is, the ability to hold information in order, as fundamentally related to the capacity of working memory and required for the phonological coding and articulation of sequences of letters or sounds. In a recent experiment, these researchers determined that successive processing and articulation were the core cognitive deficits underlying reading difficulties. Phonological coding referred to pronunciation that was derived from text, whereas articulation referred to tasks in which the speech code needed to be accessed and the motor program for pronunciation had to be executed. Linking phonological coding and articulation to successive processing accounted for the association between short-term memory span and reading.
Another study (Lehmkuhle, Garzia, Turner, Hash, & Baro, 1993) found that students with reading disabilities had various abnormalities in the temporal processing of visual information. Specifically, the response of the magnicellular visual pathway was slower in reading disabled students. It was concluded that a defect in this pathway created a timing disorder that precluded the rapid and smooth integration of detailed visual information necessary for efficient reading.

Given the fact that reading skill incorporates complex neurological functioning involving language processing within a number of modalities, it appears that training can strengthen these underlying components. Although this technique stimulates both secondary (sensory) and tertiary (integrative) areas of the brain, the parietal and frontal lobes are particularly developed (see Figure 5, p. 83).
PARIETAL TERTIARY
simultaneous analysis and cross modal integration
- hearing (holding) and seeing the correct letter
- holding same letters while looking for the next
- hearing "*—" and recognizing relationship to "dot-dash"

FRONTAL TERTIARY
evaluation of sentence
- choosing part of speech
focus of attention
- developing comprehensive sentence and repeating exactly the same twice
- holding letters to develop word
flexibility
- generating different definitions and parts of speech
- creating imaginative names
- planning sentence before saying

OCCIPITAL SECONDARY
analysis of visual stimuli
- recognizing figure/ground perception of dots, dashes
- recognizing sequence of visual patterns

TEMPORAL SECONDARY
integration of auditory stimuli
- analyzing sounds
- organizing patterns of sounds
- hearing sequence of sounds

Figure 5. Proposed impact on neurological functioning through the technique of Buzzer

Luria (see Golden, 1991)

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**Dictation and copy.** The technique of Dictation and Copy provides essential skills of language development. Thus, auditory processing, sequential thinking, visual-motor integration, reasoning, grammar, and interactive speech are all stimulated in this exercise. Guided questioning facilitates the progression from egocentrism and verbal syncretism to gradual decontextualization and higher level reasoning (Piaget, 1959).

In contrast to oral language, which usually proceeds automatically without a conscious analysis of its phonetic composition, written language is a voluntary, organized activity involving conscious analysis of its constituent sounds (Luria, 1980). Analysis of the phonetic composition of language requires adequate preservation of phonetic hearing. Investigations have revealed the complex path the motor organization of writing travels in successive stages in a child’s development. According to Luria (1961), the part played by cortical systems in this activity does not always remain the same.

Vygotsky (1962/1975) viewed written language as a separate linguistic function from oral language. Even the minimal development of written language was seen to require a high level of abstraction, since it lacked the musical, rhythmic, expressive qualities of oral language. Written language demanded conscious work because its relationship to inner speech was different from that of oral speech. The latter preceded inner speech in the course of development, while
written speech followed inner speech, presupposing its existence (Vygotsky, 1962/1975). The study of grammar appeared to Vygotsky to be of paramount importance in the mental development of the child. Grammar and writing enabled the child to rise to a higher level of language development. (Figure 6, p. 86, illustrates particular brain functioning in the technique, Dictation and Copy.)
Figure 6. Proposed impact on neurological functioning through the technique of Dictation and Copy

Luria (see Golden, 1991)
Mental math. Batchelor, Grey, and Dean's (1990) study of children with learning disabilities supports the conclusion that arithmetic ability is dependent upon both verbal and nonverbal neuropsychological abilities. Several authors have shown that arithmetic disorders frequently occur simultaneously with reading and spelling disorders (Fletcher & Loveland, 1986; Strang & Rourke, 1985). These findings indicate that deficits in language processing, including naming skills, expressive and receptive vocabulary, auditory discrimination, poor verbal memory skills, and poor phonetic decoding skills, all impact arithmetic performance.

Other studies have found that math learning disabilities are related to visual-spatial disorders, verbal deficits, use of immature strategies, weakness in developing automaticity, as well as a variable rate of processing information (Garnett, 1992). Therefore, instructional support for these students with math learning disabilities should include accurate and consistent verbalizing of math processes.

Significantly, when performing basic math calculations, students with learning disabilities have been found to function as accurately but at a slower rate than their typical peers (Goldman, Pellegrino, & Mertz, 1988). They continued to use inefficient circuitous strategies lacking fluency or automaticity of subskills. Often, teachers responded to students' poor performance by endless drill and worksheets with little effect.
Garnett (1992) emphasized interactive, oral work as well as the need to include challenging math problems, which would promote the mental math ability so needed by students who tend to cling to number lines and paper-pencil routines. The Mental Math technique capitalizes upon interactive dialogue, requiring students to develop strategies through metacognitive processing. (Figure 7, p. 89, provides a neurological overview of the Mental Math technique.)

The interactive effect of the five core techniques discussed here is critical. Built upon theories of cognitive modifiability and interactive speech, each presupposes the possible creation through language stimulation of the zone of proximal development. Together, in the hands of a skilled mediator, they stimulate deficient cognitive functioning in a global sense and encourage interhemispheric transfer leading to greater cognitive efficiency.
Figure 7. Proposed impact on neurological functioning through the technique of Mental Math

Luria (see Golden, 1991)
Summary

From the theoretical foundations of Piaget, Vygotsky, Luria and Feuerstein, to the emerging understanding of the neuropsychology of learning, educators can begin to design effective interventions for students with learning disabilities. A collaborative spirit of interactive inquiry between educators and neuropsychologists is beginning to direct the return of the LD field to its scientific roots.

The importance of interactive language in the stimulation of cognitive functioning emerged from the literature review. The need for individualized, intensive mediation aimed at boosting weak cortical functioning was well documented. Further, the active involvement of the learner in verbal interchange appeared to be essential in the formulation of efficient thought processes.

The concept of dynamic functioning gave credence to Luria’s functional systems theory of brain organization. Deficient cognitive functions, viewed as weak or vulnerable, rather than nonexistent, provided rationale for the reversibility of these functions. According to Luria (see Golden, 1991), “tertiary areas of the second unit, located primarily in the parietal lobe of the two hemispheres are responsible for cross-modal integration and simultaneous analysis of input from the sensory modalities.... There is increasing hemispheric differentiation of tasks at the tertiary level of the second unit” (p. 101). Interactive language is the tool used to
move thinking from sequential to simultaneous, from sensory to cognitive and from the secondary to tertiary levels.

A model of intervention developed by the National Institute for Learning Disabilities incorporating both theory and best practices was described in light of the literature review. It is hypothesized that the intervention will produce significant change in both academic achievement and cognitive processing in an experimental study involving students with learning disabilities.

Although specific defining parameters of students with LD are difficult to establish, there is an emerging consensus in the field that neurolinguistic functioning of these students is weak and vulnerable. Students identified with LD from private, parochial schools in eight different school systems were selected to determine the effectiveness of a specific treatment intervention. A description of methods follows.
Chapter III

Methodology

Population

In order to test the six hypotheses presented earlier, a target population was defined and a sample drawn. The study is described in terms of units (U), treatments (T), observing operations (O), and setting (S). Cronbach (1980) defined the interacting elements in an evaluation design as UTOS, where units are the larger population, treatments are the specific plan of intervention, observing operations are the instruments for data collection, and setting is the larger social context in which the study takes place. Each of these elements will be described in detail.

The target population (U) in this study was students with diagnosed learning disabilities enrolled in private parochial schools. The sample consisted of students from 6 to 18 years of age from seven different school systems throughout the United States - Missouri, Pennsylvania (2), Tennessee, Virginia, Florida and New Jersey and one English-speaking school in Venezuela. These school systems were primarily suburban; 20% urban and 15% rural (see Table 1 in Appendix). The average population size was 50,000, with the range of localities from less than 25,000 to over 500,000. A broad range of family income levels were represented,
from under $20,000 annually to over $50,000 with the average at approximately $50,000.

Students included in the sample had been given a comprehensive battery of educational and psychological tests to determine the presence of a learning disability. The diagnosis was based upon the federal definition, which first appeared in a separate set of regulations for children with LD (U.S. Office of Education, 1977). According to this definition, a student with LD has a severe discrepancy between achievement and intellectual ability in one or more of the following areas: (a) oral expression, (b) listening comprehension, (c) written expression, (d) basic reading skill, (e) reading comprehension, (f) mathematics calculation, and (g) mathematics reasoning. The diagnosis was made by a licensed psychologist and a certified educational therapist.

Seventy-two students were included in the three-year longitudinal study (see Table 1). At the onset of the study, students ranged in age from 6 to 18 and were enrolled in grades 1 through 12. There were 43 boys and 26 girls in the study (N=72). The experimental group consisted of 47 participants (n=47), the control group of 25 (n=25).

The experimental group included 19 girls (40%) and 28 boys (60%), with a mean age of 14.10 and a mean IQ score of 106.48. The mean age of girls was
14.26 and their mean IQ score was 106.89. The mean age of boys was 13.99, with a mean IQ score of 106.21.

The control group consisted of 17 (68%) boys and eight girls (32%), with a mean age of 14.03 and a mean IQ score of 106.13. The mean age of girls was 12.74 and their mean IQ score was 105.14. The mean age of boys was 14.84, with a mean IQ score of 106.56.

**Instructor Training**

Educational therapists who administered the individualized educational therapy to students in the experimental group were trained by the National Institute for Learning Disabilities (NILD). This training consisted of 80 hours of intensive instruction in a two-week introductory course taught by instructors holding master’s degrees. After at least one year of experience, educational therapists received advanced training which included an additional 80 hours of instruction. Ongoing training and supervision was provided through on-site visits by an NILD educational consultant and annual attendance at winter conferences for review of technique implementation and philosophical foundations. Each of the educational therapists was certified by NILD. To receive NILD certification requires at least three years of educational therapy experience with a minimum of three students per year. Each school in the study was accredited by NILD and educational therapists involved in the treatment had received the standardized...
training developed by NILD. Further, the treatment procedures at each of the eight schools included in the study were standardized through training and supervision.

The educational therapists included in the study were trained to implement the five core techniques as part of each student's educational therapy program. A training manual specifying implementation procedures was included as part of their standard initial and advanced training. Consultants confirmed correct technique implementation through on-site visits, and techniques were reviewed annually at area winter conferences. The data used in the study were archival, and the educational therapists were not aware that they were part of a study.

Data Collection

The study is unique in that the data were collected in a relatively controlled environment within private parochial schools. Parents were given the choice of enrolling their children in educational therapy subsequent to the testing process so treatment was not withheld from students other than by parental choice. In addition to paying the private school tuition costs, parents were assessed an additional fee for the educational therapy treatment. Those students who were diagnosed with learning disabilities but did not enter the program comprised the control group. Control-group participants remained in the general education classroom and received no other specific intervention.
Students enrolled in educational therapy comprised the experimental group. They received the treatment twice weekly in two 80-minute sessions over a period of three years. Although the specific techniques used with students varied due to diagnosed cognitive deficits, five core techniques remained standard in each student's program. These techniques will be examined in detail.

**Treatment Procedures**

The second element in Cronbach's design (UTOS) is the treatment (T). In this study, T refers to the educational therapy intervention. A critical element of learning is the social and reciprocal relationship between the teacher and the student (Lerner, 1993; Vygotsky, 1962/1975). The teacher serves as a guide, providing support and creating the zone of proximal development dependent upon a mediator (Feuerstein, 1980; Palinscar & Klenk, 1992; Vygotsky, 1962/1975).

Each of the following techniques that made up the treatment of the study is based upon the theoretical premises of mediated learning and the role of oral language in the development of thought patterns (Palinscar & Klenk, 1992). Specific technique implementation is explained in the training manual, *Teaching Techniques for the Learning Disabled* (NILD, 1993).

**Technique 1 - rhythmic writing.** This technique involves tracing three large figure eights on a chalkboard, a vertical eight, horizontal eight, and a combination of the two. As students trace the figure eight, they state the direction they are
going (right, left) and the educational therapist gives the command to “change” frequently. In addition to verbalizing direction and responding to the auditory command to “change,” the student must process a math problem given by the educational therapist at an appropriate level of challenge, such as “the sum of 36 and 29.” A variety of math vocabulary is utilized (i.e., sum, product, difference, quotient) so that the student must process the language in addition to continuing the motoric and verbal responses. Students are encouraged to develop strategies for responding to the math problems, such as rounding 29 to 30 before adding.

Rhythmic Writing requires students to cross the midline of their bodies thereby stimulating interhemispheric transfer via the corpus callosum (Best & Gladstone, 1985).

This technique strengthens the domain of executive function (Welsh, 1994), an overarching concept that transcends traditional modules of cognition. Executive function regulates, integrates, and coordinates various cognitive processes toward goal-directed behavior. As such, this skill involves planning, organizing, and self-monitoring. Additionally, establishing hemispheric dominance for language is a particular goal of this activity (Best & Gladstone, 1985). Parents are trained to supervise Rhythmic Writing at home and students practice this activity six times per week.
In addition to tracing the figure eights, students also copy motifs on the chalkboard in a cursive style that corresponds to the 26 letters of the alphabet. For example, they integrate and synchronize the motoric activity with verbal responses such as “over, back, around” during the formation of the letter “c.” Visual memory is stimulated as students are required to remember as many motifs as possible before writing. The count must correspond with the free, fluid, large arm and shoulder movement of the motoric production. The technique requires approximately 15-20 minutes to complete and is considered the facilitator of all other techniques.

**Technique 2 - blue book.** As the development of skills related to phonemic analysis has been found to be a prerequisite to reading proficiency (Stanovich, 1988), this technique consists of a small book of phonemes and related key words designed to stimulate sound/symbol associations. The letters and corresponding words are arranged strategically to facilitate memory and transfer. No pictures or compensatory devices are included, rather, students are encouraged to develop their own strategies leading to an ability to visualize a given page. One page is assigned each session, and students progress through the book consecutively and repeatedly. Opportunity for association and recall is given through related activities both oral and written. Homework is assigned regularly, which parents are to supervise providing minimal assistance with the memory work.

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The basic structure of language is both analyzed and synthesized through this activity. Depending upon the student's deficits, the educational therapist uses guided questioning to facilitate building cognitive strategies for recall and association. Designed to improve both reading and spelling, the activity is integrated into other techniques throughout the session. For example, when students encounter an unknown word in a reading passage, the educational therapist cues to help them discover the *Blue Book* key word containing that pattern. If students misspell a word, the same cueing approach is used. Students are taught to think about the specific choices they may have in both decoding and encoding. Stimulation of interactive dialogue is an integral part of this technique. Generally, the activity requires 10-15 minutes per session.

**Technique 3 - buzzer.** In this technique, students are presented with a Morse Code card on which each letter of the alphabet is represented by a signal consisting of dots and dashes. The educational therapist uses a buzzing device to present the letters of a given word, one at a time, in sequence. Students are required to build the word based upon the auditory cues, then pronounce and define the word.

The activity progresses from analysis to synthesis, returning to analysis when students are required to put the word on the board and provide the *Blue Book* key word for each phoneme. During the activity, students must use the
word in an original sentence, developing length and complexity through guided questioning. The specific part of speech is identified and students are encouraged to consider other possibilities of grammatical function. The original sentence could become the topic sentence of a paragraph developed for homework, depending upon the student’s level of proficiency.

In the initial stages of this activity, students are encouraged to “see” the word develop as each letter is buzzed, without any visual cues. This enhances visual sequential memory as well as auditory discrimination, both needed skills in reading fluency (Lerner, 1993). Educational therapists encourage strategic thinking by having students group letters into syllables, sounding out each syllable, and then combining syllables into words. Expressive language is stimulated as students are encouraged to “flex their elaboration muscles” in building longer and more complex sentences. Further, vocabulary is enriched through interactive dialogue, life application, and association with previously learned material.

Student responses are not rote; rather, there is a dynamic unpredictability in this activity, which a skilled mediator directs to the particular area of language dysfunction. From letter to word to sentence to paragraph, both language and thinking are stimulated. This technique takes approximately 10 minutes to complete and also involves a homework activity with no parental input other than making sure that the assignment is completed.
Technique 4 - dictation and copy. This activity begins with a basic understanding of paragraph function and form. Students are guided to discover the basic elements of a paragraph, then progress to hearing and writing one sentence at a time building to a complete paragraph. The paragraphs used are those in the Specific Skill Series: Getting the Main Idea (Boning, 1990). These books are chosen because of their rich language content, which stimulates cultural literacy. Dictated paragraphs are at an appropriate level of challenge.

After dictating the first sentence of a paragraph, the educational therapist encourages students to discuss its meaning through paraphrasing and making predictions about the author's purpose in writing the paragraph. Students are encouraged to make inferences, think deductively and inductively, and use clear and precise language in explaining their ideas. Individual interests are taken into account in the selection of paragraphs.

Following discussion, the educational therapist again reads the sentence. The student must repeat it verbatim, and then write it using correct paragraph form. The student reads back the sentence written and the educational therapist repeats it until correct word order is achieved, thus stimulating auditory processing. Students are encouraged to look for possible spelling errors and receive Blue Book cues. Error analysis provides the educational therapist with direction for future intervention. Finally, the book is placed beside the student with
encouragement to proofread carefully, forcing visual attention by placing one finger on the book and one on the page. Corrections are made by circling and inserting missing words and/or punctuation. A second sentence is then dictated, and students copy and proofread the rest of the paragraph for homework.

Upon returning the next session, students must explain the main idea of the paragraph, stimulating long-term memory, and then give three supporting details. Outlining is eventually incorporated into this activity. Time needed for this technique is approximately 15 minutes per session. Again, homework is assigned to provide the educational therapist with opportunity for error analysis; parental involvement in this activity is minimal.

Technique 5 - mental math. In this technique, students are again required to develop skills of visualizing and strategic thinking. A variety of math activities are presented within a 10-minute math block to promote flexibility and shifting of mental processing. The process is more important than the product, as students are required to verbalize their strategies. Metacognition is enhanced, as students are asked to explain how they arrived at an answer. For example, an educational therapist will say, “Tell me what you are thinking.”

Specific components of this technique include recitation of multiples (e.g., 4, 8, 12, 16 ...) working toward automaticity and increased speed of mental processing. Additionally, students are given a “count-by” problem (e.g., “count by
and are encouraged to verbalize the strategies they use to arrive at an answer (e.g., “How did you get from 25 to 31?” response: “I went to the nearest 10, which was 30; that was 5 and I had one more - 31.”). Questions involving time (e.g., “If it is 12:14 p.m. on August 31, what will be the day and time 16 hours later?”); place value (e.g., “What number is in the hundreds place in the following, 62,516?”); fractions; percentages; and a short word problem are also presented orally. The educational therapist is concerned more with the process and efficiency of thinking rather than just correct answers. Strategies must sometimes be modeled and taught. Students are encouraged to explore a variety of ways to reach a given answer and good strategic thinking is commended.

Math language is stimulated through interactive dialogue. Educational therapists may ask students to illustrate or prove a particular problem by putting it on the board following or during a discussion of the process. Students are kept at a level of abstraction until it is evident that it is necessary to return to concrete illustrations. Math manipulatives are used as tools, not crutches, providing proofs for given answers. For example, an educational therapist may say, “Use these blocks to prove your answer that one fourth of 24 is 6.”

If students are unable to visualize a problem such as the sum of 89 and 47, they are permitted to write it on the board; then it is quickly erased and the ones column is recalled, then the tens. Educational therapists do ongoing error analysis
throughout the Mental Math activity. Generally, math homework is given and practiced to speed mental processing. Parental involvement in this activity is merely supervisory.

Other techniques are added to the session, according to the need of the student. The five techniques just described are implemented regularly for every student although the particular dynamic may vary according to student responses. Figures 3 through 7 (pp. 77, 80, 83, 86, and 89) describe proposed impact upon neurological functioning for each of the five core techniques.

Instrumentation

The third element in Cronbach’s UTOS design is the observing operations, O. These are the instruments used to measure the treatment effect. The instruments used in the pre- and posttest measures for this study included the Wide Range Achievement Test - Revised (WRAT-R) and the Detroit Tests of Learning Aptitude - Second Edition (DTLA-2).

The Wide Range Achievement Test - Revised. The WRAT-R is the sixth edition of the test that was first published in 1936. Like the earlier versions, the WRAT-R contains three subtests: Reading (recognizing and naming letters and words); Spelling (writing symbols, name and words); and Arithmetic (solving oral problems and written computations). The authors of the WRAT-R stress that the test is designed to measure basic school codes rather than comprehension.
reasoning, and judgment processes. The test was specifically constructed to study sensory-motor and coding skills involved in learning to read, spell, write and compute. According to the authors, its purpose was to clearly differentiate between mastery of codes and mastery of thought. General uses for the test described in the manual include determining learning ability or learning disability (Harrison, 1988).

In contrast to earlier editions of the WRAT, a stratified national sampling plan was used for standardization of the WRAT-R. A total of 5,600 participants, 200 participants each within 28 age groups from 5 to 74 years of age composed the sample. Of greatest concern to reviewers is the failure to describe the actual composition of the sample (Clark, 1988; Harrison, 1988).

Reliability. The Rasch analysis provides person-separation and item-separation values given as evidence of internal consistency. With the exception of a coefficient of .82 for Level 1 Arithmetic, all median coefficients across subtests for person separation (test reliability) and item separation (sample reliability) are above .91. Test-retest reliabilities were calculated for 81 individuals in Level 1 and 67 individuals in Level 2.

Validity. The authors state that the WRAT-R’s content validity is apparent, giving the following evidence: The first edition sampled dictionaries to obtain reading and spelling items, Rasch statistics support the wide range of item
coverage, the test exhibits evidence of internal consistency, there is a developmental progression of raw scores, WRAT-R subtests have moderately high correlations with Woodcock-Johnson Tests of Achievement - Revised (1989) subtests, and the format of administration is similar to classroom activities. According to a reviewer (Harrison, 1988), none of this evidence supports content validity, and test users cannot be assured that the WRAT-R systematically and adequately samples the content taught in today's schools.

In conclusion, reviewers Clark (1988) and Harrison (1988) stated that the test does have potential as a research and clinical tool but yields a limited sample of behavior. Although the WRAT-R measures codes, an important aspect of achievement, it does not measure comprehension. Despite its limitations, the WRAT-R continues to be one of the most widely used instruments in measuring academic achievement.

**Theoretical Contributions to Aptitude Testing**

The idea that there is a type of mental (neural) energy inherent in all intellectual activity had long been recognized by theorists, who called the phenomenon "general intelligence" (Hammill, 1985). Spearman (1927) offered the formal hypothesis that intelligence was comprised mostly of global ability that is supplemented by individual abilities. Spearman named his factors "g" and "s," respectively. Subtests of the DTLA-2 were selected for their contribution to "g"
(general intelligence) rather than as representatives of particular special abilities. In building the DTLA-2, Wechsler was the role model (Hammill, 1985). The authors of the test state that “the test results can be used to determine the effectiveness of various intervention programs on intellectual test performance” (p. 11).

**Detroit Tests of Learning Aptitude - Second Edition.** The purpose of this test was defined by the authors as (a) determining strengths and weaknesses among intellectual abilities, (b) identifying children and youths who are significantly below their peers in aptitude, and (c) serving as a measurement device in research studies investigating aptitude, intelligence and cognitive behavior. The original Detroit Tests of Learning Aptitude (DTLA) appeared 60 years ago, prior to the Stanford-Binet and the WISC. The first revision was completed in 1988. The DTLA-2 is an individual intelligence scale that can be administered to students from age 6 through 17; it consists of 11 subtests.

**Standardization, reliability, and validity.** The standardization was based on a sample of over 1,500 subtests - roughly 100 at each age level from 6 to 17 years. Psychometric information is based upon a stratified random subsample. The values of alpha, averaged across age groups, range from .81 to .95 for the subtests and from .95 to .97 for the composites. For comparison, split-half reliability coefficients for the WISC-R, again averaged across age groups, range from .70 to
.86 for the subtests and from .90 to .96 for the Verbal, Performance, and Full
Scale IQ scores.

Setting

The final element in Cronbach’s design, UTOS, is the setting (S), or the
larger social context of the study, incorporating social attitudes, political divisions,
or economic considerations. Of particular importance in the present study is the
description of community and organizational characteristics, including the
characteristics of teachers implementing the intervention. Parental and student
involvement in the larger context is also of interest.

Parents and students. Because the students in the sample were drawn from
the larger population of students with learning disabilities in private, parochial
schools (U), the domains U, T, and O combined with S to define the domain of
investigation (Cronbach, 1980). Parents in the study shared a particular
commitment to educational choice and were part of a culture that values morality
and ethics. They agreed to be partners with the schools in the education of their
children. Therefore, any agreement concerning home responsibilities in the
supervision of assignments for students in educational therapy would be taken
seriously. This parental commitment was evident in both experimental and control
groups.
Students in the study were expected to comply with school rules and regulations and were socialized in a relatively disciplined environment. Students enrolled in educational therapy at the high school level had to agree to the intervention as progress necessitated compliance. Parents observed their child's first six sessions of educational therapy, and thereafter, once monthly, to ensure correct home supervision of the Rhythmic Writing process. A high level of accountability was required of both students and parents within the school culture. Additionally, as parents were required to pay a fee above the cost of the private school tuition, a financial and time commitment enhanced motivation to be involved in the learning process. For many parents, this financial commitment involved personal sacrifice.

**Teachers/educational therapists.** The teachers or educational therapists in the study all held bachelor's degrees and most were state certified in learning disabilities. These individuals also had a high commitment to educational choice, receiving salaries considerably lower than they could have earned in the public sector. In some cases, educational therapists were parents of students with learning disabilities. Others may have struggled through school with a learning disability themselves. Often, this area of difficulty was revealed through the initial training, producing a certain intensity in the commitment to be involved in assisting students. A high level of job satisfaction was maintained through consistent
observation of student progress. Each educational therapist was encouraged to pursue NILD certification through ongoing training and to work toward a master’s degree in education.

The cultural setting of the study, then, was characterized by commitment, motivation, dedication, hard work, and sacrifice. Teachers, parents, students, administrators and educational therapists worked together as a team in a defined culture to achieve mutual goals.

Research Design

The present study utilized a quasi-experimental nonequivalent control-group design. This design is probably the most widely used quasi-experimental design in educational research (Borg & Gall, 1989). It was not possible to randomly assign students to the experimental treatment (regular education with educational therapy) and to the control treatment (regular education without the educational therapy). All student participants were identified as learning disabled and recommended to receive educational therapy through the NILD program within their school. Students whose parents declined the intervention comprise the control group. Participants who received educational therapy in the NILD program comprise the experimental group.
Statistical Analysis

The main threat to the internal validity of nonequivalent control-group experiments is the possibility that group differences on the posttest are due to preexisting group differences rather than treatment effect. Analysis of covariance was selected to statistically reduce the initial effects of group differences by making comparison adjustments to the posttest means of the two groups. A separate analysis of covariance was conducted for each variable (WRAT-R reading, WRAT-R spelling, and WRAT-R arithmetic, DTLA-2 GIQ, DTLA-2 VIQ, DTLA-2 NVIQ). Note: two assumptions must be met before analysis of covariance can be used: homogeneity of group variance and homogeneity of regression. If these assumptions are not satisfied, an analysis of variance will be conducted on the posttest scores; in effect, the covariant data will be ignored.

Since the data are archival, parental consent for testing was obtained only for the control group posttesting. Letters were sent to each parent explaining the study and assurance was given of the confidentiality of the data. A proposal for the study was reviewed and approved by the dissertation chair and committee members, and a human subjects research permission form was approved and filed.

The current study is strengthened by use of a control group and compares student performance over a three-year time span. Statistical results in the areas of achievement and cognitive functioning are analyzed and conclusions are drawn in the chapters following.
Chapter IV

Analysis of Results

Introduction

The present study can best be described as a program evaluation, since the data are archival, and those who participated were not aware that they were part of a study. Annual data collection is an integral part of membership in the National Institute for Learning Disabilities (NILD). Students included in this study were drawn from member schools.

All students in the study (N=72) had diagnosed learning disabilities and were enrolled in private, parochial schools. All teachers (educational therapists) of students in the experimental group were trained over three years in the NILD method of educational therapy intervention. All students in the study were administered the same standardized tests, WRAT-R (1984) and DTLA-2 (1985), for pre- and posttests within an approximate three-year interval.

Borg and Gall (1989) cited the most widely used quasi-experimental design in educational research as the nonequivalent control-group design. The essential features of this design include nonrandom assignment of subjects to groups and administration of a pretest and posttest to all groups (Borg & Gall, 1989). In this design, it is particularly important to describe the characteristics of each group at the outset of the experiment since subjects have not been randomly assigned to
groups. In the present study, both the experimental (n=47) and the control (n=25) groups were compared on several variables prior to the intervention.

The sample included students from 6-18 years of age in grades 1-12 in eight different school systems. Subjects’ mean age was approximately 14; their mean IQ score was approximately 106. Family descriptors included parental income, which ranged from under $20,000 annually to over $50,000, with the mean income around $50,000. Demographic data are listed in Table 1 (located in Appendix).

The main threat to the internal validity of nonequivalent control-group experiments is the possibility that group differences on the posttest are due to preexisting group differences rather than treatment effect. The groups were tested for initial differences in the following ways: (a) chi-square tests were conducted to compare initial differences in gender, father’s occupation, mother’s occupation, city size, location, and income (see Tables 2-7 in Appendix); and (b) t-tests were given to determine pretest differences for reading, spelling, and arithmetic scores on the WRAT-R and for the DTLA-2 variables of general IQ, verbal IQ and nonverbal IQ (see Tables 8-13 in Appendix).

A statistical analysis of covariance (ANCOVA) was conducted to reduce the effects of initial group differences when differences were found. Statistical comparisons revealed no significant preexisting group differences for age, gender,
IQ score, location, parental occupation, WRAT-R arithmetic, DTLA-2 GIQ, VIQ, or NVIQ. However, statistical differences were found for parental income, and WRAT-R reading and spelling. Therefore, the covariates in the present study were parental income, and WRAT-R reading and spelling.

Six dependent variables were assessed for each of the 72 subjects. These included standard scores in reading from the Wide Range Achievement Test - Revised (WRAT-R), standard scores in spelling from the Wide Range Achievement Test - Revised (WRAT-R), and standard scores in arithmetic from the Wide Range Achievement Test - Revised (WRAT-R).

In addition to these three achievement variables, three cognitive variables were assessed: standard scores in general intelligence quotient from the Detroit Tests of Learning Aptitude - Second Edition (DTLA-2), standard scores in verbal intelligence from the Detroit Tests of Learning Aptitude - Second Edition (DTLA-2), and standard scores in nonverbal intelligence from the Detroit Tests of Learning Aptitude - Second Edition (DTLA-2). Each of the six hypotheses in the present study will be considered separately in the following analysis of results.

In a factorial experiment, the effect of two or more independent variables (i.e., factors) by itself and in interaction with each other is measured on a dependent variable (Borg & Gall, 1989). The effect of the interaction of two or more independent variables on the dependent variable is called an “interaction
effect.” In the current study, the factors under consideration were (a) differences between the experimental and control groups and (b) differences over time. The experiment raised three questions:

1. Are the groups different?
2. Does performance differ over time?
3. Do the groups differ by time (is there interaction of group/time)?

In other words, does the effect of one independent variable (treatment intervention) depend upon the level of another independent variable (time of treatment) with which it is combined? Thus, an interaction effect would be present when these two factors interact to produce significant differences in the dependent variables.

The statistical procedures used were the analysis of covariance (ANCOVA) and the post hoc (Tukey) test. The .05 level of confidence was applied for acceptance or rejection of hypotheses. Observed and adjusted means are listed for the covariates in Table 14 (see Appendix).

**Hypothesis 1**

The first hypothesis states that the experimental group will demonstrate significant improvement in reading scores, as measured by the *Wide Range Achievement Test - Revised* (WRAT-R) compared to a control group that received no specific intervention other than general classroom instruction. This
hypothesis was analyzed with a repeated-measures analysis of covariance. The
independent factors were group (experimental/control) and time (pretest/posttest).
The covariates were income and WRAT-R spelling. Results indicated a significant
time effect ($p=.000$) and a significant group by time interaction ($p=.001$) (see
Table 15).

If a significant interaction is obtained (i.e., group x time), a follow-up test
becomes necessary to statistically analyze the simple effects. To determine which
means varied significantly from one another, a post hoc (Tukey) test was
conducted on adjusted interaction means. For the four pairwise comparisons, the
following observations were made (see Figure 8).

Table 15

<table>
<thead>
<tr>
<th>Source</th>
<th>SS</th>
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<th>MS</th>
<th>F</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Covariates</td>
<td>6644.32</td>
<td>2</td>
<td>3322.16</td>
<td>19.66</td>
<td>.000 *</td>
</tr>
<tr>
<td>Group</td>
<td>10.07</td>
<td>1</td>
<td>10.07</td>
<td>.06</td>
<td>.808 (NS)</td>
</tr>
<tr>
<td>Error</td>
<td>11488.00</td>
<td>68</td>
<td>168.94</td>
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<td></td>
</tr>
<tr>
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<td>1659.36</td>
<td>36.78</td>
<td>.000 *</td>
</tr>
<tr>
<td>Group x Time</td>
<td>578.55</td>
<td>1</td>
<td>578.55</td>
<td>12.82</td>
<td>.001 *</td>
</tr>
<tr>
<td>Error</td>
<td>3158.20</td>
<td>70</td>
<td>45.12</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* $p<.05$.  NS = nonsignificant.

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The experimental and control groups were not significantly different prior to the treatment, nor did they differ significantly following treatment. The control group increased 3.35 points in scores over time, but this was not a significant increase. The experimental group increased by 10.9 points between pre- and posttest scores or more than 2/3 of a standard deviation, a statistically significant gain.

Figure 8. WRAT-R reading scores. *p < .05, CD = 4.39, Tukey test. (ns = nonsignificant sig = significant)
Hypothesis 2

The second hypothesis states that the experimental group will demonstrate significant improvement in spelling compared to a control group, as measured by the *Wide Range Achievement Test - Revised* (WRAT-R). The resulting scores of the experimental group were compared to those of a control group who received no specific intervention other than general classroom instruction.

This hypothesis was analyzed with a repeated-measures analysis of covariance. The independent factors were group (experimental/control) and time (pretest/posttest). The covariates were income and WRAT-R reading. As seen in Table 16, results indicated a significant time effect (*p*=.011) and a significant group-by-time interaction (*p*=.007).

<table>
<thead>
<tr>
<th>Table 16</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Analysis of Covariance for Spelling</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Source</th>
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<th>df</th>
<th>MS</th>
<th>F</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Covariates</td>
<td>9473.46</td>
<td>2</td>
<td>4736.73</td>
<td>25.03</td>
<td>.000 *</td>
</tr>
<tr>
<td>Group</td>
<td>.78</td>
<td>1</td>
<td>.78</td>
<td>.00</td>
<td>.949 (NS)</td>
</tr>
<tr>
<td>Error</td>
<td>12867.81</td>
<td>68</td>
<td>189.23</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time</td>
<td>629.57</td>
<td>1</td>
<td>629.57</td>
<td>6.90</td>
<td>.011 *</td>
</tr>
<tr>
<td>Group x Time</td>
<td>712.40</td>
<td>1</td>
<td>712.40</td>
<td>7.81</td>
<td>.007 *</td>
</tr>
<tr>
<td>Error</td>
<td>6382.92</td>
<td>70</td>
<td>91.18</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* *p*<.05.  NS = nonsignificant.
To determine which means varied significantly from one another, a post hoc Tukey test was conducted on adjusted interaction means. For the four pairwise comparisons, the following observations were noted (see Figure 9). The experimental and control groups were not significantly different prior to the treatment, nor did they differ significantly following treatment. The control group increased in scores 1.04 points over time, but this was not a significant increase. The experimental group increased 7.89 points between pre- and posttest scores, or nearly 2/3 of a standard deviation, a statistically significant gain.

Figure 9. WRAT-R spelling scores. * p < .05, CD = 6.25, Tukey test. (ns = nonsignificant sig = significant)
Hypothesis 3

The third hypothesis states that the experimental group will demonstrate significant improvement in arithmetic scores compared to a control group, as measured by the Wide Range Achievement Test - Revised (WRAT-R). The resulting scores of the experimental group were compared to those of a control group who received no intervention other than general classroom instruction.

This hypothesis was analyzed with a repeated-measures analysis of covariance. The independent factors were group (experimental/control) and time (pretest/posttest). The covariates were income and WRAT-R reading and spelling. Results indicated a significant time effect (p=.002), but a nonsignificant group-by-time interaction. Consequently, no follow-up test was given (see Table 17).

Figure 10 graphs mean scores of the two groups.

Table 17
Analysis of Covariance for Arithmetic

<table>
<thead>
<tr>
<th>Source</th>
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<th>p</th>
</tr>
</thead>
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<td>Covariates</td>
<td>4175.86</td>
<td>3</td>
<td>1391.95</td>
<td>5.05</td>
<td>.003 *</td>
</tr>
<tr>
<td>Group</td>
<td>22.65</td>
<td>1</td>
<td>22.65</td>
<td>.08</td>
<td>.775 (NS)</td>
</tr>
<tr>
<td>Error</td>
<td>18479.18</td>
<td>67</td>
<td>275.81</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time</td>
<td>943.52</td>
<td>1</td>
<td>943.52</td>
<td>9.88</td>
<td>.002 *</td>
</tr>
<tr>
<td>Group x Time</td>
<td>329.35</td>
<td>1</td>
<td>329.35</td>
<td>3.45</td>
<td>.067 (NS)</td>
</tr>
<tr>
<td>Error</td>
<td>6682.81</td>
<td>70</td>
<td>95.47</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* p<.05. NS = nonsignificant.
Figure 10. WRAT-R arithmetic mean scores.
Hypothesis 4

The fourth hypothesis states that the experimental group will demonstrate significant improvement in general cognitive functioning (GIQ) compared to a control group, as measured by the Detroit Tests of Learning Aptitude - Second Edition (DTLA-2). The resulting scores of the experimental group were compared to those of a control group who received no specific intervention other than general classroom instruction.

This hypothesis was analyzed with a repeated-measures analysis of covariance. The independent factors were group (experimental/control) and time (pretest/posttest). The covariates were income and WRAT-R reading and spelling.

As seen in Table 18, results indicated a significant time effect ($p=.000$) and a significant group-by-time interaction ($p=.027$).

<table>
<thead>
<tr>
<th>Source</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Covariates</td>
<td>2881.85</td>
<td>3</td>
<td>960.62</td>
<td>6.67</td>
<td>.001 *</td>
</tr>
<tr>
<td>Group</td>
<td>215.68</td>
<td>1</td>
<td>215.68</td>
<td>1.50</td>
<td>.225 (NS)</td>
</tr>
<tr>
<td>Error</td>
<td>9645.90</td>
<td>67</td>
<td>143.97</td>
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<td></td>
</tr>
<tr>
<td>Time</td>
<td>1625.47</td>
<td>1</td>
<td>1625.47</td>
<td>53.56</td>
<td>.000 *</td>
</tr>
<tr>
<td>Group x Time</td>
<td>154.69</td>
<td>1</td>
<td>154.69</td>
<td>5.10</td>
<td>.027 *</td>
</tr>
<tr>
<td>Error</td>
<td>2124.53</td>
<td>70</td>
<td>30.35</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* $p<.05$.  NS = nonsignificant.
To determine which means varied significantly from one another, a post hoc, Tukey, test was conducted on adjusted interaction means. For the four pairwise comparisons, the following observations were made (see Figure 11). The experimental and control groups were not significantly different prior to treatment. However, following the intervention there was a significant difference between the two groups. The control group increased significantly over time, 4.67 points. There was a greater difference in the experimental group scores over time, 9.44 points or nearly 2/3 of a standard deviation, a significant increase.

**Figure 11.** DTLA-2 general cognitive functioning scores. * p < .05, CD = 3.60, Tukey test. (ns = nonsignificant  sig = significant)
Hypothesis 5

The fifth hypothesis states that the experimental group will demonstrate significant improvement in verbal cognitive functioning as measured by the DTLA-2, compared to a control group. The experimental group’s scores were compared to those of a control group who received no specific intervention other than regular classroom instruction.

This hypothesis was analyzed with a repeated-measures analysis of covariance. The independent factors were group (experimental/control) and time (pretest/posttest). The covariates were income and WRAT-R reading and spelling. As illustrated in Table 19, results showed a significant time effect (p=.000) and a significant group-by-time interaction (p=.029).

Table 19

Analysis of Covariance for VIQ

<table>
<thead>
<tr>
<th>Source</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Covariates</td>
<td>3696.32</td>
<td>3</td>
<td>1232.11</td>
<td>6.67</td>
<td>.001 *</td>
</tr>
<tr>
<td>Group</td>
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<td>1</td>
<td>373.77</td>
<td>2.02</td>
<td>.159 (NS)</td>
</tr>
<tr>
<td>Error</td>
<td>12373.24</td>
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<tr>
<td>Time</td>
<td>1857.67</td>
<td>1</td>
<td>1857.67</td>
<td>55.10</td>
<td>.000 *</td>
</tr>
<tr>
<td>Group x Time</td>
<td>167.33</td>
<td>1</td>
<td>167.33</td>
<td>4.96</td>
<td>.029 *</td>
</tr>
<tr>
<td>Error</td>
<td>2360.16</td>
<td>70</td>
<td>33.72</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* p<.05. NS = nonsignificant.
To determine which means varied significantly from one another, a post hoc, Tukey, test was conducted on adjusted interaction means. For the four pairwise comparisons, the following observations were made (see Figure 12). The experimental and control groups were not significantly different prior to treatment. However, following the intervention there was a significant difference between the two groups' posttest means. The control group increased significantly, 5.63 points over time. The experimental group also increased significantly over time, and to a greater degree than the control group. The gain of 9.46 points in posttest means or nearly 2/3 of a standard deviation represents a statistically significant increase.

Figure 12. DTLA-2 verbal cognitive functioning scores. * p < .05, CD = 3.80, Tukey test. (ns = nonsignificant  sig = significant)
Hypothesis 6

The sixth hypothesis states that the experimental group will demonstrate significant improvement as compared to a control group, in nonverbal cognitive functioning as measured by the DTLA-2. The experimental group’s scores were compared to those of a control group who received no specific intervention other than regular classroom instruction.

This hypothesis was analyzed with a repeated-measures analysis of covariance. The independent factors were group (experimental/control) and time (pretest/posttest). The covariates were income and WRAT-R reading and spelling. As shown in Table 20, results indicated a significant time effect (p=.000) and a significant group-by-time interaction (p=.035).

Table 20

Analysis of Covariance for NVIQ

<table>
<thead>
<tr>
<th>Source</th>
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<th>F</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Covariates</td>
<td>1544.63</td>
<td>3</td>
<td>514.88</td>
<td>3.15</td>
<td>.031 *</td>
</tr>
<tr>
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<td>1</td>
<td>14.49</td>
<td>.09</td>
<td>.767 (NS)</td>
</tr>
<tr>
<td>Error</td>
<td>10949.48</td>
<td>67</td>
<td>163.43</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time</td>
<td>1154.92</td>
<td>1</td>
<td>1154.92</td>
<td>22.91</td>
<td>.000 *</td>
</tr>
<tr>
<td>Group x Time</td>
<td>232.42</td>
<td>1</td>
<td>232.42</td>
<td>4.61</td>
<td>.035 *</td>
</tr>
<tr>
<td>Error</td>
<td>3528.07</td>
<td>70</td>
<td>50.40</td>
<td></td>
<td></td>
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</table>

* p<.05. NS = nonsignificant.
To determine which means varied significantly from one another, a post hoc, Tukey, test was conducted on adjusted interaction means. For the four pairwise comparisons, the following observations were made (see Figure 13). The experimental and control groups were not significantly different prior to treatment, nor did they differ significantly following treatment. The control group increased in scores 2.75 points over time, but this was not a significant increase. The experimental group increased 9.15 points between pre- and posttest scores, or nearly 2/3 of a standard deviation, a statistically significant gain.

Figure 13. DTLA-2 nonverbal cognitive functioning scores. * p < .05, CD = 3.74, Tukey test. (ns = nonsignificant sig = significant)
Summary

Factorial designs provide information about the main effects of each independent variable and the interaction of two or more independent variables. In the present study the independent variables were (a) the specific treatment intervention and (b) the effect over time.

Hypothesis 1. As predicted, a significant main effect over time was found for the experimental group in WRAT-R reading scores. However, there was no statistically significant difference in means between the pretest and posttest standard scores for reading for the experimental and control groups, so we cannot reject the null.

$H_0$: not $H_1$.

Hypothesis 2. As predicted, a significant main effect over time was found for the experimental group in WRAT-R spelling scores. However, there was no statistically significant difference in means between the pretest and posttest standard scores for spelling for the experimental and control groups, so we cannot reject the null.

$H_0$: not $H_2$.

Hypothesis 3. As predicted, a significant main effect over time was found for the experimental group in WRAT-R arithmetic scores. However, there was no statistically significant difference in means between the pretest and posttest
standard scores for arithmetic for the experimental and control groups, so we cannot reject the null.

$$H_0: \text{not } H_3.$$  

**Hypothesis 4.** As predicted, a significant main effect over time was found for the experimental group in general cognitive functioning scores on the DTLA-2. Also, a statistically significant difference in means was found between the pretest and posttest standard scores for the experimental and control groups, so we can reject the null.

$$H_4: \text{not } H_0.$$  

**Hypothesis 5.** As predicted, a significant main effect over time was found for the experimental group in verbal cognitive functioning scores on the DTLA-2. Also, a statistically significant difference in means was found between the pretest and posttest standard scores for verbal cognitive functioning for the experimental and control groups, so we can reject the null.

$$H_5: \text{not } H_0.$$  

**Hypothesis 6.** As predicted, a significant main effect over time was found for the experimental group in nonverbal cognitive functioning scores on the DTLA-2. However, there was no statistically significant difference in means between the pretest and posttest standard scores for nonverbal cognitive functioning for the experimental and control groups, so we cannot reject the null.

$$H_6: \text{not } H_6.$$
Chapter V

Summary, Conclusions, and Recommendations

Summary

Tracing the development of the field of learning disabilities over the past 20 years has revealed ambiguity and a loss of scientific rigor in research design and methodology. According to Martin (1993), two myths about learning disabilities persist. The first myth is that LD is always a mild disorder. However, this myth is beginning to change in response to new evidence to the contrary (Seventeenth Annual Report to Congress, 1995).

Government statistics indicate that a considerable percentage of high school students identified with LD (26.7%) drop out of school prior to graduation (Martin, 1993). Another 16% diagnosed with LD exit school for “unknown” reasons. These percentages defy the myth of mildness and confirm significant needs that must be addressed in order for students to achieve in school and be well prepared for life. Outcome studies indicate that only 17.1% of students with learning disabilities pursue postsecondary education despite adequate intellectual abilities (Martin, 1993).

The second myth, according to Martin, is that supplemental education is sufficient to meet the needs of students with LD. Yet, research indicates that many students with learning disabilities do not succeed in traditional resource room
settings (Martin, 1993; Spreen, 1988; Zigmond, 1990). With the move toward inclusion of many students with special learning needs in general education classrooms, we must continue to examine the appropriateness of full-time participation in general education for students with LD (Martin, 1993). Many classrooms use extensive whole group instruction that may not be appropriate for these students (Berk & Winsler, 1995). Students with learning disabilities appear to need personal, intensive assistance to address deficient cognitive processing (Bakker et al., 1995). For these reasons, educational policy should be driven by research knowledge concerning effectiveness rather than solely on trying to achieve philosophically desirable ends (Fuchs & Fuchs, 1994). No longer can science take a back seat to the social and political forces that have shaped the LD field to date.

The present study was concerned with building a theoretical foundation for the stimulation of cognitive functioning and applying knowledge and insight from the field of neuropsychology to the field of education. A number of studies have validated the premise that cognitive functioning can be enhanced through effective instruction (Scruggs et al., 1994; Swanson, 1993). There is also evidence to support the necessity of interhemispheric collaboration for efficient cognitive processing (Bakker et al., 1995; Levy, 1985). Additionally, emerging research suggests that some deficient cognitive processes can be reversed under specific
conditions of intervention (Feuerstein, 1994; Bakker et al., 1995).

Neuropsychologists provide support for the premise that fiber pathways within the brain can be "fine-tuned" through intensive intervention (Bakker, 1994; Duane & Gray, 1991). By far, the most significant finding in this area suggests that effective verbal interchange between teacher and student can enhance interhemispheric collaboration and lead to more efficient cognitive processing (Bakker, 1994; Das et al., 1995; Presseisen & Kozulin, 1994).

This study investigated six hypotheses regarding effects of an intervention program aimed at stimulating the cognitive functioning of students with LD through interactive language. In order to test these hypotheses the following specific objectives were defined:

1. To determine if completion of an intensive, individualized program of educational therapy would differentially affect the achievement scores in reading, spelling, and arithmetic for students with learning disabilities.

2. To determine if completion of an intensive, individualized program of educational therapy would differentially affect the cognitive functioning measured by general IQ (GIQ), verbal IQ (VIQ), and nonverbal IQ (NVIQ) scores for students with learning disabilities.
Six hypotheses were formulated to examine these objectives. Each hypothesis will be discussed separately below in light of findings based upon the statistical measures, the analysis of covariance and post hoc, Tukey, tests.

**Hypothesis 1.** A significant difference at the .05 level was found in the measured improvement of reading words in isolation on the WRAT-R reading test over time for the experimental group. The increase of more than 10 points denotes a significant treatment effect. The control group also made gains over time, although such gains were not statistically significant. Finally, there was an interaction effect, but no statistically significant difference between the experimental and control groups in the posttest means.

**Hypothesis 2.** A significant difference at the .05 level was found in the measured improvement of spelling scores for students in the experimental group. The increase of nearly 8 points denotes a significant treatment effect. The control group also improved over time, but not significantly. There was an interaction effect, but no significant difference in the posttest means between the experimental and control groups.

**Hypothesis 3.** A significant difference at the .05 level was found in the measured improvement of arithmetic scores over time for the experimental group. The control group also made statistically significant gains. There was no differential growth between the two groups, that is, no interaction effect.
Hypothesis 4. A significant difference at the .05 level was found in general
cognitive functioning for students in the experimental group. The increase of
nearly 10 points denotes a significant treatment effect. The control group also
improved significantly over time. There was no significant difference between
groups prior to the intervention, but a significant difference was found between
groups following the treatment. Thus, we can conclude that there was a significant
interaction effect leading to both group and time differences.

Hypothesis 5. A significant difference at the .05 level was found in verbal
cognitive functioning for students in the experimental group. The increase of
nearly 10 points denotes a significant treatment effect. The control group also
improved significantly over time. No significant difference was found between
groups prior to the intervention; however, a significant difference between groups
was found following the treatment. Thus, we can conclude that there was a
significant interaction effect leading to both group and time differences.

Hypothesis 6. A significant difference at the .05 level was found in the
measured improvement of nonverbal cognitive functioning over time for the
experimental group. The control group also improved over time, but not
significantly. There was an interaction effect, but no significant difference in the
posttest means between the experimental and control groups.
**Summary of methodology.** Using Cronbach’s (1980) UTOS construct, defining parameters of a specific study can be designated utos. Each of these four components will be examined in detail. The population (u) for the study consisted of a sample of 72 students identified with learning disabilities through a battery of psychological and educational tests. Students were served in private, parochial schools in seven school systems throughout the United States and one English-speaking school in Venezuela. Students ranged in age from 6-18 years and were enrolled in grades 1 through 12 at the outset of the three-year longitudinal study.

Students in the experimental group (n=47) completed a program of individualized educational therapy intervention twice weekly for periods of 80 minutes or 160 minutes per week in addition to their general classroom instruction. Students in the control group (n=25) were diagnosed with LD, but received no specific intervention other than general classroom instruction.

The specific treatment (t) in the study was the intervention developed by the National Institute for Learning Disabilities (NILD), consisting of at least five core techniques administered by educational therapists trained in the NILD method. Specific technique implementation had been standardized and copyrighted in a training manual, *Teaching Techniques for the Learning Disabled* (NILD, 1993).
The instruments (o) used to measure the treatment effects and test the hypotheses were the *Wide Range Achievement Test - Revised* (WRAT-R) and the *Detroit Tests of Learning Aptitude - Second Edition* (DTLA-2). Although the WRAT-R yields a limited sample of behavior, it does measure acquisition of basic school codes, which are prerequisites for literacy. The DTLA-2 (1985), in turn, measures cognitive behavior and correlates highly with the WISC-R.

The setting (s) of the study was combined with u, t and o (utos) to define the domain of investigation (Cronbach, 1982). Since all participants in the study shared a common private, parochial school culture, the underlying norms and values defined both parental and student involvement. Students were served in a one-to-one setting, but were mainstreamed in the general classroom for the majority of their school experience.

A quasi-experimental nonequivalent control-group design was used as it was not possible to randomly assign students to groups based upon a prior diagnosis of a learning disability. Initial group differences were determined by chi-square analysis and independent t-tests. An analysis of covariance was conducted for each of the six variables: WRAT-R reading, WRAT-R spelling, WRAT-R arithmetic, DTLA-2 GIQ, DTLA-2 VIQ, DTLA-2 NVIQ followed by a post-hoc, Tukey, test. Covariates in the study were parental income, WRAT-R reading and spelling.
Conclusions

Discussion. A review of the objectives, hypotheses, results, findings, and statistical analyses suggests that the following conclusions may be drawn from the study:

1. Students in the experimental group exhibited significant growth over time on a standardized assessment of reading skills. However, this growth was not significant compared to a control group receiving classroom instruction alone. The control group achieved marginal but not significant gains over time, and the posttest scores did not differ significantly from those of the experimental group.

2. Students in the experimental group exhibited significant growth over time on a standardized assessment of spelling skills. However, this growth was not significant compared to a control group receiving classroom instruction alone. The control group achieved marginal but not significant gains over time, and the posttest scores were not significantly different from those of the experimental group.

3. Students in the experimental group exhibited significant growth over time on a standardized assessment of arithmetic skills. The control group also improved significantly over time. No interaction effect was demonstrated between group and time of treatment, so no follow-up tests were conducted.
4. Students in the experimental group exhibited significant growth over time on a standardized assessment of general cognitive functioning compared to students in a control group receiving classroom instruction alone. In addition, the control group improved significantly over time. A significant interaction effect was evidenced between groups and time of treatment.

5. Students in the experimental group exhibited significant growth over time on a standardized assessment of verbal cognitive functioning compared to those in a control group receiving classroom instruction alone. In addition, the control group improved significantly over time. A significant interaction effect was evidenced between groups and time of treatment.

6. Students in the experimental group exhibited significant growth on a standardized assessment of nonverbal cognitive functioning. The control group achieved marginal but not significant gains over time, and posttest scores were not significantly different from those of the experimental group.

Recent studies confirm that learning disabilities persist into adulthood and that interventions generally are not clearly related to outcomes. Spreen (1988) saw outcome as dependent upon the severity of the disability, parents’ socioeconomic status, and the presence or absence of neurological impairment. Additionally, evidence suggests that a language deficit subtype may result in poorer outcomes than other subtypes, since students with LD often have difficulty
learning rule-based linguistic systems (Carlisle, 1994). In the present study, it was hypothesized that intensive, individualized intervention would lead to improved academic and cognitive outcomes in students with diagnosed learning disabilities in an experimental treatment group compared to a control group.

Three questions were asked prior to the statistical analyses:

1. **Are the groups different?** The results indicated a significant difference between groups on two of the six variables used to test the hypotheses. Specifically, students in the experimental group significantly outperformed students in the control group on general and verbal cognitive processing as measured by the DTLA-2. These intelligence measures correlate highly (from .90 to .95) with the full scale and verbal intelligence quotients of the WISC-R. Generally, students with learning disabilities tend to regress in language-related standardized assessments (Spreen, 1988), so an increase of approximately 10 points on each of these variables indicates a significant treatment effect.

2. **Is performance different over time?** For each of the six variables, performance increased significantly over time for the experimental group. Thus, increases were noted in reading, spelling, and arithmetic, and in general, verbal, and nonverbal IQ scores. Two of the variables, general intelligence quotient (GIQ) and verbal intelligence quotient (VIQ), also increased significantly over time for the control group. Evidence reflects that the experimental group’s scores
increased significantly over time. There was no apparent difference between groups at the pre- and posttest levels. The trend toward growth of the experimental group, coupled with nonsignificant differences between control and experimental groups, may reflect limited sample size.

3. **Do the groups differ by time (is there interaction of group/time)?** A significant interaction effect was noted for five of the six variables: reading, spelling, GIQ, VIQ, and NVIQ. In addition, GIQ and VIQ evidenced both group and time differences. Both groups evidenced significant growth; however, the experimental group demonstrated impressive gains compared to the control group.

The treatment also seems to have resulted in successful language stimulation. On every measure, the experimental group made significant gains over time. The control group also progressed over time, although not significantly, in four of the six measures. This growth is possibly due to a smaller gap in this group between ability and achievement. That is, particular language deficits may have been less severe going into the experiment for controls.

Therefore, the conclusion can be drawn that intensive intervention using the NILD educational therapy model appeared to affect significant changes in academic achievement in reading, spelling, and arithmetic and in general, verbal and nonverbal cognitive functioning. Without the use of PET or MRI scans, it cannot be proven that neurological functioning has been enhanced. However,
since increased performance on these outcome measures over time is atypical for students with learning disabilities, it may be assumed that greater neurological efficiency is a factor (Bakker, 1994). Follow-up studies on students with LD generally confirm a regression effect in the absence of specific intervention (Horn, O'Donnell, & Vitulano, 1983).

It is noteworthy that in cognitive processing the control group also made significant gains over time. This may reflect excellent classroom instruction and stimulating interactive dialogue within a group setting. However, the performance results of the experimental group were significantly different from those of the control group following intensive, individualized intervention.

Of the three variables measuring cognitive processing, the most significant gains for the experimental group were found to be in the areas of general and verbal intelligence. Thus, on these two measures (GIQ and VIQ), there was a significant group-by-time interaction in which both the experimental and control groups showed significant gains, although the experimental group’s gain was significantly greater than that of the control group. Many of the items on these two measures (DTLA-2) involved the tertiary cognitive functioning described in areas of Luria’s Units II and III (see Figure 1). According to Luria (see Golden, 1991)
The tertiary parietal areas play a primary role in many of the tasks commonly subsumed under “intelligence.” Auditory-visual integration is necessary for reading and auditory-tactile integration is necessary for writing. Arithmetic, as well as body location in space and visual-spatial skills, depends upon visual-tactile integration. Grammatical skills, syntax, abstractions, logical analysis, understanding of prepositions, spatial rotation... are just a few of the skills mediated by the tertiary parietal area. (p. 101)

According to Luria, the tertiary area of Unit III receives information from the tertiary area of Unit II, the sensory unit, as well as from the limbic system of Unit I. This area analyzes information and plans behavioral reactions. Major tasks of this area include planning, decision-making, evaluation, temporal continuity, impulse control, focusing attention, and flexibility (Golden, 1991).

Supporters of the NILD model believe that the five core techniques may address these areas of higher cognitive functioning through the medium of interactive language. Further, it has been proposed that the intervention must be individualized and intensive.

Scruggs and Mastropieri (1994) suggested that effective interventions for students with LD should go beyond individualized tutoring. Generally, tutoring attempts to build upon student strengths and typically provides information for the
student rather than specifically requiring a student response. Tutored students
generally remain passive recipients of information rather than active participants in
the learning process. The aim of tutoring generally is to teach content, rather than
develop cognition (Kronick, 1988). Students with LD often reflect processin_g
weaknesses manifested at the sensory level. These sensory-level weaknesses may
prohibit the development of higher-level tertiary functioning. It is the process of
interactive dialogue guided by a skilled mediator that appears to direct the
integration of information impacting executive function. Access to basic school
codes such as those measured by the WRAT-R (1984) primarily involves sensory-
level processing. Whereas tasks such as those assessed by the DTLA-2 (1985)
involve greater hemispheric differentiation. It is significant that in the current
study the greatest interaction effects reflecting clear differences between
experimental and control groups were seen in general and verbal cognitive
processing.

Limitations. Continued controversy surrounding the definition of learning
disabilities impacts the present study. Defining parameters of LD should include
both ability and achievement. The mean IQ score for students in both the
experimental and control groups was approximately 106, representing the upper
end of the average band of 90-110. In terms of the LD ability-achievement
discrepancy, described as one standard deviation below the mean, students within
the experimental group fulfilled this criterion in the reading, spelling, and arithmetic pretests, but the control group did not. Generally, their achievement scores were less than one standard deviation of their IQ scores, bringing into question whether they, in fact, had learning disabilities. This lack of significant discrepancy for the control group may actually serve to strengthen the study in light of impressive gains made by the experimental group.

Although all educational therapists in the present investigation were trained and certified in the NILD approach, it is not possible to account for individual differences in technique implementation and individual proficiency. Another limitation relates to the specific assessment tools used in the study. The WRAT-R measures basic school codes, decoding, encoding, and computation skills, which are basic to academic success in these areas; however, they are not indicative of higher level reasoning or language proficiency.

Since students in the study were drawn from private schools, the question of generalizability to the public sector becomes a possible limitation. To what extent did the setting contribute to the results? Students in the present study were predominately from two-parent families with a mean income of around $50,000. Parents were generally well-educated with a commitment to their children’s education evidenced by a willingness to pay fees above private school tuition costs. Also, there was a time commitment evidenced through agreement to home practice.
and student support. Cronbach (1982) stated, "In the context of program evaluation, a conclusion about UTOS is a prediction" (p. 176). Judgment and formal reasoning must be combined in light of the evidence to reach a certain conclusion. The credibility of this conclusion depends upon the degree to which the working hypotheses are accepted by the relevant community. Conclusions drawn from the present study should be tested further to examine the findings thoroughly.

Using Cronbach’s model, we may view the specific domains of the present study as utos and reflect upon the particular generalizability of the population (u) and the setting (s). Students designated with LD in private school settings are not necessarily comparable to students with LD in public schools. First, the mean IQ scores of the private school group may be higher than in public settings. Students designated with LD in private settings are not strictly categorized according to standard IQ discrepancy formulas, nor must their achievement be two years below grade level to be determined eligible for services. Since evidence suggests (Spreen, 1988) that measured intelligence accounts for 49% of outcome variance, IQ seems to be by far the strongest of all predictors for success. It is students with the greatest intellectual potential who may benefit the most from this specific treatment intervention.
Further, the issue of parental commitment to education is important. Since the component of home practice defines the model under investigation, parental support (e.g., training in home supervision) and consistency (e.g., ongoing observations and time commitment) may be critical to the treatment’s effectiveness. Therefore, the gains of the experimental group in the present study must be clearly defined in the context in which they were found. It is possible that the results evidenced in the present study may be context specific and not generalizable to public school settings. Further studies are needed to confirm effectiveness in other settings and with different populations.

A further limitation of the current study is the lack of data regarding specific classroom performance of the students under investigation. Although test results appear to support both aptitude and academic gains, it would be important to gather data, both statistical and anecdotal, from classroom teachers describing student progress in future studies. Examples of possible classroom measures include student attitudes to learning, motivation, consistency in homework and classwork, grades on tests, daily work, and report cards. Thus, the observing operations (o) need to be redefined in further studies.

Finally, it is not yet possible to measure neurological functioning of students during or following educational treatment interventions. Scientific
evidence of increased interhemispheric collaboration awaits more sophisticated technology.

**Recommendations**

**Recommendations for future studies.** The effects of a specific treatment program have been demonstrated in this investigation. The results raise a number of important questions for researchers to explore in future studies. A primary question involves the experimental group. Are these students getting better? That is, are they achieving academic results commensurate with their ability? It appears that the treatment may have widened the gap between ability and achievement. How does that impact classroom functioning? Are these students able to complete assignments independently? What are their grades and work habits following intensive intervention? Are further modifications needed in their instructional programs? A follow-up study on these 72 students is needed to assess outcome measures relative to performance in the classroom.

Additionally, students in the experimental group were given a treatment package. It is important to examine the elements (e.g., techniques, home practice, parental consistency) within that package individually. Was one of the techniques more powerful than the others, rendering one or more of the others unnecessary? Future studies could examine each of the five techniques in isolation over a period of time to assess its effectiveness.
Further, the elements of home practice, teacher training and effective questioning serve to define the model under investigation. Therefore, the relative importance of each of these elements should be studied individually. For example, would student progress be significant in the absence of consistent stimulation with the Rhythmic Writing technique? Further, how important is ongoing training in the effectiveness of educational therapists? It is assumed that therapists improve in questioning skill over time and with practice and that advanced training facilitates competency. These assumptions should be tested in future studies.

Future studies should employ assessment tools designed to measure reading comprehension, writing proficiency, grammar skills, and applied mathematics. For example, the Woodcock-Johnson Tests of Achievement would provide data relative to higher-level reasoning and language fluency. Further, other assessment tools designed to measure executive functioning could confirm the effectiveness of language stimulation for students with LD. Results of the present study seem to indicate that both intensity of service delivery and individualization are necessary to overcome the tenacious cognitive processing weaknesses within the LD population. In this regard, the guidance of a skilled adult mediator appears to be essential. Further studies designed to compare small-group and individual instruction are needed to test these hypotheses.
Administrative implications. Clearly, there are no simple answers to the complex disorder known as LD. Although knowledge of neurological functioning supplies needed insight for educators, such knowledge introduces questions in terms of appropriate solutions. The search for effective interventions must bridge the disciplines of education, neuropsychology, and biology. To date, research domains have been parallel rather than integrated. The field of biology has provided insight regarding brain mechanisms and biological markers relative to neurological functioning. The field of neuropsychology has begun to address and test theories of functional systems and their application to educational interventions. Educators may now draw upon research from other disciplines.

Given the prevalence of LD and the changing roles of administrators as instructional leaders, school administrators might benefit from training in the philosophy and biology of learning disabilities. Such training should be incorporated as part of preparation for leadership at a graduate level and should aim at integrating the academic disciplines of education, neuropsychology, and biology. Further ongoing coursework should be required for administrators to stay current in advances in various fields and their application to learning disabilities.

In terms of staff development, all teachers might benefit from inservice opportunities designed to elaborate the physiology of learning and the importance
of guided questioning and interactive dialogue. There is a need to study and research various aspects of interactive dialogue within classroom settings.

Theoretical foundations established by Piaget, Vygotsky, Luria, and Feuerstein should be examined and discussed during preservice and inservice learning. Books such as, *The Language and Thought of the Child* (Piaget, 1959), *Thought and Language* (Vygotsky, 1962/1975), *Language and Cognition* (Luria, 1981), and *Instrumental Enrichment: An Intervention Program for Cognitive Modifiability* (Feuerstein, 1980) provide rich sources for academic discourse and have significant implications for instruction. Finally, teachers need to be taught to use guided questioning to facilitate learning.

Certain elements of the techniques used in this study could be incorporated into classroom settings. In particular, dictation and mental math could be studied to determine if their integrative properties lead to simultaneous processing. This could be studied with students of different ability levels.

It has been recommended that students with LD need intensive, individualized intervention in order to improve their cognitive processing. Some suggest that these disabilities cannot be adequately addressed in a whole class or even a small-group setting. The costs of individual therapy are administratively daunting. It is clear, however, that something must be done to curb the numbers of students with LD who continue to drop out of school in record numbers.
Further, the link between learning disabilities and juvenile delinquency has been well established (Brier, 1989). Already the cost to society is staggering. Certain treatment package elements would need to be in place to test the efficacy of implementing the NILD model in public settings. First, school administrators would have to commit to the provision of one-to-one instruction for a three-year pilot study with a sample of students diagnosed with LD. Second, these students’ parents would need to agree to the time commitment necessary to provide consistent support and home practice. Third, the students themselves, particularly at middle and high school levels, would need to be motivated and willing to become actively involved in the learning process. Finally, a system of professional collaboration would need to be instituted so that classroom teachers and trained educational therapists could work together to plan and design effective student programming. At this time, it has not been proven that the NILD intervention package would be effective in public school settings. It would be important to test the hypothesis that with administrative support and student motivation the individualized intervention would be both appropriate and effective within public schools.

In terms of staff development, building a successful intervention program for students with learning disabilities requires creative energy and the development of collaborative cultures within both schools and systems. Classroom teachers and

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educational therapists should be trained to work together in partnership dyads to share resources and mutually design appropriate accommodations for students with LD in the general classroom. Generalists and specialists would benefit from a structured problem-solving method that incorporates active listening and relationship-building components. In time, the dyads could form teams that may include families and even the students themselves.

Creative solutions for the growing numbers of students identified with LD must be explored through interagency collaboration. For example, teams composed of social workers, neuropsychologists, teachers, administrators, educational therapists, families, physicians, and other professionals could create a synergy released through the shared expertise of each. As the medical and educational fields dialogue and explore new educational possibilities based upon rigorous scientific research across disciplines, all students with learning needs would benefit.

Traditional remediation programs for LD appear to have been minimally effective because they have addressed only the symptoms and not the underlying neurological problems of students with learning disabilities (Tallal, 1994). Collaboration of the medical and educational fields could well be a model of how scientific research in the field of LD should proceed in the future. By facilitating dialogue among researchers who bring a variety of perspectives to a given issue,
scientific study can progress more rapidly. Such an approach makes wise and efficient use of both people and technology. More sophisticated technology continues to develop, bringing us closer to being able to identify specific neurological dysfunction and patterns of dysfunction within a given individual (Cruikshank, 1989).

Educators are faced with insurmountable tasks and unprecedented opportunities. They must unite with parallel disciplines to meet the needs of the burgeoning population of students with LD. Further, administrators must provide inservice opportunities for educators to learn more about the effects of interactive dialogue within classroom settings, as well as the neuropsychology of learning.

It has been suggested that current interventions are generally not powerful enough to make a difference in the LD population. Learning disabilities are not a mild disabling condition. The times demand solutions that are sound, effective, and based upon field-tested research. Studies investigating more neurologically based interventions are needed. It is hoped that the results of this study will prompt both replication of the study and further discourse among professionals.
APPENDIX
Table 1

Demographic Data

<table>
<thead>
<tr>
<th></th>
<th>Experimental Group (n=47)</th>
<th>Control Group (n=25)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Gender</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>28 (60%)</td>
<td>Male 17 (68%)</td>
</tr>
<tr>
<td>Female</td>
<td>19 (40%)</td>
<td>Female 8 (32%)</td>
</tr>
<tr>
<td><strong>Mean Age</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>13.99</td>
<td>Male 14.84</td>
</tr>
<tr>
<td>Female</td>
<td>14.26</td>
<td>Female 12.74</td>
</tr>
<tr>
<td><strong>Mean IQ Score</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>106.21</td>
<td>Male 106.56</td>
</tr>
<tr>
<td>Female</td>
<td>106.89</td>
<td>Female 105.14</td>
</tr>
<tr>
<td><strong>Location</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Suburban</td>
<td>66%</td>
<td>64%</td>
</tr>
<tr>
<td>Urban</td>
<td>21%</td>
<td>20%</td>
</tr>
<tr>
<td>Rural</td>
<td>13%</td>
<td>16%</td>
</tr>
<tr>
<td><strong>Family Income</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>under $20,000</td>
<td>0%</td>
<td>4%</td>
</tr>
<tr>
<td>$20,000 - $30,000</td>
<td>21%</td>
<td>20%</td>
</tr>
<tr>
<td>$30,000 - $50,000</td>
<td>32%</td>
<td>48%</td>
</tr>
<tr>
<td>over $50,000</td>
<td>47%</td>
<td>24%</td>
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<td><strong>Parent Occupation</strong></td>
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<td></td>
</tr>
<tr>
<td>Father</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Professional (4 yr. college)</td>
<td>45%</td>
<td>32%</td>
</tr>
<tr>
<td>Business (unknown college)</td>
<td>43%</td>
<td>36%</td>
</tr>
<tr>
<td>Laborer (no college)</td>
<td>12%</td>
<td>16%</td>
</tr>
<tr>
<td>Mother</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Homemaker (unknown college)</td>
<td>45%</td>
<td>40%</td>
</tr>
<tr>
<td>Professional (4 yr. college)</td>
<td>25%</td>
<td>24%</td>
</tr>
<tr>
<td>Business (unknown college)</td>
<td>30%</td>
<td>36%</td>
</tr>
<tr>
<td>Two-parent family:</td>
<td>96%</td>
<td>84%</td>
</tr>
<tr>
<td>Avg. treatment/no treatment time:</td>
<td>36 months</td>
<td>38 months</td>
</tr>
</tbody>
</table>
Table 2

Chi-Square Gender by Group

<table>
<thead>
<tr>
<th>Gender</th>
<th>Pct</th>
<th>Control Group</th>
<th>Experimental Group</th>
<th>Row Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1.00</td>
<td>17</td>
<td>28</td>
<td>45</td>
</tr>
<tr>
<td>Male</td>
<td></td>
<td>15.6</td>
<td>29.4</td>
<td>62.5%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>37.8%</td>
<td>62.2%</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>68.0%</td>
<td>59.6%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2.00</td>
<td>8</td>
<td>19</td>
<td>27</td>
</tr>
<tr>
<td>Female</td>
<td></td>
<td>9.4</td>
<td>17.6</td>
<td>37.5%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>29.6%</td>
<td>70.4%</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>32.0%</td>
<td>40.4%</td>
<td></td>
</tr>
<tr>
<td>Column</td>
<td></td>
<td>25</td>
<td>47</td>
<td>72</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>34.7%</td>
<td>65.3%</td>
<td>100.0%</td>
</tr>
</tbody>
</table>

Chi-Square

<table>
<thead>
<tr>
<th>Chi-Square</th>
<th>Value</th>
<th>df</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pearson</td>
<td>.49430</td>
<td>1</td>
<td>.48202 (NS)</td>
</tr>
<tr>
<td>Continuity Correction</td>
<td>.20017</td>
<td>1</td>
<td>.65458 (NS)</td>
</tr>
<tr>
<td>Likelihood Ratio</td>
<td>.49989</td>
<td>1</td>
<td>.47955 (NS)</td>
</tr>
<tr>
<td>Linear-by-Linear Association</td>
<td>.48743</td>
<td>1</td>
<td>.48507 (NS)</td>
</tr>
<tr>
<td>Fisher’s Exact Test:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>One-Tail</td>
<td></td>
<td></td>
<td>.32953 (NS)</td>
</tr>
<tr>
<td>Two-Tail</td>
<td></td>
<td></td>
<td>.61086 (NS)</td>
</tr>
</tbody>
</table>

Minimum Expected Frequency - 9.375
Table 3

Chi-Square Father's Occupation by Group

<table>
<thead>
<tr>
<th>Father's Occupation</th>
<th>Control Group</th>
<th>Experimental Group</th>
<th>Row Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pct 1.00</td>
<td>Pct 2.00</td>
<td></td>
</tr>
<tr>
<td>Professionals</td>
<td>8</td>
<td>22</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>9.9</td>
<td>20.1</td>
<td>44.8%</td>
</tr>
<tr>
<td></td>
<td>26.7%</td>
<td>73.3%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>36.4%</td>
<td>48.9%</td>
<td></td>
</tr>
<tr>
<td>Business</td>
<td>7</td>
<td>17</td>
<td>24</td>
</tr>
<tr>
<td></td>
<td>7.9</td>
<td>16.1</td>
<td>35.8%</td>
</tr>
<tr>
<td></td>
<td>29.2%</td>
<td>70.8%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>31.8%</td>
<td>37.8%</td>
<td></td>
</tr>
<tr>
<td>Laborers</td>
<td>5</td>
<td>5</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>3.3</td>
<td>6.7</td>
<td>14.9%</td>
</tr>
<tr>
<td></td>
<td>50.0%</td>
<td>50.0%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>22.7%</td>
<td>11.1%</td>
<td></td>
</tr>
<tr>
<td>Unknown</td>
<td>2</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>1.0</td>
<td>2.0</td>
<td>4.5%</td>
</tr>
<tr>
<td></td>
<td>66.7%</td>
<td>33.3%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>9.1%</td>
<td>2.2%</td>
<td></td>
</tr>
<tr>
<td>Column Total</td>
<td>22</td>
<td>45</td>
<td>67</td>
</tr>
<tr>
<td>Total</td>
<td>32.8%</td>
<td>67.2%</td>
<td>100.0%</td>
</tr>
</tbody>
</table>

Chi-Square Value df Significance

<table>
<thead>
<tr>
<th>Chi-Square</th>
<th>Value</th>
<th>df</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pearson</td>
<td>3.55698</td>
<td>3</td>
<td>.31345 (NS)</td>
</tr>
<tr>
<td>Likelihood Ratio</td>
<td>3.37179</td>
<td>3</td>
<td>.33777 (NS)</td>
</tr>
<tr>
<td>Linear-by-Linear Association</td>
<td>2.85128</td>
<td>1</td>
<td>.09130 (NS)</td>
</tr>
</tbody>
</table>

Minimum Expected Frequency - 0.985

Cells with Expected Frequency < 5 - 3 of 8 (37.5%)
Table 4

**Chi-Square Mother’s Occupation by Group**

<table>
<thead>
<tr>
<th>Mother’s Occupation</th>
<th>Control Group</th>
<th>Experimental Group</th>
<th>Row Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pct 1.00</td>
<td>Pct 2.00</td>
<td></td>
</tr>
<tr>
<td>Homemakers</td>
<td>10</td>
<td>24</td>
<td>34</td>
</tr>
<tr>
<td></td>
<td>11.8</td>
<td>22.2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>29.4%</td>
<td>70.6%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>40.0%</td>
<td>51.1%</td>
<td></td>
</tr>
<tr>
<td>Professionals</td>
<td>5</td>
<td>14</td>
<td>19</td>
</tr>
<tr>
<td></td>
<td>6.6</td>
<td>12.4</td>
<td></td>
</tr>
<tr>
<td></td>
<td>26.3%</td>
<td>73.7%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>20.0%</td>
<td>29.8%</td>
<td></td>
</tr>
<tr>
<td>Business</td>
<td>10</td>
<td>9</td>
<td>19</td>
</tr>
<tr>
<td></td>
<td>6.6</td>
<td>12.4</td>
<td></td>
</tr>
<tr>
<td></td>
<td>52.6%</td>
<td>47.4%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>40.0%</td>
<td>19.1%</td>
<td></td>
</tr>
<tr>
<td>Column Total</td>
<td>25</td>
<td>47</td>
<td>72</td>
</tr>
<tr>
<td>Total</td>
<td>34.7%</td>
<td>65.3%</td>
<td>100.0%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Chi-Square</th>
<th>Value</th>
<th>df</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pearson</td>
<td>3.70410</td>
<td>2</td>
<td>.15691 (NS)</td>
</tr>
<tr>
<td>Likelihood Ratio</td>
<td>3.60039</td>
<td>2</td>
<td>.16527 (NS)</td>
</tr>
<tr>
<td>Linear-by-Linear Association</td>
<td>2.36629</td>
<td>1</td>
<td>.12398 (NS)</td>
</tr>
</tbody>
</table>

Minimum Expected Frequency - 6.597

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Table 5

Chi-Square City Size by Group

<table>
<thead>
<tr>
<th>City Size</th>
<th>Pct</th>
<th>Control Group 1.00</th>
<th>Experimental Group 2.00</th>
<th>Row Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - 25,000</td>
<td>8</td>
<td>22</td>
<td>30</td>
<td>44.8%</td>
</tr>
<tr>
<td></td>
<td>9.9</td>
<td>20.1</td>
<td></td>
<td>44.8%</td>
</tr>
<tr>
<td></td>
<td>26.7%</td>
<td>73.3%</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>36.4%</td>
<td>48.9%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>25,000 - 50,000</td>
<td>7</td>
<td>17</td>
<td>24</td>
<td>35.8%</td>
</tr>
<tr>
<td></td>
<td>7.9</td>
<td>16.1</td>
<td></td>
<td>35.8%</td>
</tr>
<tr>
<td></td>
<td>29.2%</td>
<td>70.8%</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>31.8%</td>
<td>37.8%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>50,000 - 100,000</td>
<td>5</td>
<td>5</td>
<td>10</td>
<td>14.9%</td>
</tr>
<tr>
<td></td>
<td>3.3</td>
<td>6.7</td>
<td></td>
<td>14.9%</td>
</tr>
<tr>
<td></td>
<td>50.0%</td>
<td>50.0%</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>22.7%</td>
<td>11.1%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>100,000 - 500,000</td>
<td>5</td>
<td>5</td>
<td>10</td>
<td>14.9%</td>
</tr>
<tr>
<td></td>
<td>3.3</td>
<td>6.7</td>
<td></td>
<td>14.9%</td>
</tr>
<tr>
<td></td>
<td>50.0%</td>
<td>50.0%</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>22.7%</td>
<td>11.1%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>over 500,000</td>
<td>2</td>
<td>1</td>
<td>3</td>
<td>4.5%</td>
</tr>
<tr>
<td></td>
<td>1.0</td>
<td>2.0</td>
<td></td>
<td>4.5%</td>
</tr>
<tr>
<td></td>
<td>66.7%</td>
<td>33.3%</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>9.1%</td>
<td>2.2%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Column Total</td>
<td>22</td>
<td>45</td>
<td>67</td>
<td>100.0%</td>
</tr>
<tr>
<td>Total</td>
<td>32.8%</td>
<td>67.2%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Chi-Square Value | df  | Significance
---|-----|-----------------|
Pearson | 3.55698 | 3 | .31345 (NS)
Likelihood Ratio | 3.37179 | 3 | .33777 (NS)
Linear-by-Linear Association | 2.85128 | 1 | .09130 (NS)

Minimum Expected Frequency - .985
Cells with Expected Frequency < 5 - 3 of 8 (37.5%)
Table 6

Chi-Square Location by Group

<table>
<thead>
<tr>
<th>Location</th>
<th>Pct</th>
<th>Control Group 1.00</th>
<th>Experimental Group 2.00</th>
<th>Row Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1.00</td>
<td>16</td>
<td>30</td>
<td>46</td>
</tr>
<tr>
<td>Suburban</td>
<td>16.0</td>
<td>30.0</td>
<td>63.9%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>34.8%</td>
<td>65.2%</td>
<td>63.8%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>64.0%</td>
<td>63.8%</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1.00</td>
<td>5</td>
<td>12</td>
<td>17</td>
</tr>
<tr>
<td>Urban</td>
<td>5.9</td>
<td>11.1</td>
<td>23.6%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>29.4%</td>
<td>70.6%</td>
<td>25.5%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>20.0%</td>
<td>25.5%</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2.00</td>
<td>4</td>
<td>5</td>
<td>9</td>
</tr>
<tr>
<td>Rural</td>
<td>3.1</td>
<td>5.9</td>
<td>12.5%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>44.4%</td>
<td>55.6%</td>
<td>10.6%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>16.0%</td>
<td>10.6%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Column</td>
<td>25</td>
<td>47</td>
<td>72</td>
<td>100.0%</td>
</tr>
<tr>
<td>Total</td>
<td>34.7%</td>
<td>65.3%</td>
<td>100.0%</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Chi-Square</th>
<th>Value</th>
<th>df</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pearson</td>
<td>.58691</td>
<td>2</td>
<td>.74568 (NS)</td>
</tr>
<tr>
<td>Likelihood Ratio</td>
<td>.57951</td>
<td>2</td>
<td>.74845 (NS)</td>
</tr>
<tr>
<td>Linear-by-Linear Association</td>
<td>.08678</td>
<td>1</td>
<td>.76831 (NS)</td>
</tr>
</tbody>
</table>

Minimum Expected Frequency - 3.125
Cells with Expected Frequency < 5 - 1 of 6 (16.7%)
Table 7

Chi-Square Income by Group

<table>
<thead>
<tr>
<th>Income</th>
<th>Pct</th>
<th>Control Group 1.00</th>
<th>Experimental Group 2.00</th>
<th>Row Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Under $20,000</td>
<td>1.00</td>
<td>.3</td>
<td>.7</td>
<td>1.4%</td>
</tr>
<tr>
<td></td>
<td>1.00</td>
<td>100.0%</td>
<td>.0%</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>4.0%</td>
<td>.0%</td>
<td></td>
</tr>
<tr>
<td>$20,000 - $30,000</td>
<td>2.00</td>
<td>5.6</td>
<td>10.4</td>
<td>22.2%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>31.3%</td>
<td>68.8%</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>20.0%</td>
<td>23.4%</td>
<td></td>
</tr>
<tr>
<td>$30,000 - $50,000</td>
<td>3.00</td>
<td>8.7</td>
<td>16.3</td>
<td>34.7%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>52.0%</td>
<td>48.0%</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>52.0%</td>
<td>25.5%</td>
<td></td>
</tr>
<tr>
<td>Over $50,000</td>
<td>4.00</td>
<td>6</td>
<td>24</td>
<td>41.7%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10.4</td>
<td>19.6</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>20.0%</td>
<td>80.0%</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>24.0%</td>
<td>51.1%</td>
<td></td>
</tr>
<tr>
<td>Column</td>
<td>25</td>
<td>47</td>
<td>72</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>34.7%</td>
<td>65.3%</td>
<td>100.0%</td>
<td></td>
</tr>
</tbody>
</table>

Chi-Square Value df Significance

<table>
<thead>
<tr>
<th>Chi-Square</th>
<th>Value</th>
<th>df</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pearson</td>
<td>8.12650</td>
<td>3</td>
<td>.04347 *</td>
</tr>
<tr>
<td>Likelihood Ratio</td>
<td>8.46600</td>
<td>3</td>
<td>.03730 *</td>
</tr>
<tr>
<td>Linear-by-Linear Association</td>
<td>2.41954</td>
<td>1</td>
<td>.11983</td>
</tr>
</tbody>
</table>

Minimum Expected Frequency - .347
Cells with Expected Frequency < 5 - 2 of 8 (25.0%)
**Table 8**

**WRAT-R - Reading Pretest**

(t-Test for Independent Samples of Group)

<table>
<thead>
<tr>
<th>Variable</th>
<th># of Cases</th>
<th>Mean</th>
<th>SD</th>
<th>SE of Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>25</td>
<td>99.3200</td>
<td>11.415</td>
<td>2.283</td>
</tr>
<tr>
<td>Experimental</td>
<td>47</td>
<td>89.2766</td>
<td>13.091</td>
<td>1.910</td>
</tr>
</tbody>
</table>

Mean Difference = 10.0434

(t-Test for Equality of Means)

<table>
<thead>
<tr>
<th>Variances</th>
<th>t-Value</th>
<th>df</th>
<th>2-Tail Sig</th>
<th>SE of Diff</th>
<th>95% CI for Diff</th>
</tr>
</thead>
<tbody>
<tr>
<td>Equal</td>
<td>3.23</td>
<td>70</td>
<td>.002</td>
<td>3.105</td>
<td>(3.851, 16.235)</td>
</tr>
<tr>
<td>Unequal</td>
<td>3.37</td>
<td>55.22</td>
<td>.001</td>
<td>2.976</td>
<td>(4.079, 16.008)</td>
</tr>
</tbody>
</table>

---

**Table 9**

**WRAT-R - Spelling Pretest**

(t-Test for Independent Samples of Group)

<table>
<thead>
<tr>
<th>Variable</th>
<th># of Cases</th>
<th>Mean</th>
<th>SD</th>
<th>SE of Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>25</td>
<td>96.8800</td>
<td>12.447</td>
<td>2.489</td>
</tr>
<tr>
<td>Experimental</td>
<td>47</td>
<td>85.2766</td>
<td>17.356</td>
<td>2.532</td>
</tr>
</tbody>
</table>

Mean Difference = 11.5234

(t-Test for Equality of Means)

<table>
<thead>
<tr>
<th>Variances</th>
<th>t-Value</th>
<th>df</th>
<th>2-Tail Sig</th>
<th>SE of Diff</th>
<th>95% CI for Diff</th>
</tr>
</thead>
<tbody>
<tr>
<td>Equal</td>
<td>2.94</td>
<td>70</td>
<td>.004</td>
<td>3.922</td>
<td>(3.700, 19.346)</td>
</tr>
<tr>
<td>Unequal</td>
<td>3.25</td>
<td>63.74</td>
<td>.002</td>
<td>3.551</td>
<td>(4.430, 18.617)</td>
</tr>
</tbody>
</table>
### Table 10

**WRAT-R - Arithmetic Pretest**

(t-Test for Independent Samples of Group)

<table>
<thead>
<tr>
<th>Variable</th>
<th># of Cases</th>
<th>Mean</th>
<th>SD</th>
<th>SE of Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>25</td>
<td>96.8800</td>
<td>13.700</td>
<td>2.740</td>
</tr>
<tr>
<td>Experimental</td>
<td>47</td>
<td>89.9149</td>
<td>14.648</td>
<td>2.137</td>
</tr>
</tbody>
</table>

Mean Difference = 6.9651

Levene’s Test for Equality of Variances: F=2.460  p=.121.

(t-Test for Equality of Means)

<table>
<thead>
<tr>
<th>Variances</th>
<th>t-Value</th>
<th>df</th>
<th>2-Tail Sig</th>
<th>SE of Diff</th>
<th>95% CI for Diff</th>
</tr>
</thead>
<tbody>
<tr>
<td>Equal</td>
<td>1.96</td>
<td>70</td>
<td>.054</td>
<td>3.547</td>
<td>(-.110, 14.040)</td>
</tr>
<tr>
<td>Unequal</td>
<td>2.00</td>
<td>52.02</td>
<td>.050</td>
<td>3.475</td>
<td>(-.007, 13.937)</td>
</tr>
</tbody>
</table>

### Table 11

**DTLA-2 General Pretest**

(t-Test for Independent Samples of Group)

<table>
<thead>
<tr>
<th>Variable</th>
<th># of Cases</th>
<th>Mean</th>
<th>SD</th>
<th>SE of Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>25</td>
<td>100.5200</td>
<td>9.661</td>
<td>1.932</td>
</tr>
<tr>
<td>Experimental</td>
<td>47</td>
<td>97.3404</td>
<td>10.686</td>
<td>1.559</td>
</tr>
</tbody>
</table>

Mean Difference = 3.1796

Levene’s Test for Equality of Variances: F=1.382  p=.244.

(t-Test for Equality of Means)

<table>
<thead>
<tr>
<th>Variances</th>
<th>t-Value</th>
<th>df</th>
<th>2-Tail Sig</th>
<th>SE of Diff</th>
<th>95% CI for Diff</th>
</tr>
</thead>
<tbody>
<tr>
<td>Equal</td>
<td>1.24</td>
<td>70</td>
<td>.219</td>
<td>2.561</td>
<td>(-1.928, 8.287)</td>
</tr>
<tr>
<td>Unequal</td>
<td>1.28</td>
<td>53.56</td>
<td>.206</td>
<td>2.483</td>
<td>(-1.799, 8.158)</td>
</tr>
</tbody>
</table>

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Table 12

DTLA-2 Verbal Pretest

(t-Test for Independent Samples of Group)

<table>
<thead>
<tr>
<th>Variable</th>
<th># of Cases</th>
<th>Mean</th>
<th>SD</th>
<th>SE of Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>25</td>
<td>99.2800</td>
<td>11.513</td>
<td>2.303</td>
</tr>
<tr>
<td>Experimental</td>
<td>47</td>
<td>96.8511</td>
<td>11.922</td>
<td>1.739</td>
</tr>
</tbody>
</table>

Mean Difference = 2.4289
Levene’s Test for Equality of Variances: F=.003  p=.954.

(t-Test for Equality of Means)

<table>
<thead>
<tr>
<th>Variances</th>
<th>t-Value</th>
<th>df</th>
<th>2-Tail Sig</th>
<th>SE of Diff</th>
<th>95% CI for Diff</th>
</tr>
</thead>
<tbody>
<tr>
<td>Equal</td>
<td>.83</td>
<td>70</td>
<td>.408</td>
<td>2.917</td>
<td>(-3.388, 8.246)</td>
</tr>
<tr>
<td>Unequal</td>
<td>.84</td>
<td>50.6</td>
<td>.404</td>
<td>2.885</td>
<td>(-3.365, 8.223)</td>
</tr>
</tbody>
</table>

Table 13

DTLA-2 Nonverbal Pretest

(t-Test for Independent Samples of Group)

<table>
<thead>
<tr>
<th>Variable</th>
<th># of Cases</th>
<th>Mean</th>
<th>SD</th>
<th>SE of Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>25</td>
<td>101.6800</td>
<td>8.693</td>
<td>1.739</td>
</tr>
<tr>
<td>Experimental</td>
<td>47</td>
<td>96.7447</td>
<td>10.747</td>
<td>1.568</td>
</tr>
</tbody>
</table>

Mean Difference = 4.9353
Levene’s Test for Equality of Variances: F=2.134  p=.149.

(t-Test for Equality of Means)

<table>
<thead>
<tr>
<th>Variances</th>
<th>t-Value</th>
<th>df</th>
<th>2-Tail Sig</th>
<th>SE of Diff</th>
<th>95% CI for Diff</th>
</tr>
</thead>
<tbody>
<tr>
<td>Equal</td>
<td>1.98</td>
<td>70</td>
<td>.052</td>
<td>2.498</td>
<td>(-.046, 9.917)</td>
</tr>
<tr>
<td>Unequal</td>
<td>2.11</td>
<td>58.66</td>
<td>.039</td>
<td>2.341</td>
<td>(.251, 9.620)</td>
</tr>
</tbody>
</table>
Table 14

**Observed and Adjusted Means for Covariates**

<table>
<thead>
<tr>
<th></th>
<th>Observed Mean</th>
<th></th>
<th>Adjusted Mean</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Control</td>
<td>Experimental</td>
<td>Control</td>
<td>Experimental</td>
</tr>
<tr>
<td>WRAT-R Pre Reading</td>
<td>99.320</td>
<td>89.277</td>
<td>96.483</td>
<td>92.114</td>
</tr>
<tr>
<td>WRAT-R Post Reading</td>
<td>102.240</td>
<td>100.617</td>
<td>99.840</td>
<td>103.017</td>
</tr>
<tr>
<td>WRAT-R Pre Spelling</td>
<td>96.800</td>
<td>85.277</td>
<td>92.872</td>
<td>89.205</td>
</tr>
<tr>
<td>WRAT-R Post Spelling</td>
<td>96.520</td>
<td>94.340</td>
<td>93.765</td>
<td>97.096</td>
</tr>
</tbody>
</table>
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