2000

The Stroop Color Word test and learning disabilities

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THE STROOP COLOR WORD TEST

AND LEARNING DISABILITIES

A Thesis Submitted in Partial Fulfillment

Of the Requirements for the

Master of Arts in Clinical Psychology

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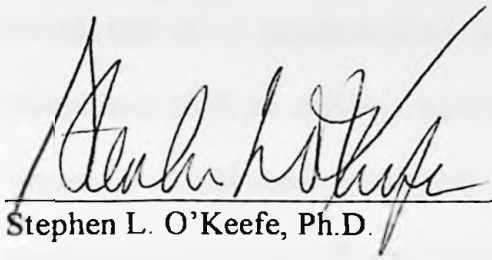
Marshall University

2000

Approved by the Thesis Committee:



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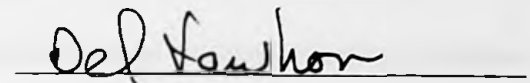

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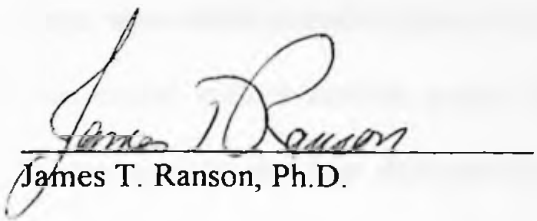

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ABSTRACT

This Thesis study critically explored the feasibility of utilizing the Stroop Color Word test as a psychological instrument to aid in the determination of learning disabilities (LD) in children aged nine to sixteen years old. Children with a previous diagnosis of LD were sought out for the experimental group by participating graduate students and, when confirmed by personal administration of intelligence and achievement tests, were administered a battery of nine neuropsychological instruments. A comparison was made with a control group of children with the same age and geographical background on the four different Stroop variables: the Word, Color, Color-Word, and Interference variables. Two of the four variables proved to be statistically significant between the experimental and control groups: the Word variable and the Color variable. Of the experimental group, the mean scores of three out of four different Stroop variables were lower than those concurrent scores of the control group. This test can be utilized to discriminate between LD and Non-LD groups when comparing the Word and Color Variables.

ACKNOWLEDGMENTS

My undying gratitude, respect, and LOVE go out to my wife, Bonnie Bailey, who has prodded me, comforted me, inspired me, calmed me, evoked me, tolerated me, and in the process, has given me everything any man would want. Thanks are owed to my parents, Nina and Ed Arnett, who have been supportive of this pursuit of higher education in every way since its inception in the Fall of 1997. To my professors and fellow classmates in the psychology department: I pray that you have learned from me a fraction of what I have learned from you. Your camaraderie and influence are appreciated.

TABLE OF CONTENTS

THE STROOP COLOR WORD TEST AND LEARNING DISABILITIES

In giving a history of the diagnosis of Learning Disabilities (LD), it is evident that progress has been fueled less by scientific research than by political necessity. Retrospectively evaluating the previous steps made in LD diagnosis through the eyes of today's clinician, it is nearly inconceivable that diagnosis, classification, and placement decisions were made in the ways explained below.

Prior to the 1940's, in the United States, children with difficulties in learning were classified as one of the following: emotionally disturbed, mentally retarded, or socially and culturally disadvantaged (Silver, 1990). Unfortunately, the children of that generation who were given such a label may not have been accurately diagnosed. Because psychology was such a young field, history implies that such diagnoses likely were given by physicians to students with learning disabilities. In the early 1940's, research findings suggested possible neurological basis for such symptoms: namely "Minimal Brain Damage". Researchers concluded that the brain damage was minimal because the children affected still looked normal.

Further technology and studies afforded in the 1950's and 1960's revealed no evidence of brain damage in children with the same symptoms. The previously used term was altered to "Minimal Brain Dysfunction" because "all of the brain mechanisms appeared to be present and operable"(Silver, 1990, p. 394). Instead of the brain tissue, scientists then implicated abnormal 'wiring' or functioning of the tissue.

Although highly criticized for her theory, Sleeter believed in 1986 that LD children struggled with "an inability to achieve certain standards for literacy" (Sleeter,

1986, p. 48). Literacy standards have been increasing proportionately with the industrial expansion of our nation since the turn of the century. The launch of the Soviet Union's Sputnik spacecraft in 1957 resulted in a major escalation in these standards. In fact, some achievement tests were re-normed to reflect higher standards of literacy shortly after Sputnik. A popular response to the Russians winning the race to space was the American public blaming our schools for failing to produce top-notch scientists, mathematicians, and technicians. As a symptom of the Cold War, critics claimed that a lax in educational standards existed.

Not surprisingly, these political reasons and popular demands prompted such a boost in literacy standards that many children were unable to maintain an appropriate reading level. These children were placed into one of five categories: "slow learners, mentally retarded, emotionally disturbed, culturally deprived, and learning disabled" (Sleeter, 1986, p. 49).

In 1975, at a time when School Psychology was a quickly expanding and newly developing profession, Public Law 94-142 was adopted by the federal government as the "Education for All Handicapped Children Act" (Batsche & Knoff, 1995). It is now known as the "Individuals with Disabilities Education Act (IDEA)". Its intention was to identify students with handicaps or disabilities and subsequently place them in a segregated, "Special Education" classroom. At that time, the assessment process, usually done by school personnel, yielded only an eligibility recommendation. Therefore, the special education placement was the intervention.

Over ten years later, in 1989, a report entitled "The Education of Students with Disabilities: Where Do We Stand?" was published by the National Council on Disability.

For the first time since the implementation of 94-142, researchers scrutinized the practice of placing children with special needs in special education classes. These classes were found to be ineffective and non-beneficial. The report specifically questioned "the appropriateness of assessment that did not lead to the development and evaluation of intervention programs" (Batsche et al., 1995, p. 569). Reports such as this serve to motivate further research in the study of specific LD assessments as well as strategies of intervention. It is time that the scientific side of learning disabilities catches up with the political side!

A few points can emphasize the importance of research in the study of LD assessment and intervention. First, a thorough medical and psychosocial history of the child as well as confirmation through neuropsychometric testing is essential in establishing an accurate diagnosis (Capin, 1996).

If the determination of learning disabilities is not answered during childhood, then the effects may lead to a second point: Learning disorders persist into adulthood (Capin, 1996). Pennington (1991) estimates that the prevalence of all people with LD, including ADHD, is within 15-25% of the total population. To deter inappropriate diagnosing and thus mislabeling of children, the neurological etiology of LD must be determined.

Definitions

The Department of Education of every state has its own definition of learning disability and exactly how it should be identified. In a 1996 study by Mercer, Jordan, Allsopp, and Mercer, a comparison was made to a previous study done by the same authors, published in 1990. They noticed an increase in states' allowance of central

nervous system impairment in their definitions of Learning Disabilities. Their most recent study stated, "A majority of states (75%) include central nervous system impairments in their definition of LD. In terms of [diagnostic] criteria, three states (6%) include the neurological component which is one more than in the 1990 survey" (Mercer, 1996, p. 226). Many states define LD using neurology but fail to diagnose LD using neurology. The goal of this paper is to encourage the inclusion of a neurological component in every state's determination criteria and definition of LD. The definition of LD that will be used for this experiment, as determined by the National Joint Committee on Learning Disabilities (1990) follows:

> Learning disabilities is a general term that refers to a heterogeneous group of disorders manifest by significant difficulties in the acquisition and the use of listening, speaking, reading, writing, reasoning, or mathematical abilities. These disorders are intrinsic to the individual, presumed to be due to central nervous system dysfunction, and may occur across the life span. Problems in self-regulatory behaviors, social perception, and social interaction may exist with learning disabilities but do not by themselves constitute a learning disability. Although learning disabilities may occur concomitantly with other handicapping conditions (e.g., sensory impairment, mental retardation, serious emotional disturbance) or with extrinsic influences (e.g., cultural differences, insufficient or inappropriate instruction), they are not the result of those conditions or influences.

Etiology

The causes of Learning Disabilities range in variety as much as the children themselves. LDs could be caused by neurological and physiological differences. One model, developed by Pennington, focuses on five functional domains: "phonological processing, executive functions, spatial reasoning, social cognition and long-term memory" (Pennington, 1991, p.5). Phonological processing, located in the left perisylvian area of the brain, causes dyslexia. Attention Deficit Disorder, a weakness in

executive functioning, can be localized to the prefrontal area of the brain. If a child shows a weakness in spatial cognition functions, then the posterior right hemisphere is affected, showing specific math and handwriting problems. The areas of the limbic, orbital, and right hemispheres are the location of social cognition. If these areas are adversely affected, then an Autism spectrum disorder is prevalent. Lastly, within Pennington's neurological model, long-term memory is in the hippocampus and amygdala. This is where a case of amnesia could be localized in the brain. These are just a sampling of neurological knowledge that was not known when learning disabilities came to the forefront of education.

Psychological causation of learning disabilities is demonstrated by the high comorbidity with depression and anxiety (Capin, 1996). Also, the relationship between another well-known childhood psychological disorder, Attention Deficit/Hyperactivity Disorder (ADHD) and learning disabilities is strongly established. "Between 15% and 20% of children and adolescents with learning disabilities will have ADHD" (Silver, 1990, p. 395). In his chapter entitled 'Predispositions, Complications, and Mechanisms,' Levine (1987) discusses the interaction of low self-esteem with LD. "As self-esteem dwindles, the above-mentioned feelings of learned helplessness are common concomitants. High levels of performance anxiety and even clinical depression may be further complications" (Levine, 1987, p. 426).

Some learning difficulties are due to low social class and environmental deprivation associated with poverty. The following are examples of such extrinsic factors: "poor nutrition, lack of appropriate adult role modeling, prenatal exposure to drugs and alcohol, heavy exposure to environmental toxins, lack of intellectual

stimulation, low parental educational achievement, and low parental expectations" (Feldman, 1990, p. 4). According to the DSM-IV, other differential diagnoses for LD include: "normal variations in academic attainment, lack of opportunity, poor teaching, cultural factors, impaired vision or hearing, mental retardation, pervasive development disorder, and communication disorders" (American Psychiatric Association, 1996, p. 47-48).

It is believed that most children who suffer from some form of learning disability are neurologically less than perfect. Unfortunately, neurological deficits are not used as a criterion for LD diagnoses. It is possible that a child who temporarily falls behind in his schoolwork due to a long school absence for medical reasons could be diagnosed with a learning disability. When in fact, this same child may lack the proper morphology and/or neurological deficits for the diagnosis of LD. This child could be mislabeled and thus misdirected for the remainder of his/her life. Conversely, there may be children who have certain known neurological deficits and are not doing well in school. However, they may not be failing badly enough or misbehaving in class to warrant a referral to the school psychologist for testing.

All too often, a child has a discrepancy between his/her IQ and Achievement scores and would benefit from a special education curriculum. Furthermore, this same child may not qualify for a LD diagnosis using current criteria. If that child shows a neurological deficit similar to others possessing the LD diagnosis, then it may be the only justification that a school psychologist would need to provide proper services for that student. All of the aforementioned children would 'fall between the cracks' of a referral system that does not include a psycho-neurological evaluation for LD. Unfortunately,

these children have an authentic need for the LD diagnosis and more importantly, an appropriate intervention.

Although the origins of learning disabilities evolved from the study of neurology (Kirk & Chalfant, 1984), the orientation of scientific concentration has recently taken a different path. Throughout the research undertaken to produce this paper, there was a noticeable lack of literature available on the assessment of learning disabilities emphasizing neurology. Since the study of neurology is defined as "that branch of medical science which deals with the nervous system, both normal and in disease" (Taylor, 1988, p.1129), then a medical, nervous system based explanation of learning disability must exist. Neurologists and other scientists using new technologies such as positron emission tomography (PET scan) and magnetic resonance imaging (MRI) are rediscovering much of the brain's connections to learning problems. "As research on the brain increases, neurological factors may come to the forefront in the diagnosis of a learning disability" (Mercer et al., 1996, p. 230). Whether or not neurological factors of LD have been researched and published is an important precedence for this experiment. However, a quest for the correct explanation of the etiology, assessment, and intervention of LD still exists. The assessment of Learning Disabilities by using tests with a neurological basis, such as the Stroop, is an important factor to research and develop.

Until science and technology reach the point where we can take a picture of a baby's brain at birth and tell the parents whether or not their child is going to have a learning disability, today's practitioner must assess a child's performance using standard work samples. Neuropsychological evaluations for LD include tests for lateral

dominance, writing handedness, sentence repetition, psycholinguistic abilities, visual perception, concentration, memory, as well as IQ and academic achievement.

Charles J. Golden, Ph.D. developed the Stroop Color Word Test in 1935 on the basis that "the difference in color naming and word reading was due to colors being associated with a variety of behavioral responses while words were associated with only one behavioral response: reading" (Golden, 1978, p. 1). The Stroop is "used clinically to assess a specific aspect of executive function, that is, selective inhibition" (Cox et al, 1997, p. 105). This simplified method of differentiation can be generalized as an ability to sort information from the environment and to react to this information in a selective manner (Golden, 1978). To assess a child's selective inhibition, this test specifically measures the 'color-word interference effect.' It is a behavioral sample of the child's ability to separate the word and color naming stimuli. When the typed word of a color, such as 'BLUE,' is typed in a different color, such as red, the confounding sensory inputs cause a delayed response.

Purpose

The purpose of this study is to determine whether the Stroop Color Word test can discriminate between nine to sixteen year old subjects classified as LD by other, more traditional measures, and non-LD subjects. In the past, it discretely has not been determined if the Stroop Color Word test has any diagnostic role in determining the LD eligibility of subjects within this age group. Having been based on the research studied, hypotheses for this study have been developed:

PRIMARY NULL HYPOTHESIS: There will be no statistically significant difference in scores between the LD sample and non-LD sample on the Stroop Color Word test.

PRIMARY ALTERNATE HYPOTHESIS: There will be a statistically significant difference in scores between the LD sample and non-LD sample on the Stroop Color Word test.

METHODOLOGY

Subjects

The control group of this study was comprised of 29 children who had never been diagnosed with Learning Disabilities or with any other complicating psychiatric or psychological disorder. This group was designated the Non-Learning Disabled (NLD) subjects. The experimental group was composed of 27 children who had been previously diagnosed with a Learning Disability or a Learning Disorder by a school system or mental health clinic. By using independent testing, the LD diagnosis in the experimental group was confirmed by using the criteria explained below. Like the control group, this group was void of any other complicating diagnoses. Examples of such diagnoses that would have complicated the results of our neurological battery of assessments are: Attention Deficit/Hyperactivity Disorder (ADHD), Fetal Alcohol Syndrome (FAS), and Epilepsy. This experimental group was designated as the Learning Disabled subjects (LD).

In order to satisfy the age requirements of all tests utilized, including the WISC-III, the WIAT, and the Children's Category Test, all subjects selected for this study were the ages of nine through sixteen years old. The developmental level of this age range provided the experimenter with a subject whom has a longer attention span, some conceptual thinking skills, and adequate school experience. Subjects were required to have an intelligence score between 80 and 120 to be eligible for the study. Potential subjects who did not fall within this range of IQ scores were excluded from the study. This restriction was instituted because the diagnosis of LD is invalid in students with a Borderline (71-84 IQ), Mild Mental Retardation (55-70 IQ), or lower level of cognitive

ability. On the opposite end of the spectrum, the same holds true. Highly gifted students with IQ's of over 120 would influence the final results of this study by completing certain testing tasks with great ease and therefore pulling averages up.

In both the control group and the experimental group, the intended male/female ratio was 50/50, however this held to be true only for the control group. The age demographics of subjects are listed in Table one of Appendix B. The control group contained an approximately 50% male to female ratio. Conversely, the experimental group was heavily outweighed in the direction of males to females by approximately 81.5%. Furthermore, the racial distribution of participating subjects in both the control group and experimental group was quite misrepresentative of the norm. Table two of Appendix B shows that approximately 4% of subjects in either group were of any race other than White. This racial bias should not adversely affect the results of this data as the Stroop Color-Word test is culturally unbiased by nature (Golden, 1978). The task of naming colors or reading the words of colors does not give any English-speaking race special advantage over another. All subjects are residents of southern counties in the state of West Virginia where English is their primary language.

Instruments

The WISC-III and the WIAT were administered to assess each subject's IQ and achievement. A computer program, written by Mr. Charles Szasz, Ed.S. of the Kanawha County Board of Education, called the "West Virginia Learning Disability Discrepancy (LDD) Version 2.0 Software Program," was utilized to determine a discrepancy between IQ and achievement. It is based on a discrepancy of 1.75 standard deviations between a

child's IQ and achievement scores at a 68% confidence limit in compliance with WV Policy 2419: Regulations for the Education of Exceptional Students Law. This program also takes into account the standard deviation of an IQ test, split-half reliabilities, statistical regression to the mean, and IQ-achievement correlation to adjust the 1.75 discrepancy, depending on the amount of information given to the program.

The Stroop Color Word test and a battery of eight other instruments were administered to all subjects, regardless of group placement, for neurological evaluation. The eight other instruments included: Children's Category Test, Level 2 (CCT-2); Children's Memory Scale (CMS); Beery-Buktenica Developmental Test of Visual Motor Integration (VMI); Grooved Pegboard; Children's Auditory Verbal Learning Test, Version 2 (CAVLT-2); Benton Visual Retention Test; DCS: A Visual Learning & Memory Test for Neuropsychological Assessment; and Trails A and B.

The reliability of the Stroop ranges from 0.71 to 0.88, depending on the experimenter (Golden, 1978). In all cases of reliability testing, the test-retest technique was utilized. No information on validity was given in the Stroop Manual. Validity would differ depending on the many uses of this test.

Procedures

The subjects for both the LD and NLD groups were chosen by graduate thesis students using common networking methods: school principals, teachers, friends, family, and parents in their local communities. Subjects' parents voluntarily contacted the thesis student to schedule a testing administration for their child. Informed consent was obtained from a parent of each subject prior to testing.

Determining whether a subject was LD or NLD mainly depended on the subject's scores on the WISC-III and the WIAT. The method devised by the West Virginia Board of Education to diagnose LD was used, including the use of the LDD computer program. After scores for Verbal, Performance, and/or Full Scale IQ were determined to be within the average range of 80 to 120, they were compared with the Reading and/or Math Composite scores of the WIAT by the LDD computer program. If the subject's Full Scale IQ as compared to his/her achievement composite scores met or exceeded the adjusted discrepancy within the computer program, then that subject was considered LD. Subjects previously diagnosed with LD that were not confirmed were rejected as potential test subjects. These same subjects were removed entirely from the experiment rather than placed into the control subjects' (NLD) group. Their exclusion prevented the possible skewing of control subjects' results towards the results of the experimental group.

Subjects were tested in a variety of locations including churches, schools, homes, and clinics. All subjects were tested at a well-lit table, with no extraneous persons in the room, and with minimal distractions. Usually, a subject was administered the WISC-III and WIAT in one three-hour session, then was administered the battery of neuropsychological tests in a second three-hour session. Such testing arrangement would 1) not cause the subject to become prematurely fatigued in the testing environment, and 2) provide an opportunity for the examiner to determine whether or not their intelligence and achievement scores warranted continuation of the test battery. The second session of testing consisted of the battery of neuropsychological tests listed above, including the Stroop Color Word Test.

Three cards were individually laid on a table in front of each testing subject. The first card had the words 'RED,' 'GREEN,' and 'BLUE' printed in black ink. The second card had 'XXXX' printed repeatedly in three different colored inks: red, green and blue. The third card had the words 'RED,' 'GREEN,' and 'BLUE' printed in non-matching red, green, and blue inks. The subject was given instructions to read the words on the first card. On the second card, the subject was directed to name the color of ink in which the XXXX's were printed. The subject was then instructed to identify the ink color of the words on the third and final card, thereby disregarding the actual word text.

Each subject was allowed 45 seconds for each of the three stimulus cards. The test was scored by the number of colors that a subject named correctly during the allocated time. If a mistake occurred, then the examiner said "No," and the testing subject was required to correct him/herself, causing a penalty by the loss of time. Raw scores were converted into age-equivalent t-scores. Based on the three age-corrected t-scores on the Word, Color, and Color-Word cards, the Interference variable score was obtained using the formula below:

$$CW - \frac{W \times C}{W + C} = INT$$

C = Age corrected Color Score W = Age corrected Word Score
CW = Age corrected Color-Word Score INT = Interference

Using Golden's criteria, the results of the test were interpreted based on the four scores: the Word Score (first card), the Color Score (second card), the Color-Word Score (third card), and the Interference Score.

RESULTS

The analysis of variance revealed significant difference on two of the four measures between LD and NLD subjects, therefore rejecting the primary null hypothesis. The mean scores for the Word, Color, and Color-Word variables were higher in the NLD group than in the LD group. This discrepancy indicates that the subjects who did not have a learning disability consistently named more colors on all three cards than the subjects who did have a learning disability, on the average. Interestingly, the LD group scored higher on the Interference variable than the NLD group. Standard deviations for the LD group were up to three points higher than the NLD group on the Word, Color, and Color-Word scores, but were almost exactly the same for the Interference score. Means and standard deviations of the four variables in both groups are shown in Appendix C.

The condensed results of the frequency procedure are shown in Appendix D. Table one of Appendix D shows how many subjects of each group per variable have scored above or below the normal range, between 35 and 65, with a t-score of 50 being the exact mean. In the Word score classification, approximately two and a half times more LD subjects scored below a t-score of 35 compared to the NLD group. Also, five times more LD subjects scored below 35 than did their NLD counterparts in the Color score classification. LD subjects scored lower than 35 more often than NLD subjects in the Color-Word scores as well. However, more NLD subjects scored lower than 35 on the Interference score classification than did the LD subjects.

In Table two of Appendix D, additional condensed results of the frequency procedure examine the number of variables (W, C, CW, and Int) that each subject scored outside the range of a normal t-score. These results provide a more case-sensitive look at

the frequency procedure than Table one. Out of the 27 subjects allocated to the LD group, approximately 52% of them had t-scores either below 35 or above 65 in one or more of their Word, Color, Color-Word, or Interference variables. Out of the 29 NLD subjects, approximately 24% of them showed t-scores either below 35 or above 65 in one or more of their scores.

The sensitivity of the Stroop in the diagnosis of LD was 52%. The calculated specificity was 76%.

DISCUSSION

The results of this experiment, although statistically significant for two of the four scores, do not confirm a case-by-case clinical significance when using the Stroop manual's guidelines of interpretation. A helpful visual aid in noticing the frequency of scores below 35 and above 65 (on the y-axis) that exists in LD subjects versus NLD subjects (on the x-axis) is provided in Appendix E.

Although this study did not classify LD subjects as specifically reading, math, or both, the comparison of averages on the three separate cards still suggest a basic defect in the learning process. The results of this study also confirm a basic defect in the criteria for diagnosing learning disabilities in today's school system. Even after duplicating the method in which six potential subjects were diagnosed by local school systems as closely as possible, this author's testing could not confirm the school systems' diagnoses of LD. A paradigm shift is needed in which a majority of public school systems incorporate a neurological component into their diagnosis, not just their definition of LD.

While one explanation for the difference in mean Word scores between LD subjects versus NLD subjects could be the decreased reading ability of LD subjects, it fails to account for the LD subjects' average lowered score on the Color test. This test involves the task of simply naming the color of ink, not reading. The difference in the mean Color score supports that learning disorders are not caused by a weakness in one specific area (i.e. reading), but has an etiology that affects other areas of the learning process. For example, that etiology could be a psychological illness that slows down tactile functioning and cognitive speed, or a nerve conduction defect of the brain causing signals to cross. The effect of both etiologies is a student who does not function as well

as his/her peers in an academic setting. A learning disability is a clinically and academically treatable disorder. The weakness of this research is the lack of functional applications in the diagnosing and treating of this disorder.

When further study is conducted on the Stroop's utility to diagnose LD, it would be beneficial to subdivide the LD classification into more specific categories such as Reading LD, Math LD, and Both. Perhaps this classification would allow better and more specific scrutiny of the data. For example, a subject with a Reading LD may score differently than a Math LD. The differences are unknown under this current test structure, but merit further study.

A comparison of the mean scores between the control and experimental groups (each consisting of approximately 30 subjects) demonstrates a seven-point difference on the Word score. However, this does not imply that if one subject scores seven points lower than another subject, then the former is learning disabled and the latter is not. This experiment succeeds in proving statistical significance between the average of the Word variable and Color variable of LD and NLD subjects, but does not succeed at establishing a clinical significance. A clinical significance would consist of an established pattern of scoring within the Stroop for LD subjects versus NLD subjects and/or specific cutoff scores for each of the variables.

The clinical interpretation of the Stroop Color-Word test is dependent on not just one of the four test scores, but on a combination of the test scores. As written in the test manual, "More important than simple cutoff points, several Stroop patterns can be identified which are useful in diagnosis" (Golden, 1978, p. 9). For example, a client with a normal Word score (a t-score of 35 to 65), a low Color score (a t-score of less than 35),

and a low Color-Word score, shows a pattern "most often associated with right hemisphere injuries which have caused an inability to classify color hues" (Golden, 1978, p.9). Also, a specifically located head injury, brain atrophy, drug abuse, or dementia can be detected from the level and variations of the four scores. In a clinical setting, an identification of specific scoring patterns within the Stroop is necessary to diagnose LD.

Even if specific scoring patterns were known, the difficulty in using the Stroop Color-Word test in a clinical setting involves the broad t-score norms. As previously stated, the t-score norms are between 35 and 65. If the determination of LD from the results of the Stroop was dependent on whether a subject had at least one or more variable t-score outside of the normal 35 to 65 range, then the practicality of these results are unacceptable.

The limited number of subjects in this experiment (n = 56) brings into question the clinical applicability of this data. According to the sensitivity of the Stroop, only one-half of true LD clients would be validated correctly as LD. Conversely, according to the specificity of the Stroop, only three out of four clients, without learning disabilities, would obtain t-scores within the normal range.

The sensitivity for the Stroop was not based on a specific pattern of scores to diagnose learning disability, as the Stroop is intended. With only fourteen of the 27 LD subjects scoring outside of the broad t-score norms, a specific pattern of scores for learning disability could not be determined. These broad t-score norms discourage the use of the Stroop in determining the diagnosis of learning disability. Further support that the clinically interpretable range of t-scores needs adjustment is reflected in the average scores of the four variables. The means of each of the four variables given fall within the

established t-score norms for both the experimental and control groups. More research may support that the t-score norms of the Stroop should be modified, or qualified differently, to establish a scoring pattern specific for learning disabilities.

The Stroop Color-Word test has a reputation for being a versatile psychological test. It can be a brief IQ test, a sensitive frontal lobe neurological screener, a measure of creativity, or a measure of distractibility, to name a few. Research has been conducted on the Stroop and on how interference proneness is related to certain psychopathologies. Such psychopathologies include schizophrenia, psychoneurosis, depression, mania (Golden 1978), Post-traumatic Stress Disorder, and Obsessive Compulsive Disorder (McNeil, Tucker, Miranda, Lewin, and Nordgren, 1999). Although this experiment succeeds in proving statistical significance for two of the four variables, the utility of the Stroop Color-Word test as an instrument to aid in the determination of learning disabilities within a clinical setting is not yet proven.

REFERENCES

American Psychiatric Association (1996) "Learning Disorders." Diagnostic and Statistical Manual of Mental Disorders: Fourth Edition, APA, pp. 46-53.

Batsche, George M.; and Knoff, Howard M. (1995) "Best Practices in Linking Assessment to Intervention." Best Practices in School Psychology III, NASP Publications, pp. 569-585.

Capin, Donna M., M.D. (1996) "Developmental Learning Disorders: Clues to their Diagnosis and Management." Pediatrics in Review (On CD-ROM), Vol. 17, Number 8.

Cox, Christiane S.; Chee, Elsbeth; Chase, Gary A.; Baumgardner, Thomas L.; Schuerholz, Linda J.; Reader, Mark J.; Mohr, Jennifer; and Denckla, Martha B. (1997) "Reading Proficiency Affects the Construct Validity of the Stroop Test Interference Score." Clinical Neurologist, Vol. 11, No. 2, pp.105-110.

Feldman, William (1990) "Diagnosis and Classification." Learning Disabilities: A Review of Available Treatments, Springfield, IL: Charles C. Thomas Publishers, pp. 3-6.

Golden, Charles J., Ph.D. (1978) Stroop Color and Word Test, A Manual for Clinical and Experimental Uses, Wood Dale, IL: Stoelting Company.

Kirk, Samuel A., and Chalfant, James C. (1984) Academic and Developmental Learning Disabilities, Denver: Love Publishing Company

Levine, Melvin D., M.D. (1987) Developmental Variation and Learning Disorders, Cambridge, MA: Educators Publishing Service, Inc.

McNeil, Daniel W., Ph.D.; Tucker, Phebe, M.D.; Miranda, Robert, Jr. M.S.; Lewin, Michael R., Ph.D.; and Nordgren, J. Chris (1999) "Response to Depression and Anxiety Stroop Stimuli in Posttraumatic Stress Disorder, Obsessive-Compulsive Disorder, and Major Depressive Disorder." Journal of Nervous and Mental Disease, Vol. 187 No. 18, pp. 512-516.

Mercer, Cecil D.; Jordan, LuAnn; Allsopp, David H.; Mercer, Ann R. (1996) "Learning Disabilities Definitions and Criteria Used by State Education Departments." Learning Disability Quarterly, Vol. 19, pp. 217-232.

National Joint Committee on Learning Disabilities (1990) "Issues on Definition. A position paper of the National Joint Committee on Learning Disabilities." Learning Disabilities, Austin TX: Pro-ED; 1994

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

Silver, Larry B. (1990) "Attention Deficit-Hyperactivity Disorder: Is It a Learning Disability or a Related Disorder?" Journal of Learning Disabilities, Vol. 23, pp. 394-397.

Sleeter, Christine E. (1986) "Learning Disabilities: The Social Construction of a Special Education Category." Exceptional Children, Vol. 53, pp.46-54

Taylor, Elizabeth J., ed. (1988) Dorland's Illustrated Medical Dictionary, 27th Edition, Philadelphia: W.B. Saunders Company, Harcourt Brace Jovanovich, Inc.

Appendix A

A REVIEW OF THE LITERATURE

Although the concept of learning disabilities has only been maturing for approximately 2 decades, the science of learning disabilities has long been researched and developed. Some origins of the nature of learning difficulties bear a history from almost 200 years ago. Excerpted below, a host of knowledge is available about the definition, diagnosis, treatments/management, neurology, and etiology of learning disabilities (LD). Also, although much less is available, some of the knowledge in today's literature regarding the Stroop Color-Word Test will be shared below.

In 1997, the National Joint Committee on Learning Disabilities (NJCLD) organized a paper called "Operationalizing the NJCLD Definition of Learning Disabilities for Ongoing Assessment in Schools." Excerpts of the definition follows: "Learning disabilities is a heterogeneous group of disorders manifested by significant difficulties in the acquisition and use of listening, speaking, reading, writing, reasoning, or mathematical skills. Although learning disabilities may occur concomitantly with other disabilities, or with extrinsic influences, they are not the result of those conditions or influences." The purposes of this paper were to highlight five constructs underlying the NJCLD definition of LD and to recommend operational procedures for 4 steps of ongoing assessment and interventions for children in preschool through secondary school. The five constructs of this definition are a guide to parents, school personnel, and students regarding the process to develop all students' educational potential, but

especially those with learning disabilities.

In their article 1996 entitled "Learning Disabilities Definitions and Criteria used by State Education Departments," Cecil D. Mercer et al. conducted a survey of 51 state departments of education (including Washington, D.C.) about how they identify and diagnose learning disabilities. The results of this survey showed that almost all of the 51 departments reflected criteria and aspects of the 1977 federal definition. This national definition did not, however, deter states from modifying it and interpreting it in different ways. Some states, to reflect the current trend in neurological research, include the neurological component of LD in their criteria. Interestingly, the researchers had conducted an almost duplicate study only 6 years before the publication of this one. The comparisons between the two studies showed multiple improvements in the states' definitions and criterion.

In a 1993 article by Ruth Kaminer, MD, the definition of LD is discussed with breadth. Her summarization is that, "Most definitions of learning disability include the following elements: Normal intelligence, a discrepancy between ability and achievement in academic skills, and a general role of the central nervous system as manifested by disorders in psychological processes that underlie learning." Without being a psychologist, this MD is impressive to state that current state criterion of diagnosing LD based on IQ – Achievement discrepancy alone is lacking in two things: 1) the identification of the neuropsychological processes causing the LD, and 2) the changing nature of the reading tasks from grade level to grade level. She states, in conclusion, that "a learning disability results only when a weakness cannot be compensated [by a child's own strategies]."

The 1996 article written by Donna Capin, MD, entitled "Developmental Learning Disorders: Clues to Their Diagnosis and Management" uses the same source as this author for a modern, official definition of LD, according to the National Joint Committee on Learning Disabilities in 1990. A quote of this definition can be seen on page 4 of this document. At the very beginning of this article, the author made some important points:

1. Developmental language disorders are the most common learning disorders.
2. Learning disorders are associated with increased comorbidity, especially depression and anxiety.
3. Learning disorders persist into adulthood.
4. The differential diagnosis of hyperactivity includes hyperthyroidism, substance abuse, autism, chaotic family functioning, lead poisoning, sleep disorders, and treatment with Phenobarbital or methylxanthines.
5. A learning disability is diagnosed in large part by a thorough history, with confirmation by neuropsychometric testing.

This article is not very scientifically based at all. It's purpose was to educate practicing pediatricians on: how to take a good, thorough neurodevelopmental history; a family history (esp. conscious of the risk for psychiatric comorbidity); how to interview the child himself; then what neurological signs to be looking for during the physical examination.

In a chapter called "Diagnosis and Classification," within the 1990 published Learning Disabilities: A Review of Available Treatments, William Feldman, M.D., F.R.C.P. is almost comical in the manner in which he describes how some diagnoses of LD are improperly diagnosed cases of "TD (Teaching Dysfunction)." In the beginning of this book, the many different reasons for difficulty in learning in school are listed: Lack of intelligence, Emotional problems, Medical problems, Environmental deprivation due to poverty, Poor teaching, and Learning disability. LD is the last item. The others before it should, if possible, be sorted out, according to Dr. Feldman. If a child meets none of

the above categories as a cause of his/her learning problems, then they should be assessed for LD, and a subtype of LD be specified to better treat the patient.

If Dr. Feldman appreciates that a specific, treatable diagnosis be given to a LD child, then he would have loved Rita Rudel's book entitled Assessment of Developmental Learning Disorders: A Neuropsychological Approach, published in 1988. This book is a very extensive look at how learning disabilities should properly be evaluated and diagnosed. The authors go into explicit, exacting detail as to the specific disorder a child may have. They use processes such as extensive interviews with the parents and developmental histories, behavioral observations in multiple settings, as well as testing (including item analyses of each test given). Specific causes of learning disabilities mentioned within the text range from "eye movement abnormalities" to "Short term memory deficits," just to name a few. The most applicable chapter in this book is where the author discusses numerous tests including: the WISC-R, the Detroit Tests of Learning Aptitude, the Peabody Picture Vocabulary Test – Revised, the Developmental Test of Visual Motor Integration, Porteus Mazes, the Stroop Color and Word Test, Trail Making, the Wisconsin Card Sorting Test, and the WRAT-R. Many of these tests contain tasks closely or exactly resembling those tasks of the data collection from which this paper is based.

In a second book about LD assessment, Bruce Pennington, Ph.D. makes some interesting remarks about a specific type of LD in a chapter entitled "Right Hemisphere Learning Disorders." Published in 1991, this book is entitled Diagnosing Learning Disorders: A Neuropsychological Framework. The right hemisphere of the brain is where non-verbal abilities are known to exist. Since learning disabilities are commonly

thought of as a complication or imperfection of a child's verbal ability, then it is interesting to know more about this less common type of LD. This book estimates that the prevalence of all LDs (including ADHD) is within 15-25% of the total population. However, of that 15-25% sample of the population who are LD, only 5-10% of them possess a prevalence of non-verbal disabilities. This visual-spatial and mathematics based form of (right hemispheric) LD is very rare, yet very diagnosable. These students usually present much like other LD students, but include specifically math and handwriting problems. These students also have general difficulty with time and money concepts, have a history of poor coordination, may hold their pencil awkwardly, are poor at building things, get lost easily in new places, and have difficulty with art. This article emphasizes the fact that care should be taken in diagnosing all children who present with LD. The more specific a diagnosis is made, then the more specific, and therefore successful, a treatment can be developed. This is the motive for the current thesis study.

The importance of giving a student a complete medical and neurological evaluation (even including an EEG) when they are suspected of having a LD is stressed in the following article. In 1993, Ruth Shalev wrote an article entitled "Developmental Dyscalculia and Medical Assessment." In this article, she examined 7 children who were diagnosed with a LD and were already involved in special education intervention in a mainstream school, but were still not progressing academically. In all 7 children, Dr. Shalev and her team were able to identify a neurological condition that had direct bearing on that child's cognitive functioning. Two of the neurological conditions found were Gerstmann syndrome and petit mal seizures. As an opposite of Dr. Feldman, Dr. Shalev warns *against* under diagnosing LD, and states, "A consensus exists that every child with

an overt neurological problem or with progressive LD needs a thorough neurological assessment."

In an article by Francine Sarazin published in 1985, a longitudinal perspective is given to LD assessment. Entitled "Fifteen-Year Stability of Some Neuropsychological Tests in Learning Disabled Subjects With and Without Neurological Impairment," this article takes a group of 7 tests and re-tests 133 adults who had been diagnosed learning disabled 15 years before, using the same tests. The results of this study compared which tests of the battery were better indicators of good long-term stability. "Measures of lateral dominance appeared to be the most stable over time, followed by IQ tests, academic achievement, handedness (writing only), and sentence repetition." Tests that were not as efficient and precise over time were those that measured Right-Left Orientation, grip strength, and the Category Test.

In another article by Ruth Kaminer, published in 1993, entitled "Learning Disabilities: Management," she discusses the specific exclusions commonly made in the differential diagnosis of LD. These would include visual, hearing, or motor handicaps; mental retardation; emotional disturbance; and environmental, cultural, or economic disadvantage (including poor teaching). More importantly, she states that the physician and school are responsible to understand and build on the child's learning *abilities*, not disabilities. The range of interventions could include altering the teaching methods, providing additional education resources (like tutoring, psychotherapy), or placing the child in a special class. It is interesting to note, again, the adequate grasp that Dr Kaminer has on the role of the pediatrician versus psychologist. She states, "While the pediatrician may not be the expert on which intervention to put in place, she or he is in a

position to monitor the results in the course of providing ongoing pediatric care." Most importantly, Dr. Kaminer instructs fellow pediatricians to gauge the level of parental acceptance of the child and his abilities. Self-esteem is severely damaged if parents have the misbelief that their child is doing this "on purpose."

In 1995, Dr. Thomas McInerny wrote an article on the management of LD entitled "Children Who Have Difficulty in School: A Primary Pediatrician's Approach." This article gives a very comprehensive outlook of treating a child with LD from the vantage point of a practicing MD. The very useful excerpts of this article are the table and their corresponding texts: Etiology of School Failure, Pathogenesis of Learning Disability, Evaluation of the Child Who Has Failed in School, Formal Tests Used in Evaluation, Management, and Alternative Therapies of Unproven Value. Specific management details are included like IEPs, medications, and case management issues. Also, the bibliography of this article contained sources to help broaden the range of knowledge for this literature review.

"Best Practices in Linking Assessment to Intervention," by George M. Batsche gives an excellent historical perspective of LD assessment, the basic considerations of the definitions and purposes of assessment, and most influentially, the best modern practices in linking assessment to the intervention of LD. They explain to the readers (primarily school psychologists) a process of assessment and intervention known as the "Referral Question Consultation (RQC) Process." This is a time-consuming yet fair 10-step procedure in which the student is adequately assessed with the ongoing input of her teacher and parents.

The article, "Medical and Pharmacologic Treatment of Learning Disabilities," written by Robert DeLong, M.D., takes the management of LD into a purely pharmacological stance. Like many of the articles mentioned above, this 'study' involved no experimental procedure at all. It was, however, a good synopsis and brief literature review of what steps can be taken, pharmacologically, in treating learning disabilities. It states and restates the complications of mixing the different disorders: ADHD, LD, and affective psychiatric disorders. This article cites another article that "estimates the rate of ADHD in the learning-disabled population range from 41% to 80%." This is discouraging for this author's thesis, because research subjects in the experimental group had diagnoses of LD without complications such as ADHD. In conclusion, the article suggested that learning disabilities could possibly be ameliorated by stimulants, if coexisting with ADHD; or with antidepressants if coexisting with depression.

The statement above is elaborated by an article entitled "Methylphenidate Effects in Learning Disabilities," written in 1976 by Rachel Gittelman-Klein, Ph.D. "This study was designed to test whether methylphenidate therapy improves the cognitive performance and academic achievement of children with learning deficits, but without appreciable behavior problems." Learning disability was operationally defined for this outdated study as being two years below reading grade level despite average intelligence. Sixty-four children, between the ages of 7 and 13, who were having significant problems in learning, participated in the study. They were then randomly assigned to placebo and methylphenidate treatment for a 12-week period on a double-blind basis. The following tests were administered at the beginning, and were repeated at 4 and 12 weeks after the

initial treatment: WISC, WRAT, Gray Oral Reading Test, Draw-a-person IQ, Porteus Mazes IQ, Visual-Motor Integration Test (VMI), Visual Sequential Memory Test, Paired Associate Test, and the Continuous Performance Test. "The results...confirm the findings that stimulants are instrumental in improving performance in children." It further speculates that "learning disabled children may have a specific defect in left hemispheric-mediated conceptual-verbal functions." This last statement is very important to this author's current research. Although it is a speculation, it is supportive of the premise that learning disabilities are neurologically based. Therefore, even back in 1976, a neurological battery of tests should have been implemented to diagnose them.

William Cruickshank wrote an article in 1983 called "Learning Disabilities: A Neurophysiological Dysfunction." In Dr. Cruickshank's point of view, the essential elements of a definition of learning disability contain certain essentialities. "First, all learning is neurological. No learning can take place without the nervous system being involved. Emotions are neurological. Memory is neurological. Sensation is neurological. Perception is neurological, and so on." The author of this article shares a very strong opinion on this topic, apparently. He is justified to say in 1983 that less inference, or 'guesswork', would be made on the definition of LD. Because of the "continuing developments in computerized axial tomography (the CAT scan), the positron-emission tomography (the PET scan), the nuclear magnetic resonance (NMR), and a variety of other devices now available," inference will be replaced with a definite diagnosis. He feels that, with the aid of technology, the future will hold proof that he is right; that a learning disability is a neurophysiological dysfunction.

More weight is directly distributed to the argument that LDs are caused by a neurological dysfunction in an article entitled "Minor Neurological Dysfunction Is More Closely Related to Learning Difficulties than to Behavioral Problems." Out of a fairly large sample size of nine year-olds (570), Mijna Haders-Algra et al. discerned that, compared to behavioral difficulties, learning problems are more closely related to minor neurological dysfunction (MND). To do so, these scientists took a subgroup of subjects from a Swedish perinatal relationship study. These subjects were born between the years of 1975 and 1978. All of these children were examined neurologically in their newborn period in a standardized method. Nine years later, all of the children in this Swedish hospital study who were classified 'neonatally neurologically deviant infants' were invited to participate in Dr. Haders-Algra's follow-up study. A random sample of non-disabled and mildly abnormal newborns from the same study was invited to participate in the control group. At age nine, subjects were given age-adequate and standardized neurological examinations, as well as short achievement tests for reading, spelling, and arithmetic. Parents and teachers supplied information on school achievement and behavior through a 13-item questionnaire regarding that subject's behaviors and attitudes. "The fact that more than half of the children with cognitive problems (such as LD) showed MND was true for both sexes." The implications of this study are as follows: the prevention of LD should focus on the neonatal biological hazards. The intervention of LD should focus on the child's environment and parents' rearing attitudes.

Published in a 1990 edition of the journal Pediatric Neurology, Roger Brumback, MD makes some interesting conclusions regarding the treatment of possible LD. The article entitled "Pediatric Behavioral Neurology: An Update on the Neurologic Aspects

of Depression, Hyperactivity, and Learning Disabilities" is a long-winded communication between Neurologists. The procedure takes children who are depressed and having learning difficulties, administers a variety of anti-depressants and other psychotropic medications, and analyzes the improvement on a case by case basis. Numerous success stories are noted in which once the depression is treated with medication, then the learning disability is improved and even IQ increases by one standard deviation. Although it is true that, under the differential diagnosis of LD, emotional problems could affect the academic behaviors of a student, this article takes that argument too far. It's results state that for almost every case of LD, a prescriptive trial of antidepressants should be attempted to cure the child's depression, and thus alleviate his academic frustrations.

Interestingly, the neurological etiology of LD is well supported in an article entitled "Learning Disability, Attention-Deficit Disorder, and Language Impairment as Outcomes of Prematurity: A Longitudinal Descriptive Study" by Miriam Cherkes-Julkowski, Ph.D. Published in 1998, this study found 48 children (28 pre-term and 20 full-term) before they were 2 months past their *expected* date of birth. That a child was born prior to term means that at the time of birth his or her central nervous system (CNS) was not fully organized for sustaining itself in the extra uterine environment. These 48 subjects were tested at periodic times using the Stanford-Binet and were also followed academically until grade 5. The mother was rated on a Likert scale by judges regarding her behavior as to the competence of her child. The results of this study state "the percentage of prematurely born children was higher than expected in each of the outcome diagnostic categories" (LD, ADD, etc.). The pattern among the children with LD was

interesting. The full-term infants who were later identified as having LD continued to be perceived as competent through 30 months. However, those children with LD born prematurely began to be perceived as less competent at 24 months. The results of this study validate that it is very important to question our subjects' parents about the birth weight, length of gestational period, etc. of their child. This alone is a consistently predictive factor. The major percentage (75%) of the children in this study, who were born mildly at risk for CNS impairment were having identifiable difficulties in school. Another strongly influential factor to the performance of her child is that of the mother's perception of her child's competence. The mothers who, at 24 and 30 month-old visits, reported low estimations of their child's competence, later found that their child had a learning disability or language impairment. This resolves that either a mother's perception of her child's competence seemed to be particularly sensitive, or that a self-fulfilling prophecy regarding school success begins at an early age.

Direct applicability to the current study is shown by Daniel McNeil, Ph.D. in his article entitled "Response to Depression and Anxiety Stroop Stimuli in Posttraumatic Stress Disorder, Obsessive-Compulsive Disorder, and Major Depressive Disorder." This study investigated Stroop test responding across groups of patients with one of three emotionally based psychiatric disorders, assessing for possible differences across these diagnostic groups and between types of general emotional stimuli in these samples. All three groups of outpatients with PTSD, OCD, or MDD showed cognitive and response slowing on general anxiety and depression stimuli (words such as criticized or hopeless), as well as color-words, compared with neutral stimuli (XXXX). This study differed from some previous ones using Stroop tests to assess cognitive processing and behavioral

response in PTSD patients. It focused on words evoking general affective negativity, rather than words related to the specific traumas. Included in this study were outpatients with either an anxiety disorder (PTSD or OCD) or an affective disorder (MDD). The use of Stroop tests that contain words of general affectivity, as opposed to specific Stroop tests, allowed direct comparisons across these diagnostic groups.

In 1996, Mechteld Visser et. al. published a study that used the Interference score of the Stroop to measure the lack of inhibition in students grouped according to their impulsivity status: cognitive or social. Entitled "Impulsivity and Negative Priming: Evidence for Diminished Cognitive Inhibition in Impulsive Children," this experiment incorporated 210 school children who were rated by their teachers as either high or low in social or cognitive impulsivity. The lack of inhibition of the students was rated according to a negative priming effect. In this study, the negative priming effect is defined by naming a target color slower if this color was the distracter in a trial immediately preceding it. Without going into great detail about the results, a reduced negative priming effect showed up with social type but not with cognitive type impulsive children. No differences were found regarding the Stroop interference score. Overall, the findings make a distinction between cognitive impulsivity and a social impulsivity.

In looking for a cheaper way to distinguish between groups of troubled teenagers, Marc Lavoie et al. conducted an experiment that tried the Stroop. The article entitled "The Discriminant Validity of the Stroop Color and Word Test Toward a Cost-effective Strategy to Distinguish Subgroups of Disruptive Preadolescents" examines 16 disruptive boys without attention deficit, 16 disruptive boys with attention deficit, and compares them to 16 control subjects. All of the subjects were French-speaking Canadian 12 year

old boys. The hypothesis that predicted that the group of boys with attention deficit would score lower on the Word, Color, and Color-Word tasks than the other groups was supported by the results. This suggests that boys with attention deficit have serious problems with the selection and extraction of just one part of the stimuli on the Color-Word task. The author states that his results confirm previous findings regarding the cognitive and processing problems of boys with attention deficits. The author, however, states his limitations when he says, "findings from the present study provide some evidence of the Stroop test's effectiveness in discriminating between [attention deficit and non-attention deficit, but] it is not yet established whether the Stroop will discriminate among psychosis, inattentiveness, impulsiveness, and overactivity.

A useful article for the current experiment is entitled "Reading Proficiency Affects the Construct Validity of the Stroop Test Interference Score," and was written by Christiane S. Cox et al. in 1997. In its basic structure, the Stroop Color-Word Test assumes that reading is an automatic process in adults. Few studies have examined the changes in the interference effect when this is not true. The participants of this study were 306 parents of children that have LD. They were administered parts of the WAIS-R and Woodcock-Johnson Tests of Achievement to determine Full Scale IQ and their reading proficiency. The subjects were then divided into five groups based on their reading proficiency. All subjects were also administered the Stroop, as well as other tests to measure executive functions. Analysis of the Stroop test variables revealed that the group with the worst reading abilities had significantly lowered Color-Word reading scores than subjects in each of the four better-reading groups. In contrast, there were no significant group differences in ink-color naming.

BIBLIOGRAPHY

American Psychiatric Association (1996) "Learning Disorders." Diagnostic and Statistical Manual of Mental Disorders: Fourth Edition, APA, pp. 46-53.

American Psychological Association (1983) Publication Manual of the American Psychological Association, 3rd Edition, Washington DC: American Psychological Association.

Batsche, George M.; and Knoff, Howard M. (1995) "Best Practices in Linking Assessment to Intervention." Best Practices in School Psychology III, NASP Publications, pp. 569-585.

Brumback, Roger A., M.D. and Weinberg, Warren A., M.D. (1990) "Pediatric Behavioral Neurology: An Update on the Neurologic Aspects of Depression, Hyperactivity, and Learning Disabilities." Neurologic Clinics, Vol 8, pp. 677-703.

Capin, Donna M., M.D. (1996) "Developmental Learning Disorders: Clues to their Diagnosis and Management." Pediatrics in Review (On CD-ROM), Vol 17, Number 8.

Cherkes-Julkowski, Miriam, Ph.D. "Learning Disability, Attention-Deficit Disorder, and Language Impairment as Outcomes of Prematurity: A Longitudinal Descriptive Study." Journal of Learning Disabilities, Vol 31, pp. 294-306.

Cox, Christiane S.; Chee, Elsbeth; Chase, Gary A.; Baumgardner, Thomas L.; Schuerholz, Linda J.; Reader, Mark J.; Mohr, Jennifer; and Denckla, Martha B.

(1997) "Reading Proficiency Affects the Construct Validity of the Stroop Test Interference Score." Clinical Neurologist, Vol 11, No. 2, pp.105-110.

Cruickshank, William M., Ph.D. (1983) "Learning Disabilities: A Neurophysiological Dysfunction." Journal of Learning Disabilities, Vol 16, pp. 27-29.

DeLong, Robert, M.D. (1995) "Medical And Pharmacologic Treatment of Learning Disabilities." Journal of Child Neurology, Vol 10, pp. S92-S95.

Feldman, William (1990) "Diagnosis and Classification." Learning Disabilities: A Review of Available Treatments, Springfield, IL: Charles C. Thomas Publishers, pp. 3-6.

Gittelman-Klein, Rachel, Ph.D. and Klein, Donald F., M.D. (1976) "Methylphenidate Effects in Learning Disabilities." Archives of General Psychiatry, Vol 33, pp. 655-664.

Golden, Charles J., PhD (1978) Stroop Color and Word Test, A Manual for Clinical and Experimental Uses, Wood Dale, IL: Stoelting Company.

Hadders-Algra, Mijna and Touwen, Bert C. L. (1992) "Minor Neurological Dysfunction Is More Closely Related to Learning Difficulties than to Behavioral Problems." Journal of Learning Disabilities, Vol 25, pp. 649-657.

Kaminer, Ruth K., MD (1993) "Learning Disability: Definition." Pediatrics in Review (On CD-ROM), Vol 14, Number 4.

Kaminer, Ruth K., MD (1993) "Learning Disability: Management." Pediatrics in Review (On CD-ROM), Vol 14, Number 6.

Kandel, Eric R.; Schwartz, James H.; and Jessell, Thomas M. (1991) Principles of Neural Science, Third Edition, New York: Elsevier Science Publishing Co., Inc.

Kauffman, James M.; Hallahan, Daniel P.; and Lloyd, John W. (1998) "Politics, Science, and the Future of Learning Disabilities." Learning Disability Quarterly, Vol 21, pp. 276-280.

Kavale, Kenneth A.; and Forness, Steven R. (1987) "History, Politics, and the General Education Initiative: Sleeter's Reinterpretation of Learning Disabilities as a Case Study." RASE: Remedial and Special Education, Vol 8, pp. 6-12.

Kavale, Kenneth A.; and Forness, Steven R. (1998) "The Politics of Learning Disabilities." Learning Disability Quarterly, Vol 21, pp. 245-253.

Kavale, Kenneth A.; Forness, Steven R.; MacMillan, Donald L.; and Gresham, Frank M. (1998) "The Politics of Learning Disabilities: A Rejoinder." Learning Disability Quarterly, Vol 31, pp. 306-316.

Kirk, Samuel A., and Chalfant, James C. (1984) Academic and Developmental Learning Disabilities, Denver: Love Publishing Company

Lavoie, Marc E., and Charlebois, Pierre (1994) "The Discriminant Validity of the Stroop Color and Word Test Toward a Cost-effective Strategy to Distinguish Subgroups of Disruptive Preadolescents." Psychology in the Schools, Vol 31, pp. 98-107.

Levine, Melvin D., M.D. (1987) Developmental Variation and Learning Disorders, Cambridge, MA: Educators Publishing Service, Inc.

McInerny, Thomas K., M.D. (1995) "Children Who Have Difficulty in School: A Primary Pediatrician's Approach." Pediatrics in Review (On CD-ROM), Vol 16, Number 9.

McNeil, Daniel W., Ph.D.; Tucker, Phebe, M.D.; Miranda, Robert, Jr., M.S.; Lewin, Michael R., Ph.D.; and Nordgren, J. Chris, Ph.D. (1999) "Response to Depression

and Anxiety Stroop Stimuli in Posttraumatic Stress Disorder, Obsessive-Compulsive Disorder, and Major Depressive Disorder." Journal of Nervous and Mental Disease, Vol 187, pp. 512-516.

Mercer, Cecil D.; Jordan, LuAnn; Allsopp, David H.; Mercer, Ann R. (1996) "Learning Disabilities Definitions and Criteria Used by State Education Departments." Learning Disability Quarterly, Vol 19, pp. 217-232.

National Joint Committee on Learning Disabilities (1990) "Issues on Definition. A position paper of the National Joint Committee on Learning Disabilities." Learning Disabilities, Austin TX: Pro-ED; 1994

National Joint Committee on Learning Disabilities (1998) "Operationalizing the NJCLD Definition of Learning Disabilities for Ongoing Assessment in Schools." Learning Disability Quarterly, Vol 21, pp. 186-193.

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

Rudel, Rita G. (1988) Assessment of Developmental Learning Disorders: A Neuropsychological Approach, New York: Basic Books, Inc.

Sarazin, Francine and Spreen, Otfried (1986) "Fifteen-Year Stability of Some Neuropsychological Tests in Learning Disabled Subjects With and Without Neurological Impairment." Journal of Clinical and Experimental Neuropsychology, Vol 8, pp. 190-200.

Shalev, Ruth S. and Gross-Tsur, Varda (1993) "Developmental Dyscalculia and Medical Assessment" Journal of Learning Disabilities, Vol 26, pp. 134-137.

Silver, Larry B. (1990) "Attention Deficit-Hyperactivity Disorder: Is It a Learning Disability or a Related Disorder?" Journal of Learning Disabilities, Vol 23, pp. 394-397.

Sleeter, Christine E. (1986) "Learning Disabilities: The Social Construction of a Special Education Category." Exceptional Children, Vol 53, pp.46-54

Taylor, Elizabeth J., ed. (1988) Dorland's Illustrated Medical Dictionary, 27th Edition, Philadelphia: W.B. Saunders Company, Harcourt Brace Jovanovich, Inc.

Visser, Mechteld; Das-Smaal, Edith; and Kwakman, Hans (1996) "Impulsivity and Negative Priming: Evidence for Diminished Cognitive Inhibition in Impulsive Children." British Journal of Psychology, Vol 87, pp. 131-140.

Appendix B

Subject Demographics

Table 1: GENDER

	Male	Female	Total
LD	22	5	27
NLD	15	14	29
Total	37	19	56

Table 2: RACE

	White	Other	Total
LD	25	2	27
NLD	29	0	29
Total	54	2	56

Appendix C

The ANOVA Procedure

Dependent Variable: WORD

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Group	1	676.651364	676.651364	10.46	0.0021
Error	54	3493.330779	64.691311		
Corrected Total	55	4169.982143			

Dependent Variable: COLOR

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Group	1	254.567620	254.567620	4.61	0.0364
Error	54	2984.985951	55.277518		
Corrected Total	55	3239.553571			

Dependent Variable: COLOR-WORD

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Group	1	25.480045	25.480045	0.24	0.6267
Error	54	5751.644955	106.511944		
Corrected Total	55	5777.125000			

Dependent Variable: INTERFERENCE

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Group	1	204.570904	204.570904	3.32	0.0740
Error	54	3328.411239	61.637245		
Corrected Total	55	3532.982143			

Level of GROUP	N	WORD Mean	WORD Std Dev	COLOR Mean	COLOR Std Dev
LD	27	38.6296296	8.36728128	39.6296296	8.74488047
Non-LD	29	45.5862069	7.72989208	43.8965517	5.96624330

Level of GROUP	N	CW Mean	CW Std Dev	INT Mean	INT Std Dev
LD	27	44.9259259	11.9644535	54.9629630	7.80769582
Non-LD	29	46.2758621	8.5142593	51.1379310	7.89088144

Appendix D

TABLE 1: The FREQ Procedure, by Number of Subjects per Variable

GROUP	Word<35	Word>65	Color<35	Color>65
LD	10	0	5	0
NLD	4	0	1	0

GROUP	CW<35	CW>65	INT<35	INT>65
LD	5	2	0	2
NLD	3	0	1	1

[Number of subjects who scored outside of the range of a normal t-score: 35 < Normal t-score < 65]

TABLE 2: The FREQ Procedure, by Number of Variables per Subject

# of Variables	LD	NLD
1 out of 4	7	4
2 out of 4	4	3
3 out of 4	3	0
4 out of 4	0	0
Total	14	7

[Number of variables (W,C,CW,INT) that a subject scored outside the range of normal t-score: 35 < Normal t-score < 65]

Appendix E: Stroop Results