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Use of the Visual-Motor Integration Test to discriminate learning disabled from non-disabled children and adolescents

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USE OF THE VISUAL-MOTOR INTEGRATION TEST TO DISCRIMINATE LEARNING DISABLED FROM NON-DISABLED CHILDREN AND ADOLESCENTS

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Abstract

Learning disabilities are fairly prevalent in the population of children today. Consensus in the area of learning disabilities (LD) is difficult to find. Definition, criteria, and detection methods are among the areas of disagreement. Assuming that LD involves central nervous system dysfunction, it follows that neuropsychological tests should be employed in the detection of LD in children. To date, no standard tests, or batteries of tests, are utilized to diagnose LD. This study examined the utility of the Beery-Buktenica Developmental Test of Visual-Motor Integration (VMI) in discriminating LD children from non-LD children aged 9 to 16 years of age. The results showed that the VMI did not discriminate between the LD and non-LD samples. However, upon further analysis, the VMI did show to discriminate LD from non-LD status in children above 10 years, 9 months of age. The mean standard scores of each group, however, were within one standard deviation of the mean, or normal range. This fact limits its clinical use as a diagnostic tool for LD. It was concluded that the VMI has little or no clinical utility in detecting LD, and it should not be included in a test battery designed to detect LD in children and adolescents of this age group.

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Use of the Visual-Motor Integration Test to Discriminate Learning Disabled from Non-Disabled Children and Adolescents

The study of learning disabilities is relatively new. The term learning disabilities (LD) was first coined in 1963 by Professor Sam Kirk in Chicago (Smith, 1998), although there was prior history of learning difficulties under other terminology. Since 1963, although research has mounted, no clear consensus on the definition of LD has emerged. The DSM-IV defines a learning disorder as a discrepancy of 2 or more standard deviations between IQ and achievement which is not due to another disorder. Mercer, Jordan, Allsop, and Mercer (1996) found eleven popular definitions of learning disabilities when examining the definitions used by the 51 state education departments. For example, the National Joint Committee on Learning Disabilities (NJCLD), the Learning Disabilities Association (LDA), and the National Advisory Committee on Handicapped Children (NACHC) all define learning disabilities differently. The U.S. Office of Education initiated public law 94-142 (PL94-142) which provided regulations for identifying students with learning disabilities (Mercer et al., 1996). PL94-142, also referred to as the IDEA definition, most closely resembles the definition used by the NACHC. The six primary components of this definition include: academic, exclusion, discrepancy, process, neurological, and intelligence (Mercer et al., 1996). Exclusion refers to the exclusion of those learning difficulties caused by other disabling conditions, i.e. physical or psychological. The discrepancy component refers to a significant difference between ability and achievement. The neurological component is the consideration of central nervous system dysfunction. Mercer et al. (1996) found that 94% of the state education departments still included the discrepancy component in their criteria, but only 27% in their definition of LD. Seventy three percent now omit intelligence as a component of the definition. These researchers found that although some components, i.e. discrepancy, are common among many state definitions, a consensus is still not reached. In the educational system, a clear definition would be especially beneficial not only for intervention purposes but also because funds are allocated based on the special education population.

In addition to the educational arena, the legal system also struggles with the lack of a clear definition of LD. In the Guckenberger v. Boston University case, Guckenberger and other students claimed that they were LD and had substantial evidence to support this. Boston University felt the evidence did not support LD status. Central to this case was the definition of LD (Siegel, 1999). Siegel (1999) in reviewing this case concluded that most definitions are too broad and are not conducive to use in making decisions about particular individuals. This author suggests that discrepancy between ability and achievement is not an integral part of the LD definition, and it is unnecessary to administer IQ tests to assess LD (Siegel, 1999).

Researchers examining different aspects of learning disabilities have the initial task of defining their view of LD as there is no widely accepted precise definition. Lyon (1994) outlined four factors that impede research in this area. The first is the fact that LD has been considered a disability group for a relatively short period of time. Secondly, since LD is multidisciplinary, it has its basis in various theoretical and conceptual views. Thirdly, there is no consensus on a clear definition. And lastly, inadequate tests and measures have been utilized in diagnosis and treatment.

For the purpose of this study, the 1990 definition of the National Joint Committee on Learning Disabilities will be used.

> 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 concomitantlly 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 (Capin, 1996).

Especially germane to this study is the component of this definition that presumes central nervous system dysfunction as a causal factor. Numerous researchers have studied some aspect of the neurological link to LD. Blumsack, Lewandowski, and Waterman (1997) found that neurodevelopmental precursors to LD exist but no consistent combination of difficulties was found. Using computed tomography (CT) or Magnetic Resonance Imaging (MRI) investigators have found that the asymmetry that characterizes most normal brains is significantly less evident in individuals with severe reading disabilities (Hynd, Marshall, & Gonzalez, 1991). Filipek (1994) however, concluded that no conclusion can be made concerning dyslexia and brain abnormalities. Filipek (1994) reviewing existing studies found conflicting results in several neuroimaging studies with regard to symmetry, corpus callosum, and temporal lobes which had all been suggested as areas of abnormality in the dyslexic brain.

Traumatic brain injury, or TBI, has also been linked to learning disabilities which further suggests the neurological basis of some LD. Closed head injury has been shown to lead to cognitive dysfunction which alters the victim's learning ability (Lord-Maes & Obrzut, 1996). These researchers also concluded that acquired head injury leads to numerous neuropsychological deficits including performance on speeded tasks, impaired memory, and difficulties processing complex visual-spatial stimuli. These difficulties lead to severe learning difficulties in upcoming years (Lord-Maes & Obrzut, 1996). Researchers have reported a patient, assessed for learning disabilities prior to a moderately severe closed head injury, maintained the same assessment profile 2 years postinjury except scores were one standard deviation lower (Arffa, Fitzhugh-Bell, and Black, 1989). These researchers, comparing LD and brain damaged (BD) subjects, also found upon cluster analysis that no cluster was exclusively composed of LD or BD subjects. These results were corroborated in a later study by Williams, Gridley, and Fitzhugh-Bell (1992). These researchers, also using cluster analysis to distinguish groups in a population of LD and BD subjects, found no cluster that was exclusively LD or BD, suggesting similarity in neural pathology between the LD and BD groups.

Other neurological links have also been suggested. Neurofibromatosis type 1 (NF-1) is a genetic disorder that affects the human nervous system. Specific learning disability is the most common neurological complication of this genetic anomaly (North et al., 1994). North et al. (1994) found that the frequency of LD in their study population with NF-1 was much higher than in the normal population; 65% of the sample showed impaired achievement in at least one area. MRI studies on NF-1 children reveal a correlation between T2 signal and risk of learning disability (North et al., 1994). However, researchers have more recently concluded that MRI should not be performed in the NF-1 patient unless focal neurologic deficits exist due to the lack of influence on educational intervention (North et al., 1997).

Regarding the neurological basis of LD, much of the research examines the brain-behavior relationship as it relates to linguistic skills, i.e. reading or writing disabilities. Neurological roots have, however, been identified in mathematical disabilities. Shalev and Gross-Tsur (1993) examined seven children that were diagnosed with developmental dyscalculia who had not made progress despite special education intervention. These researchers found that all seven children had neurological problems which had direct effects on their cognitive ability. Neuropsychological functions, both verbal and nonverbal, contribute to performance in mathematics (Batchelor, Gray, & Dean, 1990).

The importance of understanding the neuropsychological underpinnings of learning disabilities is to improve the assessment of and intervention for children with LD. Since the passing of IDEA in 1975, the prevalence of diagnosed LD children has grown. In 1976-1977, 25% of school-age children with disabilities had a learning disability (Smith, 1998). In 1994-1995, over 50% of all disabled children had a learning disability as their primary diagnosis (U.S. Department of Education, 1996). Fennell (1995) reports an estimated 3 to 4% of all school-age children have a reading, writing, or mathematic disability. In 1998, it was estimated that 5% of US children were learning disabled. Rourke and Conway (1997) reported the prevalence of arithmetic diabilities to be at least 6% of the population.

Given the relatively high prevalence rates, intervention for LD children is of utmost importance to maximize their academic success. Cruickshank (1983) concluded that special education based solely on academic weaknesses, without finding the root of the learning disability, is relatively worthless. Cruickshank went further to conclude that finding the neuropsychological dysfunction and utilizing this for intervention would yield individualized education regimens. Intraindividual neuropsychological strengths should be utilized in the design of instructional strategies (Hartlage and Telzrow, 1983).

One necessity to utilizing the neuropsychological approach to intervention for LD children is to have effective neuropsychological instruments that can detect LD.. Fennell (1995) reported on two reasons to use neuropsychological assessment with LD children. The first is to assess central nervous system functioning, i.e. cognitive, academic, social. The second is to assess strengths and weaknesses to formulate an appropriate remedial intervention. Intervention strategies should be based on the assessed brain-behavior system and take into consideration the brain area(s) shown to be affected (D'Amato, Rothlisberg, and LeuWork, 1999).

The brain-behavior relationship is complex and therefore does not lend itself to simple explanation. No single test will suffice to detect subtle brain dysfunction, but a comprehensive battery is needed (Obrzut, 1981).

The children's version of the Halstead-Reitan Battery has been utilized in several studies. Nussbaum and Bigler (1986) used this battery and cluster analysis to separate LD subgroups. These researchers found three subgroups in their sample, each with differing profiles on the neuropsychological battery.

The Quick Neurological Screening Test-Revised (QNST-R) is a short screening instrument developed to discriminate LD children ages 6 to 13 (Finlayson & Obrzut, 1993). The QNST-R has been shown to have construct validity. Poor performance by older children is a better indicator of neurological deficit than poor performance by younger children as the instrument is sensitive to a general maturity factor (Finlayson & Obrzut, 1993).

Watkins (1996) studied the WISC-III Developmental Index (WDI) as a predictor of learning disabilities. In this study, a large group of LD children obtained average scores on the WDI. It was concluded that the WDI was not effective as a tool to discriminate learning disabilities (Watkins, 1996).

The Developmental Test of Visual-Motor Integration (VMI) has been shown to be a good predictor of achievement in reading disabled children aged 5 to 8 ½ years (Hinshaw, Carte, & Morrison, 1986). The same researchers found that IQ served as the best predictor for achievement in children 8 ½ to 11 years of age.

Currently, there is no standard neuropsychological battery given to children suspected of LD. More accurate assessment and diagnosis of neurologically based LD would lead to better intervention strategies(see Literature Review, Appendix A).

The purpose of this study is to determine whether the Beery-Buktenica Developmental Test of Visual Motor Integration, 4th Edition Revised (VMI) can discriminate between LD children and non-LD children. The ultimate goal of this study is to determine if the VMI would be a useful component in a neuropsychological battery designed to detect LD.

Methodology

Overview

This study is part of a larger research study aimed to establish a neuropsychological test battery that will detect LD subjects. In addition to diagnosis, the goal of the test battery is to identify neuropsychological strengths and weaknesses useful in developing intervention strategies.

Subjects

A sample of 27 learning disabled (LD) and 29 non-learning disabled (non-LD) children participated in this study. The subjects ranged in age from 9 to 16 years of age. There were 19 female subjects and 37 male subjects. Subjects in the LD group met the following criteria for inclusion:

1. A minimum of 1.75 standard deviation discrepancy between IQ as measured by the Wechsler Intelligence Scale for Children-3rd edition (WISC-III) and the Wechsler Individual Achievement Test (WIAT).

2. Full scale IQ between 80 and 120.

3. No diagnosed comorbid disorder with neurological foundations.

Control subjects had an IQ between 80 and 120 and no diagnosed disorders. The achievement of the controls was in line with their ability levels. Consult Appendix B for sample description. Informed consent was given by the parent or guardian of each subject prior to testing or interview (see Appendix C).

Instruments

In addition to the WISC-III and WIAT, a complete test battery was administered to each subject. The battery consisted of: the Children's Category Test, Children's Memory Scale, Grooved Pegboard Test, Children's Auditory Verbal Learning Test - 2, Benton Visual Retention Test, DCS, Trails A and B. The VMI, which is central to this study, was also administered to each subject.

The VMI measures the degree to which perception and motor coordination are integrated. The authors of the test report that the "VMI is designed to measure the hyphen in the term visual-motor integration . . ." (Beery, 1997, p. 19).

The VMI is a norm-referenced neuropsychological instrument being normed on 2,614 children aged 3 to 18 years in 1996 (Beery, 1997). In 1996, the internal consistency reliability was 0.82, and the test-retest reliability was reported as 0.87 (Beery, 1997). Concurrent validity with the Developmental Test of Visual Perception and the Drawing subtest of the Wide Range Assessment of Visual Motor Abilities was 0.75 and 0.52, respectively (Beery, 1997).

Procedure

Subjects were chosen from schools in several counties of West Virginia. Following informed consent, a short interview form was completed with the parent or guardian prior to testing (see Appendix C). The WISC-III and the WIAT were administered first to establish that each subject met the LD or control criteria. The neuropsychological battery was then given to each subject. To control for order effects, every other subject was administered the battery in reverse order. All tests were administered by graduate students trained in psychometrics.

The VMI test protocols were scored based on the standard scoring criteria outlined in the test manual. Raw scores were then transformed to standard scores using the age-based norm tables. Standard scores were used for all further analysis. For a list of the VMI standard scores for each subject consult Appendix D.

Data Analysis

The data was collected for all subjects and subsequently analyzed using analysis of variance (ANOVA). The statistical level of significance was established at the $p < .05$ level. A factorial analysis was utilized to detect any group by gender interaction effects.

Results

The results of this study indicate that the VMI did not discriminate between the LD and non-LD samples. As seen in Table 1, the standard score means of the LD and non-LD samples were 96 and 100, respectively. Upon analysis of variance, the means were not statistically different ($F = .3820$).

A second analysis, examining effects of gender, was also executed. The VMI standard score means of LD and non-LD subjects of each gender, as well as means for each gender as a whole, are given in Table 1. Upon analysis of variance (Table 2), no significant difference was found between the mean VMI scores of the male and female groups ($F = .8242$). Using a factorial analysis of variance, there were no gender effects or gender x group interaction effects found (Table 3). The female LD group, however, was comprised of only 5 subjects which is too low for meaningful comparison. All means were in the normal range, within 1 standard deviation from the mean. The lowest mean score was 94 for the female LD subjects and the highest was 100 for the female non-LD subjects.

As a final analysis, the effects of age were examined. The sample was divided at the age of 10 years 9 months, yielding a younger group and an older group, which comprised 55% and 45% of the sample, respectively. The VMI means of the young LD group and the young non-LD were 100 and 96, respectively (Table 1). As seen in Table 2, the VMI means of these two groups were not statistically different ($F = .4474$).

The VMI means of the older LD group and the older non-LD group were 91 and 104, respectively (Table 1). As seen in Table 2, a statistically significant difference between these means was found ($F = .0505$). The older non-LD group scored significantly better than the older LD group. The VMI did discriminate between the LD and non-LD groups of children over 10 years 9 months of age.

Table 1

VMI Standard Score Means and Standard Deviations for All Comparison Groups

		VMI	
Group	N	Mean	Standard Deviation
LD	27	95.93	17.63
Non-LD	29	99.69	14.25
Females	19	98.47	16.38
Males	37	97.57	15.92
Female LD	5	93.60	14.48
Female Non-LD	14	100.21	17.16
Male LD	22	96.45	18.52
Male Non-LD	15	99.20	11.49
Younger LD	14	100.43	17.48
Younger Non-LD	15	96.0	13.30
Older LD	13	91.08	17.12
Older Non-LD	14	103.64	14.64

Table 2

ANOVA Results of all Comparisons of VMI Standard Score Means and Standard Deviations

Comparison Group	DF	Sum of Squares	Mean Square	F Value	Pr > F
LD vs. Non-LD	1	198.07	198.66	0.78	0.3820
Error	54	13768.06	254.96		
Corrected Total	55	13966.13			
LD vs. Non-LD for each Gender	3	238.71	79.57	0.30	0.8242
Error	52	13727.41	263.99		
Corrected Total	55	13966.12			
Younger LD vs. Younger Non-LD	1	142.02	142.02	0.59	0.4474
Error	27	6451.43	238.94		
Corrected Total	28	6593.45			
Older LD vs. Older Non-LD	1	1064.38	1064.38	4.22	0.0505
Error	25	6304.14	252.17		
Corrected Total	26	7368.52			

Table 3

Factorial ANOVA Results Assessing Effects of Gender and Gender x Group Interaction

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Gender	1	8.83	8.83	0.03	0.8556
Group	1	228.41	228.41	0.87	0.3566
Gender*Group	1	39.02	39.02	0.15	0.7022

Figure 1 displays the VMI standard score means for all groups compared. In all groups, except the young group, the non-LD children scored higher as a group than the LD children. However, the only statistically significant difference was observed in the older group. Although not statistically significant, it is interesting to note that in the younger group, the LD children scored higher on the VMI than the non-LD children.

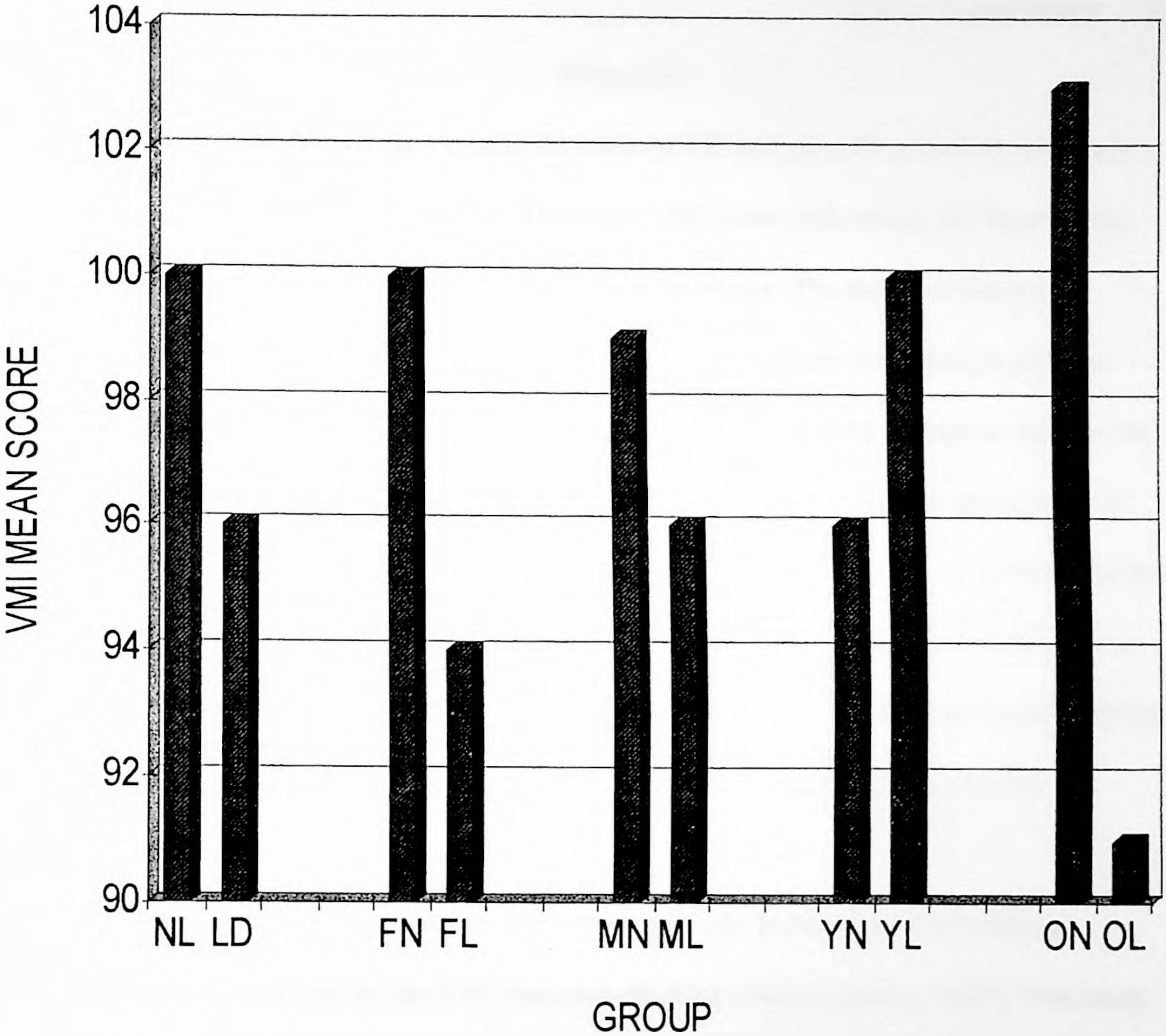

Figure 1: Displays the VMI mean scores for each group compared.
N = Non-LD; L = LD; F = Female; M = Male; Y = Young;
O = Old (i.e. ML = male LD subjects).

Discussion

The VMI did not discriminate between the LD and non-LD groups in this study. The hypothesis is therefore rejected. The mean VMI scores did distinguish between the LD and non-LD subjects above 10 years, 9 months of age. The means of these two groups, however, were both within one standard deviation from the mean, or average range. Although statistically different, this discrepancy is not great enough to support the VMI as a clinically useful tool to aid in the diagnosis of LD. For an instrument to have diagnostic utility, scores for the target group would be expected to be one to two standard deviations below the mean. It is concluded that the VMI, although a useful tool in other neuropsychological arenas, would not yield diagnostically useful information and therefore should not be an integral part of a test battery designed to detect LD in children and adolescents.

The results of this study do not corroborate that learning disabled children reportedly do less well on the VMI than non-disabled children (Beery, 1997). This study does support Hinshaw, Carte, and Morrison (1986) who found that the VMI did not emerge as a good predictor of achievement in children 8.58 to 11.08 years of age. These researchers found that the VMI was the single most effective predictor of achievement in children aged 5.75 to 8.58 years. It is feasible that this study may have shown the VMI to be sensitive to LD status had the subjects been younger. As children get older, they learn to compensate for weaknesses where possible, and this could explain the lack of findings in this study. The fact that our young group of LD subjects had a higher mean VMI score (although not statistically higher) than the non-LD group may indicate a degree of over compensation during a time when visual-motor skills are central to academic achievement.

One reason that possibly contributed to the lack of findings in this study was the use of one heterogeneous group of LD children. Numerous studies have identified homogeneous subgroups within the LD population. Tightening the criteria to only include one subgroup of LD, possibly with their main difficulties in nonverbal skills, may have yielded different results. Nussbaum and Bigler (1986) had a subgroup 3 which exhibited their main deficits in visual-spatial and visual-motor functioning. Korhonen (1991) found a LD subgroup they labeled as the visuo-motor group. Harnadek and Rourke (1994) specifically examined those LD children with nonverbal learning disabilities. They found that problems in the areas of visual-spatial-organizational skills and psychomotor coordination were characteristic of this group.

Study Limitations

One limitation of this study, as mentioned previously, was the use of one heterogeneous group of LD children. Another limitation was the relatively small sample size, but the more stringent the criteria, the more difficult it becomes to find appropriate subjects. The subjects used in this study should have included children younger than 9 years of age. However, this study was a part of a larger research project, and the age range of the subjects was selected to meet the norms of all tests employed. Finally, the subject group in this study was heavily weighted with caucasion children (96%). A more ethnically diverse sample would have been more representative of the population.

Topics for Further Study

The VMI and its discriminant validity with different subtypes of LD should be examined in future research. Also, more research on the predictive validity of the VMI in younger samples of children would be beneficial.

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Appendix A: Literature Review

Literature Review

It has been estimated that 15% of the U.S. population has some form of learning disability (LD), and 52% of all students receiving special education services are diagnosed with LD (Cramer & Ellis, 1996). Outcomes for individuals with LD are too often unfavorable, with higher incidence of juvenile deliquency, substance abuse, and unemployment as adults. More research and better intervention will aid in stopping this cycle.

One of the main problems facing researchers today is the lack of a clear definition. The DSM-IV defines a learning disorder as a discrepancy of 2 or more standard deviations between ability, as measured by a standardized IQ test, and achievement. In 1977, under public law 94-142, the U.S. Office of Education released regulations for identifying students with LD. This definition, also referred to as the IDEA definition, is a disorder "in one or more of the basic psychological processes involved in understanding or in using language, spoken or written, which may manifest itself in an imperfect ability to listen, think, speak, read, write, spell, or to do mathematical calculations..." (Mercer, Jordan, Allsopp, & Mercer, 1996). These researchers, upon examining the definitions used by the different state education departments across the U.S., found that only 71% used the IDEA definition and many of these contained some type of modification.

Gregg, Scott, McPeek, and Ferri (1999) found little consensus across state agencies in defining LD in the adolescent and adult population. These researchers found inconsistencies in not only definition and criteria for LD but also in the treatment and intervention. They concluded that consensus on definition and eligibility models needs to be reached, and these models need to address communication, behavior, social skills, and social/emotional functioning. The National Joint Committee on Learning Disabilities defines LD as:

> 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. . . . 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. (Capin, 1996)

This definition was chosen for the present study.

Definition and/or criteria of LD is not the only obstacle facing researchers. The root of LD and the various influences on LD are also areas where consensus is difficult to find. One underlying theme through much of the research is a link between difficulties in learning and neurological insult of some type. Much of the past research, whether directly or indirectly, eludes to a neurological basis to LD.

Reed, Reitan, and Klove (1965) examined the influence of cerebral lesions on performance of children 10 to 14 years of age on various psychological tests. Among the tests utilized were the Wechsler-Bellevue, the Halstead Finger Oscillation Test, Halstead

Time Sense Test, Seashore Rhythm Test, Trail Making Test, Category Test, and the Tactual Performance Test. These researchers found that the brain damaged group performed at significantly lower levels than control children on all tests employed. Although this research preceeded actual LD research, these researchers showed a link between neurological insult and skills required for learning.

Arffa, Fitzhugh-Bell, and Black (1989) examined neuropsychological profiles of children with LD and children with brain damage (BD). All children included in this study were between 9 and 11 years of age and met stringent criteria for either the LD or BD group. Eighty-three measures from the Intermediate Battery of the Halstead-Reitan among other measures such as the Developmental Test of Visual-Motor Integration and the Trail Making Test were utilized. The data was cluster analyzed which yielded 5 clusters. All clusters were composed of LD and BD children suggesting similar neurological pathology underlying both. These researchers suggest using neurological imaging techniques such as PET scans or enhanced MRI to study LD children even when no neurological insult is apparent in the history.

Later researchers, also working with LD and BD children and utilizing cluster analysis, included behavioral data in one analysis. This yielded four interpretable subtypes. The largest of these subtypes were individuals whose primary problems were in cognitive processing with little or no behavioral problems. The second group was characterized by sensory deficiencies, relatively weak skills in mathematics, and no significant behavioral problems. Group 3 was characterized by difficulty with inattentiveness. The fourth group showed normal testing profiles with their learning difficulties attributed to behavioral interference. Upon secondary analysis, in which behavioral data was excluded, only 2 subtypes emerged. One subtype was characterized as younger and demonstrated better verbal or language skills. Better language skills are generally associated with left-hemispheric function. The second subtype showed better nonverbal skills which is usually associated with right-hemispheric function. It was concluded that the examination of behavioral variables, as well as neuropsychological data, is vital for the appropriate diagnosis and treatment of LD and BD children (Williams, Gridley, & Fitzhugh-Bell, 1992).

Blumsack, Lewandowski, and Waterman (1997), using a survey format, investigated the correlation of neurodevelopmental precursors to later LD diagnosis. These researchers found that academic, sociobehavioral, and attentional difficulties were the most frequently reported early problems of those later diagnosed as LD. They found that difficulties with the later developing skills most distinguished the LD group from the non-LD group. Their findings suggest that children showing difficulties before the age of 9 years are more likely to be diagnosed LD. Their work corroborated that LD has developmental precursors. Many LD children fail to exhibit specific neurological abnormalities, however exhibit significantly more neurological soft signs than nondisabled children (Coplin, & Morgan, 1988).

LD has been correlated with certain neurological disorders. North et al. (1997) examined the frequency of LD among individuals with Neurofibromatosis type 1 (NF1). NF1 is a single gene disorder that affects the nervous system. These researchers report that 30 to 45% of children with NF1 have LD. These researchers suggest that any child with NF1 be assessed and monitored due to the high risk of LD. They, however, do not recommend that MRI be an integral part of the work-up for NF1 children unless clinically indicated, as it provides no useful information regarding the diagnosis or intervention for LD. This is in contrast to North et al. (1994) who concluded that the increased T2 signal on MRI has major implications for diagnosis and management of LD in NF1 children.

Shalev and Gross-Tsur (1993) examined seven children between 8 and 9 years of age that were diagnosed with developmental dyscalculia (DC) and were not making progress despite intervention efforts. DC was defined as a primary cognitive disorder manifested by deficits in arithmetic ability. All seven children were found to have neurological conditions which had direct bearing on their cognitive abilities, and more specifically their diagnosis of DC. These researchers suggest that children which do not improve when given appropriate intervention be medically and neurologically assessed.

Studies have been conducted to localize differences in the brains of LD individuals. Gauger, Lombardino, and Leonard (1997) utilized MRI to compare the Wernicke's and Broca's areas in children aged 5 to 13 years with specific language impairments (SLI) to children with normal language skills. These researchers found that, in SLI children, Broca's area was significantly smaller. They also found that SLI children were more likely to have rightward asymmetry of language structures.

Ackerman, McPherson, and Oglesby (1998) compared EEG spectra of adolescent poor readers to those of younger children that were poor readers. These researchers found no significant correlation between beta levels and measures of phonological skill. EEG results were not significantly correlated with standard reading scores or IQ.

Hynd, Marshall, and Gonzalez (1991) reviewed CT and MRI studies on individuals with severe reading disabilities. These researchers found that numerous studies showed that the asymmetry that is characteristic in most normal brains, is less evident in those individuals with severe reading disability. These findings are related to the posterior and plana asymmetries; both regions being associated with visual-spatial and neurolinguistic processes involved in reading. Although the studies provide support for the neurological basis of LD, no clear diagnostic anomaly emerged.

Bigler (1992) reviewed several studies regarding the neurobiology and neuropsychology of LD in adults. Bigler found, when examining three prominent studies of individuals with dyslexia using MRI, that all studies suggested anatomic irregularity in the posterior left cerebral hemisphere when compared to controls. However, there have been no pathologic markers or indicators found that are useful in the diagnosis of dyslexia. Flowers, Wood, and Naylor (as cited in Bigler, 1992), utilized regional cerebral blood flow to compare adults with poor reading ability as children and controls. They found that a lack of activation in language areas may be associated with dyslexia. They also showed that some of these critical language areas are outside areas where previous anatomic irregularities have been identified. Gross-Glenn et al. (as cited in Bigler, 1992) used positron emission tomography, or PET scans, to study adults with familial form of dyslexia. These researchers found differences in regional cerebral metabolic activity in the frontal and occipital areas during reading.

Filipek (1994) reviewed the findings of both postmortem and imaging studies. Filipek found conflicting results regarding hemispheric symmetry, corpus callosum, and temporal lobes which have all been reported to differ in dyslexic brains when compared to normal brains. Basically, Filipek concluded that no conclusions could be drawn concerning anomalies in developmental dyslexia.

Bigler, Lajiness-O'Neill, and Howes (1998) reviewed recent findings of neuroimaging, metabolic imaging, and electrophysiological studies of learning disordered individuals. Several CT studies reviewed indicated reversed cerebral asymmetry was associated with decreased verbal skills. MRI studies have shown atypical symmetry of the posterior temporal lobes; however, focal pathologic anomalies previously seen in postmortem studies were not shown in the MRI studies. This is not to imply however that they are not present, but cannot be detected by MRI. Lubs et al. in 1988 (as cited in Bigler, Lajiness-O'Neill, & Howes, 1998) found the length and shape of the left planum temporale was smaller in individuals with dyslexia. Schultz et al. (1994) however could not replicate these findings (as cited in Bigler, Lajiness-O'Neill, & Howes, 1998). To date, no diagnostic conclusions or universal abnormality has been found using neuroimaging techniques. Numerous EEG studies have also implicated greater left than right hemispheric abnormalities. Replication of such studies and finding a specific diagnostic abnormality has not been accomplished. These researchers also found no consistency in PET scan studies although several abnormalities were found. The PET scan, being expensive and intrusive, is likely not to contribute to LD assessment in the future.

Hadders-Algra and Touwen (1992) examined minor neurological dysfunction (MND) and how it relates to learning difficulties in 9 year old children. These researchers defined MND as neurological deviations that do not constitute an overtly handicapping condition. MND consists of choreiform dyskinesia, mild hypotonia, mild coordination problems, and slight deviations of fine manipulative ability. They found that both the presence and severity of MND was closely related to cognitive problems, and this relationship was stronger than the relationship to behavioral problems. These examiners, however, found no definitive relationship between specific single neurological dysfunctions and learning.

One problem that contributes to the lack of consensus among research is the failure to study specific subtypes of LD. Identifying various subtypes of LD has been the focus of some studies and appears to be a difficult task in itself, as there is little consensus on subtype basis or identification. Fisk and Rourke (1983) looked at the then current trends in the scientific community regarding LD. They found two extremes. One being that LD individuals were a homogenous group with one unitary cause for their LD. On the other extreme, some believed that LD individuals were so heterogeneous that they could only be studied by individual case study. Fisk and Rourke (1983) after reviewing current trends in research concluded that neither extreme was clinically viable, and that the focus of research should be to identify homogeneous subtypes within the vastly heterogeneous population of LD individuals.

In 1981, Satz and Morris (as cited in Coplin & Morgan, 1988) logitudinally investigated the neuropsychological test patterns of LD boys. Using cluster analysis, these researchers were able to identify five subtypes. Subtype 1 exhibited global language impairment with normal nonverbal perceptual skills. Subtype 2 was the specific language subtype being selectively impaired on verbal fluency. The 3rd subtype was mixed showing impairment on all neuropsychological measures. Subtype 4 was referred to as the visual-perceptual-motor subtype and showed impairment on nonlanguage tests. The 5th subtype displayed normal neuropsychological profiles. These researchers succeeded in identifying viable subtypes within a heterogeneous population of LD boys.

Nussbaum and Bigler (1986) identified three subgroups of learning disabled children using 13 intellectual and neuropsychological variables. The first subgroup had severe and generalized deficits in performance. It was concluded that this group may be experiencing some degree of generalized cerebrocortical dysfunction. The second subgroup exhibited a moderate degree of impairment but greater verbal impairment. This group was considered the general language disordered group, which showed a relative strength in right hemispheric functioning and a corresponding deficit in left hemispheric function. The third subgroup showed the least amount of impairment but greater deficits in visual-spatial and visual-motor functioning. This group showed superior left versus right hemispheric functioning. These researchers hypothesized that these differences were attributable to either right or left hemispheric processing or generalized impairment. They ultimately showed, however, that there are subgroups within the LD population , and these subgroups each yield differing profiles on neuropsychological and intellectual tests.

Harnadek and Rourke (1994) looked at the identifying features of one subgroup of LD, nonverbal learning disabilities (NVLD). Some identifying features of this subgroup included: significant deficiencies in visual-spatial-organizational skills, significant deficits in nonverbal problem solving, well developed rote verbal skills, and significant problems in mechanical arithmetic. NVLD is found in individuals suffering from numerous neurological diseases and disorders. Among these are damage to right cerebral hemisphere, some types of hydrocephalus, various types of head injury, and other neurological processes that result in destruction of neuronal white matter. These researchers examined the discriminant validity of the neuropsychological deficits thought to be characteristic of NVLD. They found that on tests of visual-perceptual-organizational skills, psychomotor coordination, complex tactile-perceptual skills, and conceptual and problem solving skills the NVLD performed more poorly than did other groups of LD children and controls. Further, the NVLD group had comparable scores to controls on tests of rote aspects of verbal and psycholinguistic skills.

Roman (1998), in a clinical review of NVLD, described it as a distinct diagnostic entity. NVLD is characterized by deficits in tactile and visual perception, visual–spatial skills, visual-motor skills, psychomotor coordination, nonverbal memory, reasoning, executive functions, and deficits in specific aspects of speech and language. Academic concerns lie in the areas of mathematical reasoning, reading comprehension, aspects of written language, and handwriting.

Rourke and Conway (1997) demonstrated the importance of identifying subtypes of LD, more specifically math LD. Their results showed that arithmetic LD can be subdivided into two groups discriminated by the neuropsychological impairments causing the disability. One group's impairment stemmed from verbal deficiencies, which are probably reflective of dysfunctions of the left hemispheric processes. The other group suffered impairments based on nonverbal deficiencies, which are thought to reflect dysfunction in, or lack of access to, right hemispheric processes. Subtype specification can aid in more directed intervention.

Korhonen (1991) looked at the neuropsychological stability of five valid subgroups of children over a 3 year period. The subgroups were normal, general language, visuo-motor, general deficiency, and naming groups. A battery of 12 neuropsychological tests were used to measure stability. These researchers found that the differences between the LD sample and control sample were maintained upon follow-up. Most of the neuropsychological characteristics that defined the subgroups were also maintained with evidence of a small amount of change, apparently indicating a degree of catching-up.

Given the fairly accepted relationship between neurological dysfunction and LD, it stands to reason that neuropsychological assessment would be the topic of much research. Fennell (1994) discussed the need for neuropsychological assessment of LD children. The first purpose of neuropsychological testing is to get a clearer picture of cognitive, academic, and social functioning. The second goal is to aid in developing a better and more focused intervention strategy. Neuropsychological assessment provides information concerning the child's central nervous system and specific abilities. Fennell recommends the essentials of a neuropsychological exam be a clinical history, neuropsychological testing, evaluation of social/emotional functioning, and assessment of achievement. Fennell suggests that assessment of language functions, memory, attention, visuospatial processing, sensory motor functions, and self-regulatory behavior be included in a thorough exam.

Finlayson and Obrzut (1993) examined the diagnostic utility of the Quick Neurological Screening Test-Revised (QNST-R) for the LD population. A sample of 122 subjects ranging in age from 6 to 13.5 years with at least a 2 year delay in achievement were administered this test. These researchers found that although demonstrating construct validity, the instrument is sensitive to a general maturity factor. Younger LD children had more difficulty with the instrument than did older LD children. It was concluded that poor performance on the QNST-R by older children is a better indicator of neuropsychological deficits than poor performance by younger children.

Sarazin and Spreen (1986) examined the stability of several neuropsychological measures of LD individuals over a 15 year period. Among the neuropsychological tests utilized were the Category Test, Sentence Repetition, Lateral Dominance, and Right-Left Orientation. These researchers found that these neuropsychological measures were fairly stable over the 15 year period with the LD group, but the highest measure of stability was found in the brain damaged group. This study lends support to the need for neuropsychological assessment in LD individuals and that this assessment is not just measuring transient features.

Hinshaw, Carte, and Morrison (1986) studied the predictive power and stability of several neuropsychological variables in regards to reading disabled children. The children ranged in age from 5.75 to 11.08 years and were divided into younger and older subgroups at the median age of 8.58 years. The neuropsychologicl tests employed were the Rapid Automatized Naming (RAN), Illinois test of Psycholinguistic Abilities: Sound Blending, Spreen-Benton Aphasia Test, Developmental Test of Visual-Motor Integration

(VMI), and the Purdue Pegboard Test. The tests were administered twice with an 11 to 12 month interval between administrations. These researchers found that the VMI was the single best predictor of achievement in the younger group of children. The VMI was also comparably stable over the time frame.

Williams, Zolten, Rickert, Spence, and Ashcraft (1993) examined the use of nonverbal tests to screen for writing dysfluency in school-age children. There were 146 children, ranging in age from 6 to 16 years, that were administered the tests. The tests utilized were the Coding subtest from the WISC-R, Performance IQ from the WISC-R, The Developmental Test of Visual Motor Integration (VMI), and the Grooved Pegboard Test. These researchers found that a combination of low scores on Coding, VMI, and the Grooved Pegboard Test is effective in screening children for writing dysfluency. These researchers concluded that this screening battery should be used as a tool for ruling out writing dysfluency or suggesting the need for further evaluation.

Watkins (1996) studied the diagnostic utility of the Wechsler Developmental Index as a predictor of LD in children grades 1 through 8. The WDI performed at chance levels when distinguishing between LD children, emotionally disabled (ED) children, mentally retarded children (MR), and nondisabled controls. It was concluded that the WDI is ineffectual in discriminating between LD, ED, and MR children as well as discriminating between disabled and nondisabled children. This instrument should not be included in an assessment of LD.

Given the prevalence of LD and the common failure of traditional special education, more research should be geared toward the accurate diagnosis and treatment of

LD. Finding relatively short, inexpensive neuropsychological test batteries that not only diagnose LD, but find the child's neuropsychological strengths and weaknesses, would aid in the development of more directed, more successful intervention.

Coplin and Morgan (1988) discussed two main trends of current intervention for LD children. The remedial approach focuses on the child's area of weakness. This approach has been reported as ineffective due to the concentration on the dysfunctional abilities. By focusing on the weaknesses of the child, such techniques can increase stress and anxiety. The second approach is to focus on the child's neuropsychological strengths. These strengths are then utilized to help the child acquire academic skills. The most efficient skills of the child are used to compensate for the weaknesses. For example, children with right hemispheric strengths would benefit more from a simultaneous, visuo-spatial processing method.

Hartlage and Telzrow (1983) describe the strategy of circumvention. In this intervention strategy, assistive devices and supplanting mechanisms are employed to permit learning to the best ability of the child. These researchers assert that the easiest way to teach a subject is nonproductive in some cases due to specific neuropsychological deficits. In these cases, a learning detour is taken which is intended to meet the overall learning objective. Compensatory techniques may consist of changes in the learning environment or changes in the way the child aquires the information. One example of a compensatory technique is teaching a child to use a calculator when instruction in basic mathematics has failed.

Appendix B: Sample Description

Subject Number	Status	Gender	Age Yr:Mo	Ethnicity
1	Dropped	-	-	-
2	Non-LD	Female	10:0	Caucasian
3	Non-LD	Female	9:0	Caucasian
4	Non-LD	Male	9:7	Caucasian
5	LD	Male	10:3	Caucasian
6	LD	Male	9:9	Caucasian
7	Dropped	-	-	-
8	Non-LD	Female	10:5	Caucasian
9	LD	Male	11:8	Caucasian
10	Non-LD	Male	12:1	Caucasian
11	LD	Female	9:1	Caucasian
12	LD	Male	12:6	Caucasian
13	LD	Female	15:1	Caucasian
14	Non-LD	Female	10:9	Caucasian
15	Non-LD	Female	12:5	Caucasian
16	Non-LD	Male	15:11	Caucasian
17	LD	Male	16:0	Caucasian
18	LD	Male	9:7	Other
19	LD	Male	15:0	Caucasian
20	Non-LD	Male	15:1	Caucasian
21	Non-LD	Female	15:3	Caucasian
22	LD	Male	10:0	Caucasian
23	Non-LD	Male	10:9	Caucasian
24	LD	Female	13:9	Caucasian
25	Non-LD	Male	12:1	Caucasian
26	Non-LD	Female	15:3	Caucasian
27	LD	Male	11:0	Caucasian
28	Non-LD	Male	9:0	Caucasian
29	Non-LD	Male	11:1	Caucasian
30	LD	Male	9:2	Caucasian

Subject Number	Status	Gender	Age Yr:Mo	Ethnicity
31	Non-LD	Female	12:3	Caucasian
32	Non-LD	Male	13:11	Caucasian
33	Non-LD	Female	12:4	Caucasian
34	LD	Male	14:11	Caucasian
35	LD	Male	13:3	Caucasian
36	Dropped	-	-	-
37	Non-LD	Female	10:3	Caucasian
38	Non-LD	Female	10:1	Caucasian
39	Non-LD	Female	10:9	Caucasian
40	LD	Male	10:6	Caucasian
41	LD	Male	9:0	Caucasian
42	Dropped	-	-	-
43	LD	Male	9:1	Caucasian
44	LD	Male	9:8	Caucasian
45	Non-LD	Male	9:4	Caucasian
46	LD	Male	9:4	Caucasian
47	LD	Female	11:0	Caucasian
48	Non-LD	Male	10:4	Caucasian
49	LD	Male	9:8	Caucasian
50	Non-LD	Male	11:6	Caucasian
51	Non-LD	Male	9:7	Caucasian
52	LD	Female	12:2	AfricanAmerican
53	LD	Male	12:8	Caucasian
54	Non-LD	Female	9:7	Caucasian
55	LD	Male	14:6	· Caucasian
56	LD	Male	9:0	Caucasian
57	Non-LD	Female	11:5	Caucasian
58	Non-LD	Male	10:4	Caucasian
59	Non-LD	Male	11:0	Caucasian
60	LD	Male	14:7	Caucasian

Appendix C: Consent and Interview Forms

INFORMED CONSENT

I, ______________________________, have been informed of the nature and purpose of the proposed research, Neurological Bases of Learning Disorders, and testing of my child. I do hereby give consent to Marshall University Graduate College and ________________________, graduate student, for psychological evaluation of my child, ___________________________. I understand that my child's name or other identifying information will not be used, but that testing will take approximately five (5) hours. I further understand that the results will be utilized in a research endeavor and will be detailed in unpublished theses and professional journals.

I have been informed that my child's test results will be discussed by the student psychologist with me if I make the request before testing is completed. The test results WILL NOT be made available to the public school system, any legal agency, or other public institution.

Parent / Legal Guardian ___________________________________ Date_____

Student Psychologist ____________________________________ Date______

NEUROLOGICAL BASES OF LEARNING DISABILITIES

Child ID _______ **Age** ____years ____months

Current Grade ____ **Grades Repeated** ________

Year Identified as Learning Disabled _____

LD Reading ____ **LD Math** ____ **LD Written** ____

Developmental Health History

Were there any birth difficulties and/or injuries? ______________________

____

Length of pregnancy _________________

Pregnancy difficulties ________________

Birth weight ________________ Apgar Scores _____/_____

At what age did they walk? _______

Normal YES or NO

At what age did they begin talking in single words? ___________________

Normal YES or NO

At what age did they begin using 3-4 words together when talking? _______

Normal YES or NO

Toilet trained at what age? __________

Normal YES or NO

Head Injury YES or NO If yes, explain - _________________

____

Seizures YES or NO If yes, explain - _________________

____

High temperature during childhood YES or NO If yes, explain - __

____

Enuresis YES or NO If yes, explain - _________________

____

Encopresis YES or NO If yes, explain - _________________

____

History of mental health treatment YES or NO (If yes, omit from study)

Tic, tremors, or other psychomotor YES or NO If yes, detail - ________

____

Appendix D: VMI Standard Scores

Subject Number	VMI Standard Score	Subject Number	VMI Standard Score	Subject Number	VMI Standard Score
1	-	21	98	41	92
2	103	22	128	42	-
3	68	23	87	43	100
4	104	24	83	44	88
5	79	25	95	45	98
6	106	26	102	46	102
7	-	27	85	47	113
8	124	28	101	48	79
9	88	29	82	49	85
10	94	30	118	50	104
11	99	31	83	51	100
12	110	32	124	52	97
13	76	33	111	53	104
14	130	34	73	54	105
15	82	35	83	55	82
16	114	36	-	56	92
17	109	37	97	57	117
18	140	38	84	58	98
19	108	39	99	59	101
20	107	40	92	60	58

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