2000

The ability of Trail Making Test Parts A and B for children and adolescents to discriminate between learning disabled students and non-learning disabled students

Glorene K. Evilsizor

The Ability of Trail Making Test Parts A and B For Children and Adolescents To Discriminate Between Learning Disabled Students and Non-Learning Disabled Students

By

Glorene K. Evilsizor

A Thesis Submitted In Partial Fulfillment of the Requirements for the Degree Master of Arts In Psychology

Marshall Graduate College

2000

This thesis was accepted on 7 24 2000
Month Day Year

as meeting the research requirements for the master's degree.

Advisor [signature]

Department of Psychology

[signature] 5/31/01
Dean of the Graduate College

(Short Title)

The Ability of Trail Making

Acknowledgements

I would like to express my appreciation to Dr. Lawhon and Dr. Ranson for their guidance and assistance in the completion of my project. I would also like to thank my co-workers at Women and Children's Labor and Delivery Unit, especially night shift for assisting me in many ways from trading shifts to providing me with testing subjects to listening to my "whining" throughout this project. I also would like to thank my Charleston group co-testers Michelle, Jessica, and especially Nathan, who entered the stats, for assisting me in the project. Finally, I would like to thank my family Scott, Selena, Adam, Krista, and Seth for "putting up" with me throughout this endeavor. Without their love and support, I never would have made it through. Thank you all!

Dedication

I would like to dedicate this project to my husband, Scott. He gave me support by typing and assisting with computer queries. However, most of all, he gave me love and support. For without these, the completion of this thesis would have been impossible.

Table Of Contents

Table 1 ANOVA for Trail Making Test Parts A and B

Abstract

The Trail Making Test Parts A and B is a neuropsychological test that has long been thought to be a highly reliable and valid test that is able to discriminate cerebral dysfunction. In the present study, an investigation was completed in order to determine whether or not the Trail Making Test Parts A and B could differentiate learning disabled students from non-learning disabled students in four counties in West Virginia. Fifty-six students ranging from ages 9-16 (mean age 9.9) were involved in the study. The convenience sample consisted of 27 learning disabled students and 29 controls or non-learning disabled students.

Results indicated, using a one-way ANOVA, that there was a statistically significant difference between the performance on Trail Making Test Part B but not on Part A. The results of the present study confirmed the previously held belief that Trail Making Test Part B is able to differentiate between learning disabled children and non-learning disabled children. Trail Making Test Part B is more sensitive to neurological deficits than Trail Making Test Part A since it requires that the individual be able to switch between a numerical and an alphabetical series. In summary, the present study supports the premise that the Trail Making Test can be employed as a tool to distinguish between LD and non-LD children. Further research needs to be completed.

The Ability of Trail Making Test Parts A And B For Children and Adolescents to Discriminate Between Learning Disabled Students and Non-Learning Disabled Students.

When looking at the incidence of learning disabilities (LD), it has been found to range anywhere from 1 to 30%. This wide range is due to various factors. The first of these is the criteria utilized to determine what constitutes eligibility for services. The more stringent the criteria used to diagnose LD, the lower the number of students that are classified LD. Thus, a more stringent criterion places fewer students in LD and a more lenient criterion places more. (Lerner, J. 1993) Other factors which affect the variation in the numbers will be discussed when we look at defining LD and its etiology.

Prior to the passage of Public Law 94-142 in 1975, there was really no way to get an accurate count as to the number of LD students. With the implementation of the Education of All Handicapped Children Act (PL 94-142) in 1977 along with the individuals with Disabilities Education Act (PL 101-476) in 1990, which followed, the number of LD students could be more accurately obtained. The now required IEP or the written individualized education program for each student allows for a nationwide count of the number of students with particular disabilities and the number in each specific disability. Since the passage of the aforementioned law, the number of LD students has gradually increased from 800,000 the first year to over 2 million in 1990. The increase in LD students rose at a steady pace for the first seven years following the passage of the law. After that, the increase has gradually slowed. (Lerner, 1993)

Several factors were responsible for the increase in the number of children classified as LD following the passage of law (PL 101-476) in 1990. The factors included a greater awareness of learning disabilities and improvement in the procedures for identifying and assessing learning disabilities and social acceptance as well as a preference for the classification of the disorder. In addition, cutbacks in alternative programs such as remedial reading along with court orders, which required children to be reclassified, were responsible for an increase in the number of LD children. The court order found labels such as "mentally retarded" to be discriminatory. (Lerner, J., 1993) In 1990, the percentage of children found to be LD was 3.6%. In 1994, the prevalence of LD was found to be 3-4%. (Fennell, E.B.1994) Most recently, sources place the number of LD children in the United States as 2-10%. (Lerner, J. 1997) The variance is due to the reasons that were discussed early on in the paper.

With the increased number of LD students, LD education was found to be an essential requirement for these children for several reasons. The first of these is the fact that the goal of education in the United States is to have equal educational instruction for each child based on his or her individual learning needs. Unless the child with LD is taught in a way that will maximize his or her learning potential, he or she will not be given the same educational opportunities as the "normal child". The end results of ignoring the LD child's needs have been found to be academic failure, feelings of inadequacy, behavior problems, disapproval of their teachers and peers, and finally despair and disgust for school (Kauffman, J.M. & Wallace, G. 1993). Other problems that can result from untreated learning disabilities are depression and anxiety. Since it has been shown by researchers such as Levinson (1988) that neuropsychological dysfunction continues into adulthood, it is important that treatment begin in childhood. However, it has required court orders and passage of legislation in order for changes in educational instruction of the LD child to become the norm. (Kauffman, et. al., 1993)

Learning disability has been defined by the National Joint Committee on Learning Disabilities in 1990 as 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 concurrently with other handicapping conditions, sensory impairment, mental retardation, serious emotional disturbance, or with extrinsic influences, cultural differences, insufficient or inappropriate instruction), they are not the result of those conditions or influences. (Capin, D.M. 1996),

Developmental language disorders are the most common of the learning disorders. (Kauffman, et. al. 1993)

The purpose of this study is to determine whether the Trail Making Test Parts A and B for children and adolescents can discriminate between LD students and non-LD students. A secondary purpose is to determine if Trail Making Test Parts A and B can discriminate between neurologically based LD and non-neurologically based LD.

Ho1: There is no difference between LD and non-LD performance on Trail Making Test Parts A and B.

Ha1: There is a difference between LD and non-LD performance on Trail Making Test Parts A and B.

Rationale

Since all learning originates in the brain, a learning disorder can be caused by a dysfunction in the central nervous system. However, it is often difficult or even impossible to determine by medical examination or other medical tests if a neurological condition exists as the underlying cause of a learning disability. Thus, behaviorally oriented means are the only way to determine if a dysfunction of the central nervous system is present. This dysfunction has been found to be neurologically based through brain research in the past. (Lerner, J. 1993)

The neurological basis for LD is based on the fact that all learning is neurological. According to Cruickshank (1981),

> There is nothing else that it can be. All aspects of the senses involve the neurological system. No learning can take place without the involvement of the nervous system. Everything from emotions to memory to perception is neurological. Any environmental stimuli that the organism comes in contact with results in response whether it is motor, subliminal, autonomic, active, or any other. Likewise perceptual processing is a neurological phenomenon, which is very important to learning. (p. 28)

Cruickshank went on to note that learning also involves conditioning. Conditioning like perceptual processing has a neurological basis in the organism. Research such as that done by Pavlov and his dogs as well as others has supported this viewpoint. (Cruickshank W.M. 1981) According to Cruickshank, the neuropsychological dysfunction concept of learning disabilities places a great deal of responsibility on the neuropsychologist and the neurologist to properly evaluate the LD child. However, once this is done, an educational regimen can be implemented which will assist the child to learn. Finally, Cruikshank believes that the progress of children with LD can be greatly improved by an increase in the number of neuropsychologists. An increase in the number of neuropsychologists would lead to an increase in testing and proper diagnosis as well as a definition of the problem. Cruikshank goes on to say that the diagnosis without definition of the problem is useless. (Cruikshank, W. M. 1981)

There are at least two major reasons to conduct a neuropsychological assessment on a child with a learning disability. The first reason is to provide information about the functional integrity of the child's central nervous system. Testing, which includes an assessment of attention, memory, visuomotor skills, sensorimotor functions, and language are constructed to determine whether or not the child's behavior deviates from brain function that is appropriate for his or her age. The second purpose is to determine the child's strengths and weaknesses, which in turn are critical to develop a treatment or remediation strategy, appropriate for the child.

A thorough neuropsychological exam must include four essential elements. The elements are clinical history, neuropsychological testing, and evaluation of social and emotional functions, and an assessment of achievement as well as IQ. In addition, a clinical history, which involves a history taken from the child's medical records and interview of the parents, must be performed. The history should focus on any past or present medical or environmental factors that could contribute to behavioral or specific learning problems. It is also important to obtain the child's progress in school along with any interventions and any history of learning disabilities in the family. (Cruickshank, W. M. 1981)

The neuropsychological assessment is advantageous in identifying disorders such as LD because it examines the system of factors that impacts the child. The neuropsychologist can use his knowledge of the central nervous system in order to understand and anticipate how the child may respond to learning. The neuropsychological assessment is both Quantitative and Qualitative. The Quantitative aspect compares the data obtained through assessment to a normative group to detect discrepancies. The resulting data is thus evaluated in four ways: 1) level of performance;

2) pattern of performance; 3) right hemispheres; and 4) indicators of brain damage. The other approach is Qualitative. It requires a mixture of tests that both formally and informally assess any of the following systems: sensory and perceptual, motor functions, intelligence/cognitive abilities, memory/learning/processing, communication/language skills, academic achievement, as well as a history inclusive of any family or environmental influences. (D'Amato R.C., Rothlisberg, B.A., & LeuWork, P.H., 1999)

Finally, the reasons for conducting a neurological exam are to 1) provide information as to the child's central nervous system and functions such as attention, memory, and sensorimotor function and 2) provide information as to the abilities of the child.

The neuropsychological evaluation can also assist the child's learning by profiling recommendations based upon his problems in higher brain functioning as well as detailing the specific deficiencies in processing deficiencies that impact learning. Interventions that can be done include specific instruction and testing modifications as well as possible environmental modifications and behavioral management techniques. (Cruikshank, W. M. 1981)

Although there has been research done in the past in regard to the neurological basis of LD, more research must be done. Additionally, research is necessary so that those children with a neurological basis of LD can be identified and assisted in their educational endeavors. The result will be to promote optimum performance as they proceed through life.

Method

For the purpose of the study, male and female subjects ages nine to sixteen were selected as part of a convenience sample from the students in Kanawha, Boone, Lincoln, and Wood counties in West Virginia. All students were Caucasian with the exception of one black and one biracial student. There were 19 females and 37 males. Students were obtained from both rural and urban areas of West Virginia. IQ range for both controls and the LD group were 80-120. IQ was confirmed using the Wechsler Intelligence Scale for Children-III. The controls were students who had never been diagnosed as LD. The LD group included those students who had been given a diagnosis as LD as well as no other comorbid conditions such as another neurological or behavioral disorder. Criteria used for LD was that criteria which is employed in WV of 1.75 standard deviations between achievement and IQ. All participants required an informed consent signed by their parents. The informed consent included the purpose of the study and how the results of the testing could or could not be used. Achievement criteria were based on the results of the Wechsler Individual Achievement Test in the areas of reading and math.

Instrumentation

The overall battery of tests included a specified preselected group of longstanding neuropsychological tests that had previously been found through their validity and reliability to identify some form of organicity[sic] or neurological dysfunction. The tests chosen for the study are as follows: Children's Category Test, Children's Memory scale, Berry-Visual Motor Integration Test, Grooved Pegboard, Children's Auditory Verbal Learning Test-2, Benton Visual Retention Test, DCS: A Visual Learning & Memory Test For Neuropsychological Assessment and Trail Making Test Parts A and B for Children and Adolescents.

The instrument that was selected for this particular study was Trail Making Test

Parts A & B, specifically the intermediate form, since it is the form employed for ages 9-14 or those ages selected for the study. Even though the normative data for the intermediate form for adolescents and children only goes up to age 14, the same normative data was employed for the 15 and 16 year old students in the study since the adult version begins with age 20. Trail Making Test Parts A and B was part of the individual test battery of Army Alpha and Beta first employed by Robert M. Yerkes, a psychologist, in 1917. (Benjafield J. G. 1996) The test was later used by Reitan in the Halstead Battery of Testing. The Trails Making Test measures speed of visual search, attention, mental flexibility, and motor function. The Trail Making Test from the Halstead-Reitan Neurological Test Battery has also been described as "measuring the focus-execute component of attention." (Lyon, p. 85) In regard to reliability, Reitan previously found a "correlation of .54 between chronological age and the Halstead-Reitan Impairment Index for a normal population between ages of 15-65". (Greenlief, C.L., Margolis, R.B.& Erker, G.J. 1985) Although this is not the same population as listed in the present study, an inference can be drawn that would affirm a significant level or reliability in the Trails Making Test. Literature by Lezak in 1983 linked performance on part A to vocational potential. Part B necessitates that the individual be able to mentally track and switch between a numerical series and an alphabetical series. Additionally, Lezak found that differences in performance between Part A and Part B could indicate a difficulty in following a mental sequence or alternating between two types of cognitive activity. Part B requires recognition of numbers and letters, visual scanning, and shifting attention. Validity has been established in the Trails Making Test as it has been repeatedly shown to be "very sensitive to the presence of cerebral dysfunction by

Armitage in 1946, Reitan in 1955, Reitan in 1958, Spreen and Benton in 1965 and Gordon in 1972. (Greenlief, et. al., 1985) The Trail Making Test's validity and reliability has been supported repeatedly. Additionally, other support came again from Reitan in 1958 and Lezak in 1983, Abreu in 1987 and Sareen in and Strauss in 1991. (Okkema, K. 1993)

Trail Making Test Part A has been found to be sensitive to right hemisphere brain damage when the score is lower than Trail Making Test Part B. Trail Making Test Part B is sensitive to L-hemisphere damage when the score is lower than on Trail Making Test Part A. (Lawhon, D. 1999) According to Reitan in 1958, if the individual displays a wide discrepancy between performance on Part A and Part B, the problems may be attributed to difficulty with alternating attention and mental tracking. If the individual has problems with both parts of the test, primary attentional deficits, visual perceptual problems, or impaired language skills may be the cause. (Okkema, K. 1993)

Trail Making Test is administered in the following manner. The individual is given a copy of the test and a pencil. The test has two parts, Trails A and Trails B. Both Trails A and B have a sample practice test which is to be done prior to Test A or B. Sample Test A is to be completed without error prior to be completing Test A. Trails A consists of numbers and Trails B consists of numbers and letters. The individual is told under timed conditions in Trails A to begin with the number one and proceed to number two by drawing a line in a consecutive number order until he reaches the highest integer. The individual is told to keep the pencil on the paper throughout the entire test until he has completed the procedure and to correct any mistakes made but not to stop once the test administration has begun. Timing continues once the test has begun; however, the errors are to be pointed out to the student and corrected immediately while the timing continues. (Okkema, p.146)

In Trails B, the directions are the same except the individual is to begin with the number one and proceed to the letter A, then number two to B and so on until the test procedure is complete. As in Trails A, the sample is to be completed without error prior to Trail Making Test Part B. Scoring on the test involves employing the time involved to complete both Trails A and B and comparing the times to normal subjects for the subjects' particular age range. The tester must be attentive to the person's responses on Part A and Part B. This is important to determine whether or not the language component or the ability to search for and organize spatial information or rather the capacity to shift attention causes the greater difficulty. (Okkema, K.pp.145-146) Scores are then interpreted in the form of percentiles based on the individual's score and norm scores.

Procedure

1) Informed consent was obtained for both controls and LD subjects from their parents or guardian.

2) At the same time that the informed consent was obtained, a brief history of the child's medical, behavioral, and educational history has been obtained.

3) Administration of the WISC, WIAT was individually completed in an appropriate testing setting in order to confirm or rule out LD in those children who have already been determined by the school system to be LD.

4) Administration of the neuropsychological testing individually and again in an appropriate testing situation was completed. Additionally, students were divided into odd

and even numbers. The neuropsychological tests were administered in a certain predetermined order for the even-numbered students and in the reverse order for the odd-numbered students.

5) Tests were scored and evaluated.

6) Following the testing, an analysis of variance was run to compare both hypotheses.

7) The comparison was done to see if there was a significant enough difference on both hypotheses to determine that in fact there was a difference.

Results

The hypothesis of the study was to determine if there was a significant difference between test performance of a convenience sample of learning disabled students versus non-learning disabled students on Trail Making Test Parts A and B. Data were analyzed using a one way analysis of variance (ANOVA). On the Trail Making Test Part A, there was no significant difference between the groups at the .05 level of significance ($F, 1=1.931, p>.05$) Thus, in regard to Trail Making Test Part A, we can accept the null and state that there is no difference between LD performance and non-LD performance as a result of our study. However, in regard to Trail Making Test Part B, it was found that there was a significant difference between the performances of the LD versus non-LD students. ($F,1=4.664, p<.05$) Thus, we can reject Ho in favor of the alternative hypothesis. As a result of the present study, it can be stated that there was a statistically significant difference between performance of LD versus Non-LD students on Trail Making Test Parts A and B due to the increased sensitivity of Trail Making Test Part B.

Conclusions and Recommendations

The results of the study were supportive of our proposed hypothesis. It was found that the data supported our alternate hypothesis in terms of Trail Making Test Part B but not Part A. Trail Making Test Part B is indicative of left-sided brain functioning. However, this outcome was not surprising in light of other research completed. Other researchers generally support the premise that Trail Making Part B is also more sensitive than A in determining a neurological deficit. Many researchers do not even analyze Trail Making Part A when they look at the data. It is employed more as a trial to determine if the subject is able to execute the test successfully and is not as sensitive in determining cerebral deficits. Thus, even though Trail Making Test Part A did not support the alternative hypothesis, the study did gives us sufficient evidence to support with confidence the alternative hypothesis that there is a difference in test performance on the Trail Making Test Part B between LD and non-LD students. Results of the present study tend to support past research regarding the ability of Trail Making Test Parts A and B to diagnose a neurological deficit. Since according to Cruickshank (1981) "all learning is neurological," (p.28) we are able to perceive how a neurological deficit can ultimately be associated with a learning deficit.

It is well to note the possible limitations to the present study. The first is the fact that we employed a convenience sample. Because of this, we did not include a diverse sampling group. The sample included only two non-Caucasian students. The sample only came from four counties in West Virginia. Thus, though we included a population representative of the racial mixture of West Virginia, it would be difficult to extrapolate the results of the present study to areas outside of West Virginia. Another limitation to the study was due to the fact that there were a total of 10 testers rather than one. This affects the reliability somewhat even though the tests have all been proven to have interrater reliability. A third limitation of the study was the fact that the testers were aware of which children were LD and which were the controls prior to the testing. This "halo effect" would tend to improve the results of the control group and diminish the effects of the LD group.

In conclusion, even though the study did include several limitations, the results of the present study did support the use of The Trail Making Test (Part B) to distinguish between LD and non-LD students. However, further research needs to be completed outside of West Virginia in order for the results to have ramifications for other parts of the country.

References

Barkley, R. A. (1994) "The assessment of attention in children." In Lyon, G. R. (Ed.), Frames of reference of the assessment of learning disabilities (p. 85), Baltimore, Maryland: Brookes Publishing Company.

Benjafield, J. G. (1996) A History of Psychology. Needham Heights, MA: Allyn and Bacon.

Capin, D.M. (1996). Developmental learning disorders : clues to the diagnosis and management. Pediatrics in Review, 17 (8).

Cruickshank, W.M. (1983). Learning disabilities: A neurophysiological dysfunction. Journal of learning disabilities, Volume 16, Number 1, pp.27-29.

D'Amato, R.C., Rothlisberg, B.A., & Leu Work, P.H. (1999). "Neuropsychological assessment for intervention." In C.R. Reynolds & T.B. Gutkin (Eds.). The Handbook of School Psychology (pp. 452-475). New York: John Wiley & Sons, Inc.

Fennell, E.B. (1994). The role of neuropsychological assessment on learning disabilities. Journal of Child Neurology, 10,536-541.

Greenlief, C.L., Margolis, R.B. & Erker, G.J. (1985). Application of the Trail Making Test in differentiating neuropsychological impairment of elderly persons. Perceptual and Motor Skills, 61, 1283-1289.

Kauffman, J.M., & Wallace, G. (1973). Teaching Children with Learning Problems. Columbus, Ohio: Merrill Publishing Company.

Lawhon, D. (1999). Neuropsychological testing. Adult Psychological Assessment: An Instructional Guide (pp.78-80). Morgantown, WV: Lawhon & Associates, Morgantown Printing & Binding.

Lerner, J. (1997). Learning Disabilities: Theories, Diagnosis, and Teaching Strategies. (7th Ed.). New York: Houghton Mifflin Company

Lerner. J. (1993). Learning Disabilities: Theories. Diagnosis & Teaching Strategies. Boston, MA: Houghton Mifflin Company.

Levinson, H.N. (1988). The cerebellar vestibular basis of learning disabilities in children, adolescents, and adults: hypothesis and study. Perceptual and Motor Skills , 67, 987-1006.

Okkema, K. (1993). "Cognitive and perceptual evaluation techniques." Cognitive evaluation guide." Cognition and perception in the stroke patient (p.27) (pp. 145-146)

Gaithersburg, Maryland: Aspen Publication.

Trail Making Test Manual Courtesy of Reitan Neuropsychological Laboratory, 1338 East Edison Street, Tucson, Arizona 85719.

ANOVA for Trails Making Test Parts A and B

Table 1

		Sum of Squares	df	Mean Square	F	Sig.
Trails A	Between Groups	257.012	1	257.012	1.931	.170
	Within Groups	7186.828	54	133.089		
	Total	7443.839	55			
Trails B	Between Groups	2102.244	1	2102.244	4.664	.035
	Within Groups	24340.595	54	450.752		
	Total	26442.839	55			

Appendix A

Data

Table 3

Group	Type	Gender	Age	Race	Trails A	Trails B
Non LD		F	10;0	White	15	37
Non LD		F	9;0	White	46	33
Non-LD		M	9;7	White	39	54
LD	Read	M	10;3	White	31	32
LD	Read	M	9;9	White	32	58
Non-LD		F	10;5	White	11	41
LD	Read	M	11;8	White	15	32
Non-LD		M	12;1	White	22	57
LD	Math	F	9;1	White	37	73
LD	Read	M	12;6	White	29	27
LD		F	15;1	White	20	62
Non LD		F	10;9	White	67	82
Non LD		F	12;5	White	23	82
Non LD		M	15;11	White	17	28
LD		M	16;0	White	29	53
LD		M	9;7	Other	58	94
LD		M	15;0	White	14	37
Non LD		M	15;1	White	27	23
Non-LD		F	15;3	White	29	23
LD		M	10;0	White	25	43
Non LD		M	10;9	White	19	47
LD		F	13;9	White	17	40
Non-LD		M	*	White	31	48
Non LD		F	*	White	16	21
LD		M	*	White	41	51
Non LD		M	*	White	22	37
Non-LD		M	*	White	30	59
LD		M	*	White	47	68
Non-LD		F	12;3	White	21	26
Non-LD		M	13;11	White	17	23
Non LD		F	12;4	White	29	24
LD	Math	M	14;11	White	36	40
LD	Both	M	13;3	White	32	66
Non-LD		F	10;3	White	29	83
Non-LD		F	10;1	White	34	49
Non-LD		F	10;9	White	28	38
LD	Both	M	10;6	White	41	56
LD	Read	M	9;0	White	52	80
LD		M	9;1	White	32	47

LD		M	9;8	White	41	80
Non LD		M	9;4	White	38	41
LD		M	9;4	White	33	36
LD		F	11;0	White	20	68
Non-LD		M	10;4	White	40	70
LD	Both	M	9;8	White	24	88
Non-LD		M	11;6	White	17	29
Non-LD		M	9;7	White	26	83
LD	Read	F	12;2	Black	47	85
LD	Math	M	12;8	White	14	26
Non LD		F	9;7	White	40	65
LD	Both	M	14;6	White	33	113
LD	Read	M	9;0	White	44	82
Non LD		F	11;5	White	28	61
Non-LD		M	10;4	White	29	49
Non-LD		M	11;0	White	33	51
LD	Both	M	14;7	White	38	64

* Data unavailable at the time of report.

Appendix B

To All Parents

We are a group of Marshall Psychology Graduate students who are in the process of a research thesis involving learning disability students and non learning disability students. Besides performing our own screening to confirm a learning disability, we are employing a battery of neuropsychological tests to determine a possible neurological basis for learning disabilities. Our research is in need of students between the ages of 9 and 14 who have a learning disability. Therefore, we are asking parents whose child has been diagnosed with a learning disability or those parents who suspect that their child may have a learning disability to permit their child to be tested. Although, because this is a research project, we cannot give out a formal evaluation of the results, we can give the parents an oral interpretation of the results. This is an opportunity for those parents who think that their child may have a learning disability to obtain an initial screening. In addition, this is also an opportunity for those parents whose child has been diagnosed with a learning disability to possibly obtain further information as to the the basis for their child's learning disability. Because we must complete our research in the next few weeks, it is essential that we complete the testing as soon as possible. If you are interested in testing for your child, please contact Glo Evilsizor at the following number. 345-6827

Thank you, Marshall Graduate Research Group

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 or made public. I understand that no harmful or injurious techniques will 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 <u>WILL NOT</u> 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

Literature Review

The history of learning disabilities (LD) according to Lerner, J. (1993) can be broken down into 4 phases. The phases are: The Foundation Phase, Transition Phase, Integration Phase, and Contemporary Phase.

The Foundation Phase (1800-1930) was marked by a period of scientific research on the brain and its disorders. Early researchers were physicians who studied patients who had suffered from stroke, accidents, or disease. In addition, all of these patients displayed some behavioral deficits such as the inability to speak or read. These same individuals were studied postmortem through an autopsy of the brain to determine the damaged areas. Various individuals were noteworthy in the study of the brain and its relation to function. Paul Broca discovered that the left frontal lobe was damaged in individuals who had lost their ability to speak. In fact, the term Broca's Aphasia has since been the term used for the loss of speech.

Carl Wernicke spoke of another portion of the brain, (the temporal lobe), which he attributed to the understanding and comprehension of speech.

Another individual, Sir Henry Head, studied aphasia and developed a method for data collection and testing for it. Head employed clinical observation through which he determined that patients with aphasia did not suffer from a deficiency in intellectual functioning, even though they had sustained brain damage evidenced by language impairment.

A physician, James Hinshelwood (1917), coined the term "word blindness". He defined the condition as the inability to interpret written word even with normal vision. He discovered this condition while studying a boy who was found to be intelligent yet was unable to learn to read. He speculated that the problem was in the angular gyrus portion of the brain.

Another researcher, Kurt Goldstein (1939), hypothesized through treating brain-injured soldiers during World War I that brain damage affects one's behavior. He noted that brain damage causes two behaviors, distractibility and perseveration. Distractibility is a difficulty in perceptual impairment that is characterized by a problem in distinguishing between figure and ground. Heinz Werner and Alfred Strauss (1940) expanded Goldstein's work to brain-injured children.

Brain research did not end following the Foundation phase but continues today with increased fervor and with the employment of much more precise instruments of measurement and evaluation.

During the Transition phase (1930-1960), the scientific studies of the brain developed into applications. Changes in the methods of teaching resulted. Psychologists and educators developed instruments for assessment and remediation. They also studied types of learning disorders that were found in children. Important in this period was a neurologist by the name of Samuel T. Orton (1937). Orton developed the theory of cerebral dominance as a cause of children's language disorders. This development leads to a teaching method known as the Gillingham method. In order to honor Orton's work, the Orton Dyslexia Society was formed and is still active in the field of learning disabilities today. Others influential in this period were Grace Gernald (1943), an educator who developed a remedial reading approach to reading and spelling and Mildred McGinnis (1963) a speech pathologist who completed investigation and teaching of children with language disorders and aphasia.

During the Integration phase (about 1960-1980), learning disabilities became established in the schools throughout the country. During this period, learning disability programs were organized, teachers were trained in the field, and LD classes were begun.

Also during the integration phase, a major advancement in the field of LD occurred when Congress passed the Children with Specific Learning Disabilities Act (PL 91-230, 1969). This legislation was important because this was the first time that the field of learning disabilities was acknowledged by federal law. The end result meant teacher training could now be federally funded.

Federal funding also provided for the beginning of learning disabilities model programs throughout the country called Child Service Demonstration Centers. These centers allowed for innovative programs to be developed and experimented upon. Programs that were found to be beneficial were replicated in other areas of the country. Besides the centers, research institutes were also established. Begun in 1978 by the Office of Education, the institutes conducted research related to learning disabilities. The five institutes increased the understanding in the field of learning disabilities in five specific areas. The areas included adolescents with learning disabilities and learning strategies in regard to their curriculum, social competence and communication, cognitive theory and controlling attention, improving basic skills, and assessment and evaluation.

One of the most noteworthy items that occurred during the Integration phase was the aforementioned Public Law 94-142 or the Education for all Handicapped Children Act or later called the Individuals with Disabilities Education Act. The aforementioned act had the greatest influence on the integration on learning disabilities into the public schools. (Lerner, J. 1993)

Three factors have been thought to be causative of learning disabilities. The first of the three is biological or neurological/physiological. Both genetics and physical condition have a profound effect on the child's learning. Such problems as birth trauma, oxygen deprivation, infectious disease, drug intoxication, malnutrition, and congenital defects, as well as possibly others can influence learning ability.

The second factor that is thought to be responsible for learning disabilities is environmental. The child's social and cultural background can inescapably affect his ability to learn. Such areas as his family relationships, social class, and expectations of the educational system, and belonging to a particular subcultural group can be determinant factors in his development and learning. Specifically, poverty, racial discrimination, rigid school policies, cultural norms and taboos, and other cultural elements influence how the child responds to learning in the school.

The third factor, which affects a child's learning ability, is that of a psychological origin. Anxiety which a child experiences over such concerns as separation from his parents, gaining his own identity, traumatic events, expressing his emotions appropriately, building trust, or simply the anxiety over growing up are all related to learning in school. It has been generally accepted that normal psychological development removes some of the obstacles that impede learning. (Kauffman, et. al. 1973)

Opinions have been diverse in regard to the value of neuropsychological testing in order to diagnose brain damage. Some researchers in the past have not felt that a battery of tests could diagnose brain damage. Yates (1964) supported this concept. He concluded that " therefore it does not seem feasible, as many have suggested, to graft the aphasia model onto a learning disability diagnosis when there is still no solid research that damage to a specific area of the brain will cause a specific processing deficit or that this deficit can be picked up consistently in a battery of psychometric tests." (Johnson,C. 1981 p.227) In support of Yates' opinion, Pond in 1961 noted "In spite of the vast array of tests and observations available, many investigators are still forced to the same painful conclusion:

> "There are… no absolutely unequivocal clinical signs, psychological tests, or physiological tests that can prove a relationship between brain damage and any particular aspect of disturbed behavior." (Johnson, C. 1981, p.227)

Einhart (1963) found conflicting results from Yates and Pond when he gave a battery of tests to preschool children and determined that there was no single test accurate enough but that the combination of all the scores identified seventy-five percent of the brain-injured children and incorrectly identified only ten percent of the normal children.

Other researchers are in support of neuropsychological testing to differentiate brain damage but stress that they believe that it must be a battery of testing rather than one specific test. Haynes and Sells (1963) believed that there are several reasons for this. They believe that employing a battery rather than one test in order to diagnose brain damage overcomes the problem that there are so many different types of brain damage that affect so many areas of functioning that one test cannot measure all the tasks. The battery also decreases the chance that a normal subject can be considered brain-damaged because he has performed poorly on one test. (Johnson, C. 1981)

In support of a battery of testing versus one test, Johnson (1981) also felt that there is no single test that can reliably select the brain-damaged child from the healthy child. This has led to the theory that "brain functioning is so complex that only a battery of tests will ever diagnosis brain damage." (pp.225-226)

The Halstead-Reitan Neuropsychological Testing Battery (HRNTB), from which the Trail Making Test was derived, was originally developed for adults by Reitan in 1955. However, after much research by Reitan on younger and younger children, he determined and published in 1969 a revision that was appropriate for children aged 9-14. This revision was referred to as the Halstead Neuropsychological Test Battery for Children (HNTB-C). It only varied from the adult version in the number of items used and the organization of them. Both the adult and the child versions of the Halstead-Reitan are reported to measure areas of language, perception, sensation, abstract thought, sensory-motor integration, lack of perception, and dexterity.

The sensitivity to cortical dysfunction of the Halstead-Reitan battery for children and adults has been continuously researched since their development. Most of the early studies of their validity came from a "clinical blind technique" published by Dean in 1982 and again in 1985. This involved the administration and interpretation of the batteries without knowing the subject's diagnosis as published by Reitan in 1974. The test results were then compared to other information independently obtained from x-rays, surgical procedures, and/or autopsies. Dean (1985) noted that one problem with this approach is the fact that results may vary from tester to tester. Additionally, since the early research, more rigorous actuarial procedures and methods have been made to the batteries as noted by Finkelstein in 1976. (Dean, R.C. & Gray, J.W. 1990)

Group studies with the Halstead-Reitan Battery have shown that the battery differentiates between normal controls and those neurologically impaired with 84 to 85%

accuracy as published by Bell in 1981. Numerous researchers have offered data that is in favor of localization of brain damage for acute lesions rather than chronic neuropathology as published by Reid and Reitan in 1963 and earlier by Reitan in 1955.

In children, the research to indicate that the Halstead-Reitan is sensitive to childhood neurological dysfunction came from Boll in 1974; Klonoff & Low in 1974; Reed et. al., 1965; Reitan,1971;Rietan & Heineman,1968. However, validation of the research as in adults through surgeries and autopsies are more opportunistic. Additionally, children's neuropsychological functioning has many more variables that influence it.

Boll and Reitan noted in 1974 that children also differ from adults in the fact that they are impaired in most measures rather than just an isolated few. Neuropsychological assessment of children is in fact more likely to reveal global impairment of functioning than is the assessment of adults with similar structural damage as demonstrated by Ernhart et al., 1963; Reed & Reitan, 1969; Reed et. al.,1965; and Reitan, 1974. This general depression of cognitive functioning is likely to be the result of the fact that children do not have certain learned skills already firmly established. Those children over 11 years of age with neurological dysfunction display a greater discrepancy from normals on higher-level language and motor functions than do younger children. In summary, Boll in 1981 noted that it is more difficult to localize the brain damage in children than adults even though the Halstead-Reitan has been shown to have much validity and reliability in diagnosing brain damaged children. (Dean, R. C. & Gray, J. W. 1990)

In a study by Morris and Bigler in 1985, the Halstead-Reitan (of which the Trail Making is a part) also was employed to assess the relationship between the Kauffman Assessment Battery for Children, (K-ABC) and the WISC-R. The study was completed to determine hemisphere functioning in brain-injured children at a neurology clinic. The children, in addition to the neurological testing, were given computed axial tomography (CAT) scans and electroencephalograms (EEG's). Based on the neuropsychological test results, computed scores were computed for right and left hemisphere functioning. These scores were correlated with WISC-R and scores from the K-ABC. The study concluded that the K-ABC was more highly related to right hemisphere or simultaneous processing and left-hemisphere or sequential processing than the Weschler. It was also concluded that the WISC-R was not able to significantly diagnose right-hemisphere dysfunction. This study demonstrated the benefits of neuropsychological testing to validate other tests. (Kamphaus, R.W. Kaufman, A.J., Harrison, D. L. 1990)

Additionally, the Halstead-Reitan Battery in a study by Reitan in 1974 was given to 112 adult patients. The battery correctly predicted eighty-nine percent of the focal lesions, ninety-six percent of the diffuse lesions and sixty-six percent of the focal lesions in the proper area of the brain. During the same year, Reitan again repeated the same study to children. He employed the WISC and over a dozen other tests. He found that the WISC-Full Scale was the best discriminator between brain-injured and normal children. This was followed by the WISC-Verbal IQ, a speech making test, the Trail Making Test, the Seashore, finger tapping, and time sense. The results were not as impressive with the children probably because the normal children had an IQ around 100 and the brain-injured had a mean IQ of 78. This would explain why the WISC-Full Scale was the most sensitive test and raised the question as to whether any of Reitan's battery would be sensitive to the problems of LD children who have normal intelligence.

In another study by Reitan and Boll in 1973, a control group of children with an IQ of 110, a minimal brain damage group (MBD) with behavior problems with an IQ of 107, and an LD or Learning Disabled group with a mean IQ of 100 were compared. Results indicated that there was no significant difference between the LD and the MBD group on the Reitan battery except for Verbal and Full-Scale IQ and no differences between the MBD and control group on all the variables except for Verbal IQ. Thus, the results confirmed that the Reitan Battery is not very effective in diagnosing MBD from LD children. (Johnson, C.1981)

Although many batteries have been offered for neuropsychological testing, the Halstead-Reitan (HRNTB) remains the most widely used and researched measure in North America according to Seretny and other researchers in1986. The battery, developed originally by Halstead in 1947 was created to operationalize his theory that biological intelligence exists. However, its present form is due more to the efforts of Ralph Reitan in 1955. Halstead originally had a collection of 27 measures that were decreased to 10 by Reitan in 1955. These 10 were determined to be the best to discriminate between normals and those with definitive neuropathology. In order to achieve the definitive final ten tests, Reitan employed extreme quantitative values in which individual results were included only after there was a sufficient amount of evidence for the incremental validity of those measures in the differential diagnosis of the various forms of brain damage. He published his results in 1974. This allowed for the battery to be more sensitive to cortical dysfunction. However, the procedures that Reitan employed to increase the sensitivity to cortical dysfunction also compromised the use of the HRNTB to assess such areas as abstract reasoning. (Dean, R. J. & Gray, J.W. 1990)

Presently, the benefits of neuropsychological testing have become evident in many diverse facets of life. Baseline neuropsychological testing is now completed on athletes. This testing began on professional teams and it is spreading to colleges and high schools. A definite need for this testing exists due to the fact that 300,000 traumatic sports related brain injuries occur a year. The benefits of the neuropsychological testing are many. Baseline testing identifies individual differences in order to gauge head injury effects. It provides early evidence of symptoms immediately following concussions. It also prevents players from hiding the symptoms of the injury. The testing also provides for follow-up evaluations. The testing assists the physician in determining when and if the athlete can return to play. Finally, the long-term effects of multiple concussions can be assessed. Thus, neuropsychological testing has been found to be a valuable tool to assist the physician in determining when an athlete can return to play. (Schnirring, L. 1998)

In support of the value of neuropsychological testing, a study involving 393 athletes from four university football teams across the United State was completed. Baseline evaluations were performed between May 1997 and February 1999. Subjects who had subsequent football related concussions also underwent a neuropsychological comparison with matched control athletes from within the sample. Measures employed were a clinical interview, neuropsychological testing, one of which was the Trail Making Test Form B, concussion symptoms, and scale ratings at baseline and after the concussion. Results of the study concluded that neuropsychological assessments could be useful in evaluating cognitive functioning in athletes. Additionally, the study also concluded that both listing of multiple concussion and learning disabilities are associated with reduced cognitive performance. It was also concluded that there is an additive effect between learning disabilities and concussions. Thus, those athletes already having a learning disability with 2 or more concussions performed in the brain-impaired range of functioning. Thus, the use of neuropsychological testing can give objective information as to when, and if, an athlete should return to play. (Collins, M.W. et. al. 1999)

Neuropsychological testing was also completed on amateur soccer players to determine its usefulness in relating evidence of chronic traumatic brain injury. This is the additive effect of long-term neurological consequences of repeated concussions and sub concussive blows to the head. This impairment previously has been found in retired active and professional soccer players. The results of the study indicated that participation in amateur soccer in general and concussions specifically are related to impaired performance in memory and planning functions. The findings suggested that participation in amateur soccer " may" be associated with chronic traumatic brain injury as evidenced by the impaired performance in memory and planning. (Matser,E.J.T. & Kessels, A.G.1999)

Besides the area of sports, neuropsychological testing has been found to be useful in other areas involving children with particular problems. Children whose mothers abused alcohol during their pregnancy but who did not display the physical features of Fetal Alcohol Syndrome versus children who had no alcohol exposure were tested. Children were placed in groups such as the control group with no alcohol exposure, a Fetal Alcohol Syndrome group that had alcohol exposure and obvious facial abnormalities, and the third group which had alcohol exposure and no facial abnormalities. Results indicated that both the Fetal Alcohol Syndrome group and the group with alcohol exposure were impaired on tests of language, fine motor speed, and visual-motor integration. Here, again, neuropsychological testing can be valuable in assessing impaired cognitive functions even when obvious abnormalities are not present. (Mattson, S.N., Riley, E. P., Jones, K.L., Delis, D.C. 1998)

In a study conducted by Taylor & Schatschneider (1992), two "working assumptions" in regard to neuropsychological assessment were studied. The study included 127 post meningitis children who were recruited from three major Canadian children's hospitals between 1972-1989. The children were between 6 and 17 years of age. Ninety-seven controls were included in the study but the study focused on the children who had had meningitis and their variations of neurological insult. Neurological tests were then administered on the children.

Results of the study indicated that neuropsychological measures can be useful in their sensitivity to assess neurological results. Additionally, the results revealed that neuropsychological skills are generally a better predictor of learning or behavior than the WISC-R Verbal IQ and Performance IQ. Finally, the study revealed the need for more critical appraisal of neuropsychological assessment. The tools of neuropsychological assessment can be valuable as the assessment of cognitive functioning in behavior and learning and in treatment decisions. (Taylor, G. & Schatschneider, C. 1992)

In another study specifically involving children with learning disabilities, research was done to assess cerebellar deficient through cognitive testing assessed through fine motor skills in children with learning disabilities. The study included 57 children with learning disabilities and 67 control children. The children were given a battery of neuropsychological tests. The study concluded that there is support for learning disabilities and cerebellar dysfunction anomalies. The results also suggest strongly that the cerebellar structure is one of the key structures involved in dyslexia. Thus, from the study, one can hypothesize that cerebellar tests when used with established tests for learning disabilities can identify those children at risk for educational failure. (Faucett, A.J.& Nicholson, R.I. 1999)

In another study, the construct validity of a few neuropsychological tests was evaluated. The study consisted of 117 community living persons who were either self-referred or referral from a state department of rehabilitation services. Ages ranged from 18-61 years. Groups included in the study ranged from normal children, to head injured and learning disabled, to various other brain disorders. A battery of tests was given to the clients. The tests included the Halstead-Reitan, which included Trails Making Test Parts A & B, WAIS R, Visual Search and Attention Tests and the Paced Auditing Serial Addition Task. Results revealed two noteworthy dimensions of the neuropsychological fundamentals. Low and moderate correlations were found to be present among the measures. The fixed dimension included mental processes, and psychomotor speed along with focused attention. The second dimension reflected abstract conceptual processing. The first factor accounted for 50% of the variance between them. The second factor accounted for 20% of the variance. Results also concluded that attention and conceptual ability could not be interchanged. All tests correlated significantly with the full scale IQ. In conclusion, the measures all reflected the constructs of "attention" and "conceptual ability". (O'Donnell, J.P., MacGregor, L.A., Dabrouski, J.J., Oestreicher, J. M., Romero, J. J. 1994)

Additional research pertaining to neuropsychological testing and learning disabled children was completed by Sarazin and Spreen over a period of 15 years on 133 Learning Disabled subjects, and for subgroups with hard neurological signs and without neurological findings. Results revealed high and significant correlation coefficients between time one (mean age 10 years) and time two (mean age 25 years) even though for some tests, a change from the children's to the adult version occurred. At the time of the original assessment three diagnostic group were defined on the basis of the neurological examination:

1) Those with definite neurological indications of brain damage.
2) Those with minimal brain dysfunction as indicated by one or more "soft" signs.
3) Those learning disabled children without any neurological indication of brain dysfunction.

The retesting of learning disabled subjects provided an opportunity to evaluate IQ test performance and neuropsychological performance over time. Psychometric intelligence did not seem to be as significant a prognostic indicator of stability of scores since the less stable or learning-disabled group was the one with the best intellectual level. However, neurological absence or presence may be more critical. While neurological signs persisted in two of the groups, BD (brain dysfunction) and MBD (minimal brain dysfunction), the learning disabled group was free of neurological signs at time one but present later on in life.

The results revealed that there is a persistence of neuropsychological deficits as the child matures from middle childhood to adulthood. Additionally, the children with MBD should have poor outcomes as compared to those without any evidence of brain damage (LD) but better outcomes than the group with definite neurological impairment (BD). Findings also were consistent with the idea that subjects with organicity show less improvement and persistent difficulties in later life. (Sarazin, F. A. & Spreen, O. 1986)

In a study by Fitzhugh-Bell, Gridley, and Williams (1992) on "Cluster Analysis of Children and Adolescents with Brain Damage and Learning Disabilities Using all Three Variables of Neuropsychological, Psychoeducational, and Sociobehavioral", the study concluded that there is a need for future research which includes other behavioral measures in addition to the psychoeducational and neuropsychological variables. Employing a greater number and variety of these variables would enhance the results according to the study. The study went on to support the contention that there may be parallels that exist in cerebral function and/or structure that involves the nervous system. (Fitzhugh-Bell, K., Gridley, B.E., & Williams, D.L. 1992)

In another study by Bigler, Lajiness-O'Neill and Louise Howes (1998) it was concluded after looking at various forms of brain evaluations by the CT, EEG and PET, that even though progress has been made and some consistent patterns have begun to evolve in the assessment of learning disability with the aforementioned technologies, many challenges remain with neuroimaging and neurophysiological and metabolic imaging techniques. The study went on to conclude that LD has been unable to be diagnosed utilizing present technological methods. (Bigler, E.D., Howes, N., & Lajiness-O'Neil, R. 1998)

In an interview regarding the history of learning disabilities and central nervous system dysfunction by Hynd, Marshall, and Gonzalez (1991), a study of the postmortems of individuals with dyslexia was performed in order to determine if there was a direct relationship between brain morphology and severe reading disabilities. It was found that most of the brains were asymmetrical favoring the left side, mainly the inferior frontal, superior temporal and parietal regions. The study found that in the dyslexic population, symmetry was found with a greater frequency. The study also noted that it couldn't be concluded that all learning disabilities are due to central nervous dysfunction. However, research on dyslexia suggests that there is a potential for investigation with other forms of learning disabilities. Additionally, postmortem and neuroimaging studies provide support for the historical conceptualization that severe learning disabilities are indeed due to neurological factors that originate in early development. (Hynd, G. W., Marshall, R., & Gonzales, J. 1991)

Results indicated that neurological measures could be useful in their sensitivity to assess neurological results. Additionally, neuropsychological performance varies independently of the child's social-familial status. The study also supported psychological validity. Neuropsychological skills were found to be a better predictor of learning on behavior than the WISC-R Verbal IQ and Performance IQ. The findings supported the need to assess multiple abilities in addition to IQ. In addition, the study supported further follow-up in regard to neuropsychological assessment. Neuropsychological assessment can be valuable in assessment of cognitive functioning in behavior and learning and in treatment decisions. (Taylor, G. & Schatschneider, C. 1992)

In another study by Rourke and Conway (1997) current research on the brain-behavior connection pertaining to a learning disability was reviewed in the area of Arithmetic Learning Disabilities. As a result of their research, they found evidence in support of two types of children with learning disabilities who exhibited equally impaired levels of functioning in arithmetic but very different neuropsychological profiles. One group displayed left-hemisphere or (nonverbal) learning disabilities. Additionally, they found distinctively different patterns of neuropsychological assets and deficits that are present in an arithmetic disability. It was also a supposition that the nonverbal learning disability group could be exhibiting the results of a cumulative effect of developmental events that have been disrupted which in turn skewed the normal course of cognitive development. (Rourke, B. P. & Conway, J. A. 1997)

Specifically, the Trail Making Test Parts A and B has been employed in testing to determine if the test could identify lesions in the frontal lobe. The Trail Making Test Parts A and B has been found to have both validity and reliability in determining organicity. In this particular study, two neuropsychological tests were chosen, the Category Test and the Trail Making Test.

The study consisted of 32 individuals with frontal lobe lesions and 32 subjects with nonfrontal lesions. Both groups were given the Category test and Trail Making Test Parts A + B. However, only the results of part B were analyzed. Results indicated that there was no significant difference on performance of persons with frontal and non-frontal lesions in either the Category test or Part B of the Trail Making Test. However, both tests do measure functioning of the entire cerebrum. Thus, from the study, the Category Test and the Trail Making Test Part B can provide important information about an individual's cognitive ability since they are sensitive to the neuropsychological aspects of brain functioning. (Reitan, R.R. & Wolfson, D. 1995)

Davids, Goldberg, and Laufer in 1957 gave the Trail Making Test to three groups of children. The groups were normal, cerebral-palsied with brain damage and emotionally disturbed children. All children were matched for age, sex and IQ. Results indicated that the test correlated well with IQ. There was also a significant difference between all three groups with the normal children doing the best, followed by the emotionally disturbed, and finally the brain-damaged. Camp in 1965 gave the Trail Making Test to a large group of nine to fifteen-year old children who being seen at a children's diagnostic center. They then published norms for this test by IQ level. However, they were not able to determine if this test could distinguish brain-injured children from normal ones. (Johnson, C. 1981)

In summary, much research has been completed in both neuropsychological testing in general and the specific area of learning disabilities in adults and children as well as the specific neuropsychological test, Trail Making A and B.

Bibliography

Bigler, E.D. Howes, N., & Lajiness-O'Neill, R. (1998). Technology in the assessment of learning disability. Journal of Learning Disabilities, 31 (1), 67-82.

Collins, M.W., Grindel, S. H., Lovell, M.R., Dade, D. E., Moser, D.J., Phalin, B.R., Nogle, S., Wasik, M., Cordry, D., Daugherty, M.K., Sears, S.F., Nicolette, G., Indelicato, P., and McKeag, D.B., (1999), "Relationship between concussion and neuropsychological performance in college football players", JAMA, September, 8, Volume 282, Number 10.

Dean, R. S. & Gray, J. W. "Traditional approaches to neuropsychological assessment " In Reynolds, C. R. and Kampheus, R. W. (EDS). Handbook of psychological and educational assessment of children, children intelligence and achievement. (pp. 377-381). New York: Guilford Press.

Faucett, A. J., Nicholson, R. I. (1999). "Performance of dyslexic children on cerebellar and cognitive tests." Journal of Motor Behavior, Volume 31, Issue 1, pp.68-79.

Fitzhugh-Bell, K., Gridley, B.E., & Williams, D.L. (1992). Cluster analysis of children and adolescents with brain damage and learning disabilities using neuropsychological, psychoeducational, and sociobehavioral variables. Journal of Learning Disabilities, 25, 290-299.

Hynd, G.W. Marshall, R., & Gonzales, J. (1991). Learning disabilities and presumed central nervous system dysfunction. Learning Disabilities Quarterly:Journal of the Council for Learning Disabilities, 14, 283-296.

Johnson, C. (1981) " The medical and neurological diagnosis" The diagnosis of learning disabilities. (pp. 224-227). Boulder, Colorado: Pruett Publishing Co.

Kampheus, R.W., Kaufman, A. S., Harrison, P. L. "Clinical Assessment Practice with the Kaufman Assessment Battery for Children (K- ABC)". In Reynolds, C.R., and Kampheus, R. W., (EDS.), Handbook of psychological and educational assessment of children, children intelligence and achievement. (p. 268). New York: Guilford Press.

Kauffman, J.M., & Wallace, G. (1973). Teaching Children with Learning Problems. Columbus, Ohio: Merrill Publishing Company.

Lerner, J. (1993). Learning Disabilities: Theories, Diagnosis, and Teaching Strategies. Boston, MA:Houghton Mifflin Company.

Okkema, K. (1993). "Evaluation of cognition and perception: overview of occupational therapy practice." & "Cognitive evaluation guide." Cognition and perception in the stroke patient (pp.27-28 & pp145-146) . Gaithersburg, Maryland: Aspen Publication.

Matser, E. J. T., and Kessels, A. G. (1999). "Neuropsychoogicial impairment in amateur soccer players", JAMA, September, 8, Volume 282, Number 10.

Mattson, S.N., Riley, E.P., Jones, K.L., Delis, D.C., (1998). "Neuropsychological comparison of alcohol-exposed children with or without physical factors of fetal alcohol syndrome." Neuropsychology, Volume 12, Number 1, pp. 146-153.

O'Donnell, J.P., MacGregor, L.A., Dabrouski, J.J., Oestreicher, J. M., Romero, J. J. (1994). "Construct validity of neuropsychological tests of conceptual and attentional abilities." Journal of Clinical Psychology, July, Volume 50, Number 4, pp. 596-600.

Reitan, R. R., and Wolfson, D. (1995). "Category test and Trail making test as measures of frontal lobe functions." The Child Neuropsychologist Volume 9, Number 1, pp. 50-56.

Rourke, B. P. and Conway, J. A. (1997). "Disabilities of arithmetic and mathematical reasoning: perspectives from neurology and neuropsychology", Journal of Learning Disabilities, 30(1), pp. 34-46.

Sarazin, F.A.and Spreen, O. (1986). "Fifteen year stability of some neuropsychological tests in learning disabled subjects with and without neurological impairment." Journal of Clinical and Experimental Neuropsychology, Volume 8, Number 3, pp. 190-200.

Schnirring, L. (1998), ":Baseline Neurologic Testing Grows." The Physician and Sports Medicine, Volume 26, Number 7, July, pp. 13-15.

Taylor, G. and Schatschneider, C. (1992). "Child neuropsycholoical assessment: A test of basic assumptions", The Clinical Neuropsychologist, volume 6, Number 3, pp. 259-275.