AN INVESTIGATION OF COGNITIVE MEASURES OF ELEMENTARY STUDENTS IDENTIFIED AS HAVING A SPECIFIC LEARNING DISABILITY

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To the Dean of the Graduate School:

I am submitting herewith a dissertation written by Lynda M. Nielsen entitled "An Investigation of Cognitive Measures of Elementary Students Identified As Having A Specific Learning Disability". I have examined this dissertation for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy with a major in Special Education.

Jane Pemberton

Jane Pemberton, Ph.D., Major Professor

We have read this dissertation and recommend its acceptance:

Associate Dean, College of Professional Education

Accepted:

Jennifer Martin

Dean of the Graduate School

DEDICATION

This dissertation is dedicated to my mother, Clyde F. Maxwell, Ed. D. 1927 – 1996, who believed that education is lifelong, beginning with the ability to read. A unique individual whose acceptance of others was unconditional, she possessed a wonderful gift for inspiration. She would express her unflagging confidence and belief in others with such heartfelt conviction that any self-doubt was immediately banished in the face of her relentless reassurance. Her incredibly positive attitude and enjoyment of life helped family, friends and colleagues to not only grow and develop, but to find peace and perspective in the process.

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ABSTRACT

LYNDA M. NIELSEN

AN INVESTIGATION OF COGNITIVE MEASURES OF ELEMENTARY STUDENTS IDENTIFIED AS HAVING A SPECIFIC LEARNING DISABILITY

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The Individuals with Disabilities Education Improvement ACT of 2004 (IDEIA; 2004) regulations makes provisions for the use of a pattern of cognitive strengths and weaknesses to identify students with a specific learning disability. The assessment batteries, WJ-III COG and the WJ-III ACH, provide cluster scores for cognitive processing abilities and achievement which can be interpreted both normatively and ipsatively to determine a pattern or profile of abilities. The purpose of the study was to determine if students who identified using a pattern of strengths and weaknesses with a deficit in reading, displayed a specific pattern of cognitive abilities.

Participants were students who had been identified with a learning disability through interpretation of a pattern of cognitive strengths and weaknesses. A total of 55 students met the criteria of the study: students were in first, second, or third grade; assessment using required 7 subtests of the WJ-III COG*; an identification of a reading deficit as evidenced by the reading components of the WJ-III ACH test; and an initial identification of a learning disability. *Comprehension-Knowledge (*Gc*), Long-Term

Retrieval (*Glr*), Visual-Spatial Thinking (*Gv*), Auditory Processing (*Ga*), Fluid Reasoning (*Gf*), Processing Speed (*Gs*), and Short-Term Memory (*Gsm*).

Multiple regression analysis was used to evaluate the predictive abilities of the cognitive cluster scores. Only *Gf* was determined to be predictive of the reading ability, reading comprehension (Beta =.503, p=.006). Correlational Analysis found moderate correlations between the COG tests of *Gf, Gc* and *Gsm* and the ACH tests of Basic Reading Skills (BRS) and Reading Comprehension (RC). The percentage of students making scores less than 85 on a cluster was greatest for *Gsm* (70%), *Glr* (69%), and *Gc* (50%), indicating that most students were identified with at least one of these scores as a normative deficit. Subtests scores (or narrow abilities) which demonstrated a moderate correlation with reading scores were: Verbal comprehension, Visual Auditory Learning, Concept Formation, General Information, Auditory Attention and Analysis Syntheses (for RC only).

Results of independent sample *t* tests indicated that there were no differences in gender among scores of cognitive abilities. Grade level differences indicated a significant difference between third grade *Glr* scores and first grade *Glr* scores. Scores related to ethnicity showed significant differences in *Gc, Gf* and *Gsm* between Caucasian students and student who were either Hispanic or African American.

This study demonstrates that *Gf* may be predictive of reading ability in the area of reading comprehension, but *Gsm, Glr* and *Gc* may be the most importance factors to consider when determining the student's needs for instruction and remediation.

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CHAPTER I

INTRODUCTION

For almost a century, intelligence assessment has been an integral component in the determination of educational placement and programming for students who exhibit academic deficits (Fiorello, Hale, Holdnack, Kavanagh, Terrell & Long, 2007). Advances in the theoretical concepts of intelligence led to further research designed to define areas of cognitive processing abilities. This research has driven the development of assessment instruments that, more specifically, identify and measure cognitive processing abilities. Consequently, current evaluations of cognitive ability provide standardized information on a range of intellectual abilities, which is in contrast to relying on a single or global score representative of ability or an intelligence quotient (IQ).

Multiple broad cognitive abilities have been identified and each is constructed using qualitatively different narrow abilities. Factor or cluster scores are computed for each broad ability and reported as a standardized measurement. The resulting cluster scores from this information have become a fulcrum for making decisions regarding student identification and eligibility for services in special education. However, controversy persists related to the analysis of these test scores (Floyd, Keith, Taub, & McGrew, 2007; Fiorello, et al., 2007; Mather & Kaufman, 2006; Johnson, Humphrey, Mellard, Woods, & Swanson, 2010).

Among leaders in the field, there is a lack of consensus on the acceptable use of cognitive assessment (Fiorello, Hale, & Synder, 2006; Flanagan, Fiorello, & Ortiz, 2010; Fletcher, Francis, Morris & Lyon, 2005; Johnson, et al., 2010; Fiorello, et al., 2007; Torgesen, 2001b; Gresham & Vellutino, 2010). Much of the debate centers on how populations of students are defined and the interpretation of empirical data (Benson, 2003). At the center of much of this disagreement is the identification of students with learning disabilities and the question of whether profiles or patterns of cognitive abilities exist that can be used to identify students with learning disabilities (Evans, Floyd, McGrew, & Leforgee, 2001; Fiorello, et. al, 2007; Fiorello, et al., 2006; Naglieri & Paolitto, 2005).

The expression 'pattern of strengths and weaknesses' was found throughout the literature to describe an uneven acquisition of academic skills based on a weakness in cognitive processing abilities (Evans, et al., 2001; Flanagan, et al., 2010; Hale et al., 2010; Smith & Watkins, 2004). Researchers describe unexpected underachievement as an identifying marker when describing the construct of specific learning disability (SLD) (Flanagan et al., 2010; Fletcher, Lyon, Fuchs, & Barnes, 2007). The term intra-individual has been used by researchers to describe the concept used when examining test scores that may reflect differences within the individual's intellectual abilities. Each cognitive ability is assessed and reported as a standard score (Schrank, Flanagan, Woodcock, & Mascolo, 2002). Whether the differences between scores are significant is determined by using a statistical method of analysis. One standard deviation or more below the mean is the most frequent interpretation of a score that identifies a deficit or weakness.

Flanagan and colleagues (2010) described Naglieri's use of a pattern of strengths and weaknesses to identify students with a SLD. Naglieri proposed that students should be evaluated:

> with the goal of uncovering weaknesses that are consistent with the concept of disorder – that is performance in one or more processes is weak relative to both the individual and the norm group. Moreover, the child's cognitive processing weakness(es) must be consistent with his or her academic weakness(es), and the child must also demonstrate cognitive processing strengths (i.e., significantly better performance in certain cognitive processes as compared with those that are weak. (p.742)

The recent reauthorization of the Individuals with Disabilities Education Improvement Act (IDEIA, 2004) mandated that the provision of a pattern of strengths and weaknesses may be used to determine the existence of a learning disability. When identifying a learning disability, educators now have the option of interpreting a student's assessment scores by determining whether the scores indicate a pattern of cognitive strengths and weaknesses. This stipulation in the law also mandates that the use of a discrepancy model (ability – achievement discrepancy) is no longer required in the identification of learning disabilities.

Hanson, Sharman, and Esparza-Brown (2009) presented three research-based models that describe patterns of strengths and weaknesses, which can guide local education agencies (LEAs) in establishing the criteria for identifying a student with a learning disability. All three models are based on the same four general principles. First, use of the full-scale IQ is not a useful point of reference unless deducing the criteria for mental retardation (intellectual disability). Second, students with an identification of a learning disability have a pattern in which most academic skills and cognitive abilities are within the average range. Third, these students have isolated (unexpected) weaknesses in both academic and cognitive functions. The deficits in cognitive processes are aligned with specific areas of academic concern. Fourth, cognitive abilities that do not relate to the area of academic concern are average or above. This is consistent with the guidance provided to Local Education Agencies (LEA) by the Texas Education Agency (TEA). While the TEA provides parameters for using a pattern of strengths and weaknesses to identify SLDs, LEAs determine the specific procedures used as part of their assessment practices (see Appendix A).

Since regulations regarding IDEIA (2004) have been implemented at the LEA level, students identified as having a learning disability may also have been determined to exhibit a pattern of cognitive strengths and weaknesses. As part of this identification process, a deficit in a cognitive ability has been linked with lack of achievement in an academic area.

The intent of this study is to determine if students with a learning disability who demonstrate normative deficits in reading exhibit a specific pattern of cognitive abilities. This study was designed to analyze cluster scores from cognitive assessments used as the criteria for determining a learning disability in a suburban school district in Texas.

Statement of the Problem

Is it possible to identify a specific pattern of cognitive strengths and weaknesses as indicated by standard scores for students who are identified as having a learning disability in the area of reading? Cognitive assessment is typically a major component of a full individual evaluation when a referral in made to determine if a student has a learning disability. How the results of these cognitive assessments should be interpreted has been the focus of much professional discussion and theoretical research. Multiple studies have attempted to define specific cognitive patterns that consistently reflect deficits in an academic disability.

The IDEIA (2004) included the use of a pattern of strengths and weaknesses as a method for identifying a learning disability and the TEA endorsed this method for interpreting test results (Texas Education Agency, 2007). LEAs have a variety of test batteries available for student assessment, many with the ability to measure identified cognitive processing areas. The scores calculated by using these assessments can provide a framework to determine if normative cognitive weaknesses are present and can be analyzed to determine the *intra* cognitive strengths and weaknesses of an individual.

Compared to early investigations of cognitive profiles, the most significant difference in this study is that a pattern of strengths and weaknesses within cognitive cluster scores has already been utilized as a criterion to identify students with a learning disability. Student's cluster scores were analyzed to determine whether similar patterns of cognitive processing were evidenced by the population of students identified with a learning disability. The purpose of this study was not to determine how students with a learning disability differ from typically performing students, but instead to determine whether there is uniformity of cognitive processing deficits when a pattern of cognitive strengths and weaknesses is required in the identification of a learning disability. While an intra-cognitive discrepancy procedure was used to identify each individual, the question was whether those discrepancies were consistent or similar at a significant level across students who were identified with a learning disability.

Purpose of the Study

The purpose of this study was to investigate whether elementary school students who had met the eligibility criteria for special education, due to both a learning disability and demonstrated deficits in the area of reading, exhibited a pattern of cognitive skills defined by the Cattell-Horn-Carroll (CHC) theory as strengths and weaknesses (Evans, et al., 2001). Research on theories of cognitive profiles or patterns has yielded conflicting results regarding the validity of such profiles in the identification of students with learning disabilities. This study used the research-based construct of cognitive ability as defined by the CHC theory and the definition of a learning disability as defined by both the Federal Statues and by the state of Texas to investigate further the theory of cognitive patterns.

Research Questions

1. Can a cognitive profile, as identified through cluster scores, be predictive of a learning disability in elementary age children who demonstrate reading deficits?
2. Is there a CHC subtest pattern for elementary students identified with a learning disability who demonstrate reading deficits?
3. Is there a gender difference in the CHC profile for students who are identified with a learning disability and a deficit in reading?
4. Is there a grade level difference in the CHC profile for identified students who are identified with a learning disability and a deficit in reading?

Significance of this Study

This study provides additional documentation for current research related to patterns of cognitive processing abilities and the relationship to identification of learning disabilities. The possible identification of a specific pattern of strengths and/or weaknesses of cognitive abilities that aligns with academic achievement in the area of reading could provide tools for educators to use when determining appropriate instruction. The discovery of predictable patterns of cognitive abilities may lead to the development of a method to screen elementary students who are not responding to evidence-based practices of reading instruction. The utilization of patterns of cognitive abilities has the potential to promote increased accuracy in the assessment process as well as in the design of individualized education programs that enhance the ability to tailor instruction to students with reading deficits.

Limitations of the Study

This study presented at least four limitations:

1. The state of Texas provides for an identification of dyslexia under the 504 provision of the Americans with Disabilities Act (Americans with Disabilities Act of 1990 42 U.S.C. §§ 12101 *et seq.*). Because of this alternative method of identifying and providing services for students with dyslexia, those students are not consistently evaluated or served through special education in the state of Texas. Therefore, students with an identification of dyslexia may or may not be included in the population of students evaluated and identified with a learning disability. This study, if conducted in a state without such a division in the resources provided for students who demonstrate reading disabilities, may offer different results.
2. Not all students who were identified with a learning disability and qualified in the area of reading during the time period when the data for his study was gathered had been administered the full Woodcock-Johnson Cognitive Assessment, Third Edition (WJ-III COG) (Woodcock, McGrew, & Mather, 2001b) and the Woodcock-Johnson Achievement Test, Third Edition (WJ-III ACH) (Woodcock, McGrew, & Mather, 2001a). Students who had not been administered the full assessment did not meet the criteria for this study and were not included in the

analysis. The smaller number of students who met the criteria for this study was not representative of the total number of students identified using a pattern of strengths and weaknesses.

3. Although it is assumed that assessments were administered and interpreted with fidelity, the researcher had no control over the accuracy or interpretation of the available data used in this study.
4. This study does not compare scores obtained by students identified with a learning disability to students considered to be typically performing.

Definition of Terms

Cattell-Horn-Carroll (CHC) Theory: CHC is a three-level model of human cognitive abilities that includes General Intelligence 'g', nine broad cognitive abilities, and more than 100 narrow cognitive abilities. See Appendix B for descriptions of all broad and narrow cognitive abilities as defined by CHC.

Cluster analysis: Cluster analysis is a statistical technique that is exploratory and reductionistic in nature. This procedure allows the researcher to identify natural grouping in data, which suggests the occurrence of specific and unique samples (Gay, Mills and Airasian, 2009).

Cluster scores: Derived from factor analysis and thought to represent an underlying trait or ability (of general intellectual ability), these scores are the statistical computation that result from the administration of two or more subtests that provide narrow measures of that ability. Factor analysis is a way to take a large number of variables and group them into a smaller number of cluster called factors. Factor analysis computes the correlations among all variables and then derives factors by finding groups of variables that are correlated highly among each other but weakly with other variables. The factors identified, rather than the many individual items within the factors, are then used as variables. Factor analysis produces a manageable number of factor variables to deal with and analyze (Gay, et al., 2009).

Discrepancy model or method: The discrepancy model resulted from the original regulations guiding the identification of students with a learning disability. This method required the determination of a *severe discrepancy* between the student's ability (usually assessed by an IQ score) and the student's level of academic functioning. Severe discrepancy was generally interpreted as one standard deviation below the norm.

'*g*' (general intelligence) factor: Charles Spearman, in 1904, proposed '*g*' as the factor that stands for *general intelligence*. It is a measure of mental ability and includes *the ability to learn*. It is considered the vertex of a hierarchy of wide range of cognitive abilities (Floyd, McGrew, Barry, Rafael, & Rogers, 2009; Lubinski, 2004).

Global score: A global score is thought to reflect global intellectual ability, 'g'. This score is considered the overall mental capacity of an individual and has the highest correlations to general achievement.

Intra-individual: Is used in the literature in two different comparisons. In the original regulations that governed the determination of a learning disability, intra-individual described the comparison between a student's intellectual ability and actual achievement levels. Currently, and for the purposes of this paper, the term intra-individual describes any differences within an individual's cognitive or processing abilities.

Ipsative score: An ispsative score is described by Drossman, Maller, and McDermott (2001) as "a statistically significant difference between an examinee's individual subtest score and personal mean across subtests as a strength or weakness" (p. 58).

Learning disability: The term *specific learning disability* means a disorder in which one or more of the basic psychological processes involved in understanding, or in using spoken or written language, may manifests itself in the imperfect ability to listen, think, speak, read, write, spell, or perform mathematical calculations. This term includes conditions such as perceptual disabilities, brain injury, minimal brain dysfunction, dyslexia, and developmental aphasia. Such term does not include a learning problem that is primarily the result of visual, hearing, or motor disabilities; of mental retardation; of emotional disturbance; or of environmental, cultural, or economic disadvantage (IDIEA, 2004). Although, Specific Learning

Disability is included in the title of this investigation, for the purpose of this paper specific learning disability (SLD) and learning disability (LD) are used interchangeably as referenced by various authors and the era represented.

Pattern of strengths and weaknesses: When a cognitive assessment battery has been administered that measures multiple intellectual abilities, a pattern is determined when within an average profile of scores there is one or more significant cognitive weakness as measured by standard scores.

Profile analysis: The method of determining an individual's strengths or weaknesses based on subtest scores of an intelligence test The analysis of patterns of scores was utilized to develop hypotheses about a child's cognitive functioning (Sattler, 2008, p. 366).

Qualifying areas for a learning disability in reading: Federal regulations identify three qualifying areas of reading for students identified with a learning disability. Basic Reading Skills, which include a measure of phonetic decoding and sight word recognition aligned with grade level norms; reading comprehension, which is a measure of the ability to understand the meaning of words and passages aligned with grade level norms; and reading fluency, which is a measure of rate and accuracy aligned with grade level norms.

Standard scores: A standard score is a calculation that expresses how far an individual student's test score is from the mean, in standard deviation units. The standard score reflects how many standard deviations a student's score is above or below the mean. A standard score is appropriately used when the test data are from an interval or ratio scale. The most commonly reported and used standard scores allow scores from different tests to be compared on a common scale through valid mathematical operations.

CHAPTER II

REVIEW OF LITERATURE

For more than 50 years, researchers have investigated the components or structure of formal cognitive assessment in an attempt to identify more precisely the cognitive processes that are related to deficits in academic achievement. One objective of the research was to determine if there was a pattern of cognitive strengths and weaknesses that was consistent among students with learning disabilities. These investigations have focused primarily on the relationship between cognitive abilities and the academic area of reading. Important to this research were the changes to recent federal and state laws and regulations as well as significant advances in identifying individual constructs of cognitive processing abilities that have been used to develop assessment instruments.

The purpose of this literature review was to identify research related to patterns of cognitive ability, present current theories regarding cognitive processing and the ability to isolate those factors that may have the most impact on academic achievement, and review research that identified components of reading and their relationship with cognitive processing abilities.

Historical Perspectives

By the early twentieth century, researchers in the field of education began to develop theories to explain why children with average abilities could not read. In 1962, Samuel Kirk first used the term learning disability, which he defined as:

> a retardation, disorder, or delayed development in one or more of the processes of speech, language, reading, writing, arithmetic, or other school subject resulting from a psychological handicap caused by a possible cerebral dysfunction and/or emotional or behavioral disturbances. It is not the result of mental retardation, sensory deprivation, or cultural and instructional factors (Swanson, Harris, & Graham, 2003).

Kirk's original definition of a learning disability was instrumental in creating a focus on the processing abilities of students who demonstrated unexplained deficits in achievement. National interest in Kirk's concept soon lead to federal legislation regarding students with learning disabilities (Swanson, et al., 2003) and the definition was incorporated in the *Education for All Handicapped Children Act* (EAHCA) of 1975 (Public Law [PL] 94-142). Since the implementation of EAHCA, 1975, the evaluation of a student's intelligence or cognitive ability has been an essential component in the process of identifying learning disabilities (Newton & McGrew, 2010).

In 1965, Barbara Bateman (Swanson, et al., 2003) proposed the following as a definition for learning disabilities: "Children who have learning disorders are those who manifest an educationally significant discrepancy between their estimated potential and actual level of performance related to basic disorders in the learning process…" (Swanson et al., 2003, p. 22). In 1977, regulations for the implementation of PL 94-142 to identify the presence of a learning disability were based on this interpretation

(Assistance to States for Education of Handicapped Children: Procedures for Evaluating Specific LD, 1977, p. 65083). This method became known as the discrepancy method.

The discrepancy method required a significant discrepancy between the student's intellectual ability (or IQ) and academic achievement in one or more of the following areas: oral expression, listening comprehension, written expression, basic reading skill, reading comprehension, mathematics calculation, and mathematics reasoning. The process of establishing a severe discrepancy involved the administration of individualized ability (intelligence) tests and academic (achievement) tests and a direct comparison of obtained standard scores. The student's age rather than grade level was generally used to compute these scores. Average standard scores usually extended from 90 to 110, with a mean (or average score) of 100. If the difference in scores was one or more standard deviations below the mean, the obtained IQ and achievement scores were compared to determine if a severe discrepancy existed between the two scores. If the difference in scores was a standard deviation or greater below the mean, the difference was determined to be significant. This interpretation of discrepancy became the formula and the primary method for identifying students with learning disabilities until IDEA was revised in 2004.

As increasing numbers of students who demonstrated deficits in academic achievement were identified as having a learning disability (Swanson et al., 2003), researchers questioned the criteria used to make this determination. Flanagan, Ortiz, and Alfonso (2007) suggested that the methods and procedures (referring to discrepancy methods) that had been used to determine SLDs lacked reliability and validity and that

"...methods purported to diagnose this condition have been distilled down to rote, simplistic clinical exercises that are neither psychometrically not theoretically justifiable" (p. 127).

In a white paper published in 2010, Hale and colleagues reported that literature had identified the following problems with the discrepancy method:

- uniform discrepancy application is insensitive to developmental differences in cognitive and achievement;
- unclear which IQ score should be used to establish "ability" for discrepancy calculation;
- difficulty with distinguishing between children with SLD and low achievers:
- inconsistent application of the approach across school, districts, and states;
- over-identification of student from diverse backgrounds;
- measurement problems that result in poor decision-making;
- early identification is unlikely although it is critical for ameliorating problems (a "wait-to-fail" model); and
- encourages "test and place" practices which are neither an accurate nor an effective use of resources (p. 227).

Dissatisfaction with outcomes of the discrepancy model and conclusions based on current and theoretically based research eventually culminated in revisions to the federal laws during the reauthorization of IDEIA in 2004. While the revision maintained the actual wording of previous definitions of SLD, regulations for implementation (published in 2006) included significant changes in the methods of determining eligibility for special education services as a student with a learning disability.

The most significant difference in determining eligibility was the removal of the significant discrepancy model as a requirement for determining a learning disability. The regulation includes: "the State—(1) Must not require the use of a severe discrepancy between intellectual ability and achievement for determining whether a child has a [SLD], as defined in §300.8(c)(10)" (Definition of Learning Disability and Regulations Supporting Discrepancy Model, 1977, p. 65083).

New regulations included a procedure for using scientific- and research-based interventions (Response to Intervention) to provide information for evaluations. In addition, the determination of a pattern of strengths and weaknesses in academic performance, achievement (or both), or intellectual development was now suggested as a component of the process of evaluating a student for a learning disability.

> (ii) The child exhibits a pattern of strengths and weaknesses in performance, achievement, or both, relative to age, State-approved grade-level standards, or intellectual development, that is determined by the group to be relevant to the identification of a [SLD], using appropriate assessments, consistent with §§300.304 and 300.305. (See Appendix C: Federal Determination of a Learning Disability).

These changes challenge school districts to determine the most appropriate methods of identifying students. To implement the current legal expectations, educators will require a knowledge and understanding of cognitive processing abilities and their relationship to deficits in academic achievement.

Early Research

Although not formally stated in the original definition of a learning disability, the concept of intra-individual differences was put forward by Kirk's explanation of individual functioning. Kirk noted that although an individual was functioning below average in some areas, he or she was functioning at average or above in other areas (http://www.nrcld.org/resources/ldsummit/kavale.pdf). This concept of student abilities moves beyond an ability-discrepancy model to a model where, as determined by cognitive assessment, weaknesses in core cognitive processes can be used to identify the source of academic underachievement (Fletcher et al., 2007).

Early research efforts to isolate profiles or patterns of strengths and weaknesses in students with learning disabilities relied on studies based on the theoretical concept of profiles suggested by Alexander Bannatyne. Bannatyne's theories on visual spatial dominance of the right hemisphere of the brain and his understanding of auditory-vocal processing and deficits led him to depart from the accepted verbal/performance dichotomy most often used by the Wechsler Intelligence Scale for Children (WISC) (Kaufman, 1981).

Bannatyne, in 1968, investigated the cognitive attributes of students with dyslexia by re-categorizing subtests of the WISC into three cognitive processing categories. The spatial score was the sum of scaled scores of Picture Completion, Block Design, and

Object Assembly. The conceptualization score was the sum of scaled scores of Comprehension, Similarities, and Vocabulary. The sequencing score was the sum of scaled scores of Digit Span, Picture Arrangement, and Coding (Lerner, 1971). Bannatyne hypothesized that those students with reading disabilities would consistently score higher on spatial tasks and lower on sequential tasks. A proposed pattern of scores reflecting Spatial >Conceptual>Sequential abilities was suggested by his findings.

Replication of Bannatyne's work (Gutkin, 1979; Henry & Wittman, 1981; Kaufman, 1981; Smith & Watkins, 2004) has occurred using a variety of student populations. Rugel (as cited in Henry & Wittman, 1981, p. 517) reported that Bannatyne's re-categorization of subtest patterns fit a broad spectrum of readers who were struggling. Rugel suggested that the validity of the re-categorized subtest scores could be improved if the Arithmetic subtest were substituted for the Picture Arrangement subtest in obtaining the Sequential score. Gutkin (1979) determined that the group means on re-categorized subtests for Caucasian children did follow a Spatial >Conceptual>Sequential pattern. However, a similar pattern was not evident for Hispanic children with learning disabilities.

Kaufman (1981) found that Bannatyne's re-categorization of WISC subtests were relevant to learning disability identification. He stated, "Although the groupings do not facilitate differential diagnosis, they still provide a convenient framework for understanding the" assets and deficits of a child with a learning disability (p. 522). He further suggested that future research should investigate homogeneous populations of students with disabilities, "especially in terms of the group's mode of processing information" (p. 523). Smith and Watkins (2004) suggested that additional research regarding the validity of Bannatyne's re-categorization pattern was necessary.

Henry and Wittman (1981) reported Bannatyne's pattern as evident on a group-wide basis, but not as a means to identify individual children. Vance, Wallbrown, and Blaha (1978) conducted a study to determine if it was possible to identify subgroups of children with reading disabilities based on similarities on the WISC-R profiles. Of 128 children who had been identified as "reading disabled," 104 of the students met criteria for the purpose of the profile analysis. Based on the results of this study, Vance and colleagues (1978) summarized that the Wechsler Intelligence Scale for Children – Revised (WISC-R) was "frequently useful in understanding the ability patterns of reading disabled children" (p.58). They reported that recent studies at that time of WISC-R profile analysis, while not confirming a single profile, suggested several different profiles. Although research results based on Bannatyne's model were inconsistent, there was some agreement that these studies promoted advancements in the identification of processing abilities related to learning disabilities (Bell, McCallum, & Cox, 2003; Kaufman, 1981; Vance et al., 1978).

Over time, the accuracy or value of Bannatyne's studies was refuted or reviewed negatively, (D'Angiulli & Siegel, 2003; Kaufman, 1981; McGrew & Flanagan, 1997; Watkins, 2003) as ongoing research determined that analysis of the scatter of IQ subtest scores was limited in its ability to identify diagnostic groups of students with a consistent pattern or profile of abilities. Watkins (2003) disputed the accuracy of profile testing with criticisms of statistical testing, reliability of groupings, small samples of convenience, impact of using scores over time, validity of using test scores both to identify and then profile, lack of comparison to typical groupings, and the use of ipsative measurement instead of normative measurement.

Advances in statistical applications, as well as changes in the theoretical constructs of newly developed tests of cognitive abilities, reduced ongoing WISC / WISC-R profile research. However, the relevance of profile analysis continues to be a controversial topic among professionals who provide test interpretations (Fiorello et al., 2007; Fiorello & Primerano, 2005; Fletcher, Francis, Morris, & Lyon, 2005; Machek & Nelson, 2010). Dehn (2008) defended the current practice of profile analysis with the acknowledgement that the revision of test batteries has increased their reliability. He further stated that profile analysis demonstrates more credibility when interpreted in conjunction with a normative analysis that compares the individual to the scores of same-aged peers. The major departure from identifying profiles or patterns of abilities from subtest scores has been the move toward the interpretation of clusters, as developed in conjunction with the CHC theory, instead of ipsative scores based on mean differences of subtest scores (Fiorello & Primerano, 2005).

CHC Theory

For the past two decades, psychometrically-driven research of cognitive ability resulted in the revision and construction of assessment batteries that provide a measure of multiple specific cognitive abilities (Dehn, 2008; Fiorello & Primerano, 2005; Newton & McGrew, 2010). As a result, cognitive ability is frequently interpreted as a function of multiple abilities in lieu of a single global (i.e., IQ) score.

The development of the CHC theory of cognitive abilities changed the landscape of intellectual assessment. CHC theory evolved from the research of Raymond Cattell, John Horn, and later, John Carroll (Flanagan et al., 2007; Sattler, 2008). Cattell and Horn put forward two types of intelligence, Fluid Intelligence and Crystallized Intelligence, or *Gf-Gc* Theory (Flanagan et al., 2007). Carroll's three stratum theory consisted of many narrow abilities, which combined attributes to form broad clusters, and a single factor of intelligence is represented by '*g*'. The decision to combine both theories of intelligence resulted in a model that provides a framework for examining cognitive functioning as defined by broad ability clusters (Flanagan et al., 2007).

The CHC model is described as a theory of intelligence that comprises nine broad abilities: Fluid Reasoning (*Gf*), Comprehension-Knowledge (*Gc*), Visual Processing (*Gs*), Decision/Reaction Time Speed (*Gt*), Auditory Processing (*Ga*), Processing Speed (*Gs*), Short-term Memory (*Gsm*), Long-term Retrieval (*Glr*), and Quantitative Ability (*Gq*). More than 70 narrow CHC abilities have been identified and defined (Flanagan & Ortiz, 2001). See Appendix B for an expanded explanation of each broad and narrow CHC ability.

Flanagan and colleagues (2010) explained the importance of the CHC theory as compared to other measures of intellectual functioning by describing its research base.

They emphasized the decades dedicated to conducting research by synthesizing hundreds of factor analyses using different intellectual assessments. This psychometric approach has resulted in the ability to apply normative results to functions of the processing systems (Dehn, 2006). Flanagan and colleagues (2007) reported that this research supports CHC theory as a valid method to use in test interpretation, and, by examining profiles of CHC cognitive abilities; one will have a clearer understanding of possible strengths and weaknesses (Fiorello et al., 2006; Hale, Naglieri, Kaufman, & Kavale, 2004; Kavale & Nye, 1985-6; Mather & Wendling, 2010).

McGrew and Wendling (2010) maintained that the critical question is, "What CHC broad or narrow cognitive abilities hold promise either as early screening markers or collectively as pattern indicators of a potential SLD process disorder?" (p. 652). Based upon ongoing research in the relationship of cognitive abilities and academic achievement, Flanagan and colleagues (2010) discussed the importance of understanding how cognitive abilities are related to academic skill areas. Knowledge of these relationships is an important aspect of interpreting strengths and weaknesses (Flanagan, et al., 2010).

Woodcock-Johnson III Tests of Cognitive Ability, Third Edition (WJ-III COG)

The WJ-III COG is the most recent battery of the Woodcock-Johnson Tests of Cognitive Abilities (Woodcock, McGrew, & Mather, 2001b). The WJ-III COG is a battery of tests used to measure cognitive abilities and was based on CHC theory since the initial format, Woodcock-Johnson Psycho-educational Battery-Revised WJ-R: 1989, was published (Keith & Reynolds, 2010). The WJ-III COG provides a measure of general intelligence *g* identified in scoring results as the General Intellectual Ability (GIA). A standard GIA score is established by the use of subtests 1 through 7. An extended GIA score is determined by the use of seven additional subtests, 11 through 17. Although the GIA scores are expected to be the most useful for predicting global achievement, skills differentiated by each subtest or cluster score are anticipated to relate to specific areas of achievement (Mather, Wendling, & Woodcock, 2001).

The use of the WJ-III COG cluster scores provides the option for interpretation of processing strengths and weaknesses from both an ipsative and normative approach. Instructional manuals for the WJ-III COG provide the following information for seven cluster scores and the subtests which are measures of narrow abilities.

1. Comprehension-Knowledge (*Gc*), the breadth and depth of knowledge of a culture

   Verbal Comprehension – lexical knowledge; language development

   General Information – general verbal information

2. Long-term retrieval (*Glr*), the ability to store and retrieve information;

   Visual-Auditory Learning- associative memory

   Retrieval Fluency – ideational fluency

3. Visual-Spatial thinking (*Gv*), the ability to perceive, analyze, synthesize, and think with visual patterns;

   Spatial Relations – visualization

   Picture Recognition – visual memory

4. Auditory Processing (*Ga*), the ability to analyze, synthesize, and discriminate auditory stimuli;

   Sound Blending- phonetic coding synthesis

   Auditory Attention- speech-sound discrimination; resistance to auditory stimulus distortion

5. Fluid Reasoning (*Gf*), the ability to reason form concepts and solve problems (using unfamiliar information or novel procedures);

   Concept Formation- inductive reasoning

   Analysis-Synthesis – general sequential reasoning

6. Processing Speed (*Gs*), the ability to perform automatic, speeded cognitive tasks under pressure to maintain focused attention;

   Visual Matching – perceptual speed

   Decision Speed –semantic processing speed

7. Short-Term Memory (*Gsm*), the ability to hold information in immediate awareness and then use it within a few seconds

   Numbers Reversed – working memory

   Memory for Words – memory span (Mather & Woodcock, 2001; McGrew & Woodcock, 2001).

By administering the individual subtests of the WJ-III COG that form an ability cluster, a cognitive factor score, can be obtained (Schrank, Flanagan, Woodcock, & Mascolo, 2002). The comparison of these factor scores is the foundation for "determining whether information processing strengths and weaknesses exist" (p. 95). Appendix D provides a more complete description of cognitive cluster scores assessed by the WJ-III COG and the subtest scores that make up each cluster score.

The Woodcock-Johnson III Tests of Achievement (WJ-III ACH; Woodcock, McGrew, & Mather, 2001a) is also based on the theoretical foundations of the CHC theory. It contains 22 tests in five academic areas: reading, mathematics, written language, knowledge, and oral language. Diagnostic capabilities are enhanced by its co-norming with the WJ-III COG. The areas of reading achievement that are measured by the WJ-III ACH test are described below (Mather & Jaffe, 2004).

Basic Reading Skills Cluster (BRS)

The Basic Reading Skills cluster is a combination of two subtests, Letter-Word Identification and Word Attack. This cluster measures the student's ability to recognize letters and /or sight words and their ability to decode nonsense words (phonics).

Letter-Word Identification : Letter-Word Identification measures the student's word identification skills. Initial items require the student to identify letters by naming each letter when requested. The student is then required to read increasingly difficult words, and to pronounce them correctly. The student is not required to demonstrate that he/she knows the meaning of any word. Age ranges are provided to indicate start points on this subtest.

Word Attack: The Word Attack subtest measures the student's ability to apply phonetic and structural analysis skills to the pronunciation groups of letters. The task begins with the sounds for single letters, then the student is required to read increasingly complex combinations of phonetically consistent letter combinations that structurally resemble real words, but are non-words.

Reading Comprehension Cluster (RC): The Reading Comprehension cluster provides a measure of reading comprehension skills. Student's abilities include comprehension of short reading passages, knowledge of vocabulary (meanings) and reasoning ability.

Passage Comprehension: Passage Comprehension is measured by requiring the student to silently read a passage with a single word missing. The student's understanding (comprehension) of the passage is necessary to select an appropriate word. Initial passages include pictures. Word knowledge and reading comprehension are measured.

Reading Vocabulary: Reading Vocabulary is measured through the administration of three subtests of word knowledge: Synonyms, Antonyms, and Analogies. Students are first required to read a word aloud and then supply the appropriate synonym. Second, the student must read the word aloud and the respond with an appropriate antonym. The final subtest requires the student to read three words of an analogy and supply a fourth word which would appropriately complete the analogy. Both word reading and knowledge of word meanings are required for this measure of ability.

Reading Fluency (Rfl): Reading Fluency is a timed subtest that measures how quickly a student can read a sentence and determine whether the statement is true or not. The student's answer is indicated by circling with Y for yes, or N for no. The student is given three minutes to complete as many sentences as possible. This subtest does not represent a cluster score. In addition, because of the level of difficulty at which the initial sentences are presented, it is not an appropriate measure of ability for a non-reader. (Mather & Jaffe, 2004). (See Appendix E for WJ-III ACH Reading Chart)

Cognitive Processing Abilities and Reading Achievement

Fiorello and colleagues (2006) reported that the most common referral for assessment is "difficulty with reading acquisition" (p.835). While it is evident from research that there are many contributing factors in the acquisition of reading skills (Evans et al., 2001; Fiorello et al., 2006; Fletcher et al., 2007), there is not always agreement as to what those factors are. Fiorello (2006) and colleagues discuss several subtypes of students with reading disabilities, and for each subtype, a different combination of cognitive strengths and weaknesses led to specific patterns of reading achievement. Therefore, to accurately identify the specific abilities and provide remediation of reading deficits, it is essential to conduct comprehensive evaluations that can identify processing difficulties which have been correlated with a student's reading deficits. (Fiorello et al., 2006).

The possible correlations between cognitive abilities identified by CHC theory and assessed by the WJ-III COG and various measures of academic functioning have been investigated by numerous researchers in the fields of psychometrics and education. Vanderwood, McGrew, Flanagan, and Keith (2002), Evans, et al. (2001), Konold, Juel, and McKinnon (1999), and Floyd et al. (2007) all explored the relationships between cognitive abilities as defined by CHC and tests of reading achievement. Their aim was to identify the specific cognitive abilities that are required for reading achievement.

Vanderwood and colleagues (2002) conducted a study that used the standardization sample of the Woodcock-Johnson Psychoeducational Battery-Revised (WJ-R), which consisted of 6,359 subjects aged 24 months to 95 years, to analyze how five specific cognitive abilities contributed to reading achievement at five developmental levels. Students from kindergarten to grade 12 (3,425 students) were divided into five levels: Grades 1-2, 3-4, 5-6, 7-9, and 10-12. Correlation matrices and standard deviations for the 18 subtests were produced at each level for both samples. Three general conclusions were: (a) specific cognitive ability/reading achievement relations were better models than those not related; (b) CHC-specific cognitive abilities and reading achievement changed at each developmental level studied; and (c) *Gc* and *Ga* were strongly related to basic reading and reading comprehension skills. Data from this study supported the belief that CHC-specific cognitive abilities were able to explain academic/ achievement deficits, better than a single *g* score.

Evans and colleagues (2001) used the WJ-III COG to identify relationships between cognitive abilities and reading achievement. Participants were 6- to 19-year-olds who had participated in the standardization of the WJ-III COG scores and who had taken the BRS (n = 4,338) and RC (n = 3,303) clusters of the WJ-III ACH tests. Standard regression coefficients were plotted for each cognitive cluster with each reading cluster. *Gc* and *Gsm* were consistently related to at least one of the reading clusters. The *Gc* cluster demonstrated the strongest and most consistent relationship with both BRS and RC. *Gsm* was moderately correlated with BRS but had a weaker correlation with RC. During the formative years of reading skill acquisition, analyses of *Ga*, *Glr*, and *Gs* revealed consistent patterns of significant relations with both BRS and RC. Relations between *Ga* and BRS and RC were moderate from ages 6-9, and *Glr* was moderate with BRS for ages 6-0 and RC for ages 6-11. *Gs* results demonstrated moderate effect with BRS and RC from ages 6 to approximately 10. *Gf* and *Gv* results demonstrated no consistent pattern. *Gc* was the strongest predictor of BRS and RC. Its predictive power was less for early reading acquisition than other CHC factors: *Glr* and Phonetic Coding. *Gsm* appeared to decrease in importance in reading comprehension as children mature. The relationship between *Ga* and BRS was moderate and a slightly weaker relationship with RC.

Glr results demonstrated moderate relations with both reading clusters during the early school-age years. *Gs* was moderately associated with both BRS and RC from approximately ages 6-10. *Gf* was not strongly related to either reading cluster. *Gv* results were consistently weak.

Konold and colleagues (1999) selected 1,604 children, ranging in age from 5 to 10 years (M = 7.8; SD = 1.6) from the Woodcock Diagnostic Reading Battery (WDRB) (Woodcock, 1997) standardization sample. The four cognitive constructs of *Ga*, *Gc*, *Gs*, and *Gsm* were used to investigate their "joint influence on reading outcomes" (Konold et al., 1999, p. 92). Means and standard deviations were used to develop normative profiles through cluster analysis.

The following questions were of particular interest for this study:

1. What are the most common profiles of important reading abilities?
2. Which profiles are associated with success in reading, and what patterns are likely to result in reading acquisition difficulty?
3. Are the same profiles that are associated with success in one aspect of reading (e.g., word recognition) also associated with success in other reading areas (e.g., comprehension)?
4. What is it that actually develops in students over time? Do the same abilities continue to develop (i.e., do they continue to display similar profile configurations) or do they acquire different strategies for dealing with words and test (i.e., do their profiles change)?
5. What type of instruction contributes to this development? (p. 5).

Six profiles were identified based on the relationship of the four cognitive constructs and the reading achievement scores of: Letter-Word Identification, Word Attack, Reading Vocabulary, and Passage comprehension. The core profile types were identified as:

- Slightly Below Average Reading Ability
- Below-Average Reading Ability
- Average Reading Ability With Strengths in *Gc* and *Gsm*
- Above-Average Reading Ability
- Average Reading Ability with Strengths in *Ga*
- Average Reading Ability with Elevated *Gs* (p. 8).

Each profile type was compared on literacy outcome measures. Students with strengths in all areas performed the best on these measures, while students with weaknesses in all areas performed the worst. Students of average reading ability performed better when they had one or more secondary strengths compared to students with average reading ability without secondary strengths. A strength in *Ga* predicted higher achievement in reading than strengths in *Gc* and *Gsm*, which in turn predicted higher achievement than a strength in *Gs*.

Floyd and colleagues (2007) also conducted a study of 4,321 participants from the standardization sample of the WJ-III COG and WJ-III ACH. Five age-based samples were formed: 5 to 6 ($n = 639$), 7 to 8 ($n = 720$), 9 to 13 ($n = 1{,}995$), 14 to 19 ($n = 1{,}615$), and 20 to 39 ($n = 1{,}409$). Eighteen subtests from the WJ-III COG and four tests from the

Tests of Achievement were used. In addition, six tests and one composite were used from the Woodcock-Johnson III Diagnostic Supplement (WJ-III DS). This study was designed to examine the effect of cognitive ability, as measured by the CHC theory, on reading decoding skills. The five broad abilities that demonstrated the most significant effects on Reading Decoding Skills included: *Ga*, *Gsm*, *Glr*, *Gc* and *Gs*. When aligning the cluster scores with age groups, *Glr*, and the narrow ability, Associative Memory had strong effects on Reading Decoding. *Gc*, Listening ability and General Intelligence demonstrated strong direct effects. At ages 5-6, Listening Ability was significant, but, beginning at ages 7-8, direct effects of General Information were the largest of any broad or narrow ability. *Gs* had strong effects at the earliest age levels. *Gv* and *Gf* were not important influences on Reading Decoding Skills at any age level. It was concluded that a complete battery of cognitive scores is not necessary for students referred for reading decoding analysis. The authors of this study recommend administering narrow measures that "come closest to the core "psychological processes" deemed important to reading" (p. 223).

Urso (2008) explored the relationship of *Gs* as a predictor of poor reading. Forty-four students in Grades 1-3, aged 6- to 10-years-old were selected from two environments: 19 students from a private school for students with learning disabilities and 25 from a Kindergarten through Twelfth Grade math and science charter school. The participants were administered the WJ-III ACH of Letter-Word Identification, RF, and Word Attack. In addition, they were administered the WJ-III COG subtests of Verbal

Comprehension, Visual-Auditory Learning, Sound Blending, Visual Matching, Numbers Reversed, Decision Speed, Rapid Picture Naming, Pair Cancellations, and Cross Out. Pearson correlations and coefficients of determination were used to evaluate relationships between achievement and cognitive measures. Results indicated a strong relationship between *Gs* ($r = .749$), and poor word recognition. The two subtests of *Gs*, Visual Matching and Decision Speed, had the strongest correlations with poor word reading skills. Visual Matching, Rapid Picture Naming, Pair Cancellation, and Cross Out all had significant moderate correlations with *Gs*. The BRS cluster and the test of Letter-Word Identification were both moderately correlated at various strengths with different formats of *Gs* tests.

Kearns (2010) explored cognitive differences among students with reading disability, with reading or math disability, or attention-deficit/hyperactivity disorder (ADHD); Two hundred fifty-two elementary age students met the study's criteria for reading problems and IQ. IQ was a minimum T score of 30 on either the Wechsler Abbreviated Scale of Intelligence, Vocabulary, or Matrix Reasoning subtest. Reading Disability was identified as word reading or reading comprehension below the 16th percentile. A discrepancy between IQ score and reading was not required. The typically-performing (typical ability; TA) group was comprised of 51 students.

Reading comprehension was tested on the WJ-III ACH Passage Comprehension subtest. Students with reading disabilities were found to differ from peers with typical abilities in their patterns of cognitive performance. They appeared to have relatively strong visual spatial working memory but weak phonological awareness and expressive language skills. Cognitive performance of students in this study identified as Reading Disabled (RD) had a lower cognitive performance than students who were identified as TA. However, students who were RD did not appear to have different cognitive strengths and weaknesses from each other.

Kearns (2010) found that students who are RD differ from their peers with TA in their patterns of cognitive performance. Students who are RD appear to have relatively strong visual-spatial working memory, but weak phonological awareness and expressive language skills compared to those identified as TA.

Keith, Reynolds, Patel, and Ridley (2007) examined whether gender differences existed in general and broad cognitive differences as identified by the WJ III COG. A total of 3330 males, and 3640 females were chosen from the 6 to 59 year old age group of the standardization sample of the Woodcock Johnson III Cognitive Tests of Abilities. Because quantitative reasoning had previously been suggested to demonstrate a gender difference, quantitative reasoning (RG) was modeled as a separate factor in addition to the seven cognitive processing abilities of comprehension-knowledge (*Gc),* long-term retrieval (*Glr*), visual-spatial ability (*Gv*), auditory processing (*Ga*), fluid reasoning (*Gf*), processing speed (*Gs*), and short-term memory (*Gsm*).

This study used a developmental MIMIC model (multiple indicator-multiple cause) to examine the possible gender differences in 'g' (general ability) and the eight broad abilities across the selected ages. Females demonstrated a moderate and consistent mean difference in processing speed (Gs). Males had a small consistent difference favoring comprehension-knowledge (Gc). Males also demonstrated an advantage on the quantitative reasoning (RG) factor and on the visual-spatial factor (Gv). However, Gv was only statistically significant at older ages. Differences in the 'g' or general ability favored females during adulthood. No gender differences were evident for *Gsm, Glr, Gf,* or *Ga.*

Researchers attempting to correlate cognitive abilities with reading ability have consistently demonstrated that several cognitive abilities appear to influence the acquisition of reading skills (Evans et al., 2001; Evans et al., 2001; Fiorello et al., 2006; Fiorello & Primerano, 2005; Floyd et al., 2007; Konold et al., 2003; Vanderwood et al., 2002). Fletcher and colleagues (2006) stated that by using a profile of strengths and weaknesses developed by analyzing cognitive scores, not only can students be identified with a learning disability, but that subtypes of learning disabilities can be differentiated.

Proponents of the use of strengths and weaknesses, or intra-individual differences, to identify students with learning disabilities also favor using assessment results to develop educational programming with individualized interventions for those students (Everatt, Weeks, & Brooks, 2007; Fiorello et al., 2006; Huang, 2004; Kavale, Holdnack, & Mostert, 2006; Konold et al., 2003; Schrank, et al., 2002). Kearns (2010) suggested that the reason students do not make progress is because the interventions used are not appropriate. By identifying specific cognitive deficits associated with a corresponding academic deficit in reading, interventions could be provided that match the cognitive need (Fiorello et al., 2006).

Some researchers propose that a limited number of processing clusters can be administered for the identification of cognitive processing deficits (Floyd et al., 2007), while Urso (2008) and Fiorello and colleagues (2006) stated the importance of a complete comprehensive cognitive evaluation in assessing students for their learning strengths and weaknesses. Torgenson (2001b) proposed that assessing specific processes responsible for academic failure would benefit the early identification of students with learning disabilities.

Summary of Literature Review

The Education for All Handicapped Children Act (EAHCA, 1975 94-142) identified a category of disability defined as a Specific Learning Disability. Regulations for implementation of this law provided for a discrepancy between a student's ability and achievement as a method of identification for a Specific Learning Disability. The primary method used to determine the student's ability was the administration of an IQ test.

At the same time, researchers began exploring intra-cognitive differences by attempting to identify a profile of cognitive abilities using a deviation from the mean. Lack of reliability, as well as advances in statistical applications and advanced theoretical constructs, led to a decline in these studies. However, an interest in the concept of patterns of cognitive abilities continued to develop.

Dissatisfaction with the discrepancy method eventually resulted in revisions to the laws governing special education and the identification of learning disabilities. New regulations now prohibit the use of one test score as a method for determining a learning disability and encourage the use of a pattern of cognitive strengths and weaknesses. Theoretical advances in the understanding of intelligence that resulted in the CHC theory and the creation of cognitive assessments to measure those attributes have provided the tools with which to measure scores in defined cognitive areas.

Multiple studies have been conducted to determine the relationships between cognitive abilities and reading skills. Many of those have used the standardization data from the test developers for the data for their study. In addition, studies have depended on a discrepancy model to identify students in the experimental grouping. These studies have consistently identified correlations between reading and a range of cognitive scores.

CHAPTER III

METHODOLOGY

Overview

The primary purpose of this study was to determine whether elementary-aged students, who were initially identified with a learning disability through use of a method that identified a pattern of cognitive strengths and weaknesses, exhibit specific patterns of cognitive processing abilities as measured by seven CHC cluster scores of the WJ-III COG. In addition, this study attempted to determine if there were gender, grade level, or ethnicity differences in the patterns. Students who met District eligibility criteria for a learning disability in the area of reading were considered for the purpose of this study. This chapter describes the participants, the data collection process, type and parameters of data collected, and the data analysis used for this study.

Participants

Participants for this study were elementary grade students in first, second, and third grades from a large suburban school district in North Texas. The participants were selected by using the initial referral data maintained by the district special education department. All participants were students who were referred for evaluation and were assessed during the 2008-2009 and 2009-2010 school years. All participants met the criteria which were used to determine the presence of a learning disability as established by the school district and followed guidelines provided by the TEA. Additional criteria for this study required that the learning disability be the primary eligibility; that the student had been administered the extended battery of cognitive testing from the WJ-III COG; that achievement scores were reported from the WJ-III ACH; and that the student demonstrated a normative deficit in at least one the qualifying areas of a reading disability: BRS, RF, or RC.

As the data used were obtained from the records of students already identified as having a learning disability, exclusion factors that may be the cause of lack of achievement (i.e., visual, hearing, or motor disability; mental retardation; emotional disturbance; cultural factors; environmentally or economically disadvantaged; or limited English) have been eliminated as their elimination is part of the criteria for eligibility (IDEIA, 2004). It was important to note that specific testing procedures, as determined by the school district, were used to initially identify the students whose test data was used for this study.

District assessment procedures for identification of a student with a learning disability required that the student demonstrate a pattern of strengths and weaknesses within a cognitive profile. These requirements specified there must be significant cognitive deficits present in an otherwise well-developed profile of cognitive abilities. A significant cognitive deficit (weakness) is described as a standard score of less than 85. Specifically stated is that two or more weaknesses must be identified. District guidelines for assessment of students also required the evaluation of at least seven cognitive processing areas: *Gc*, *Glr*, *Ga*, *Gv*, *Gf*, *Gs*, and *Gsm*.

District guidelines required answers to the following questions in the identification process when determining that a student met the criteria for a learning disability:

1. Does the student exhibit a pattern of cognitive strengths and weaknesses?
2. Does the student have a normative deficit in academic achievement? *
3. Is there a relationship between the cognitive deficits and academic deficits? (Guidelines regarding the relationships between cognitive processing abilities and specific areas of academic abilities are provided for the test examiner.)
4. Is there evidence of functional impairment? (See Appendix F)

This study evaluated only the information provided by the WJ-III ACH scores of reading to determine reading ability. However, a comprehensive assessment would also take into consideration state and grade-level assessments, teacher grades, Curriculum Based Measurements (CBAs) and work samples. Therefore, it is possible that additional information (in addition to deficits on reading scores) was instrumental in an identification of a deficit in reading ability.

A pattern of cognitive strengths and weaknesses was assumed for each set of scores used. A total of fifty-five elementary age students in first grade through third grade met this specific profile.

Data

A proposal to conduct the study was submitted to the Executive Director of Special Education with the school district. Upon the approval of the Executive Director of Special Education, Texas Woman's Institutional Review Board (Appendix G) and the dissertation committee, data collection was initiated. Due to confidentiality reasons, the district used for the purpose of this study will hereby be known as "a large school district in North Texas." The research approval letter is on file in the IRB office at Texas Woman's University.

Data were collected from individual student reports that are maintained electronically by the selected school district. Each school district is required by the TEA to document timelines for initial referrals. This initial referral information was provided by the district and was used to identify students initially referred and evaluated during the designated 2-year period. Individual reports for these students were then accessed from a secure, password protected, electronic file system.

Confidentiality of student information was assured by the structure of the data collection process. The Director of Special Education for the school district selected a professional educator, employed by the district, to access student information electronically and select the requested forms and assessment results that met the required criteria as determined by the researcher. The required criteria included: student demographic information including grade, gender, ethnicity, specific cluster scores and subtest scores from the WJ-III COG and WJ-III ACH, documentation of eligibility (district eligibility report), and areas of LD in which the student qualified. The professional educator used electronic and/or manual methods to assure that all information identifying the student was blacked out and that each data report was instead assigned a sequential number for identification purposes. Each student was given a unique identification code, and any personal identification was removed from the data set. Once all the reports had been collected and processed, the professional educator submitted the information to the Special Education Director, who verified the provisions of confidentiality and then provided these reports to the researcher.

Data were extracted from the reports and entered the information onto a data sheet that was designed to record student information, cognitive test scores, and achievement tests scores. A paper representation of this data sheet is available in Appendix H, however, the data sheet was utilized electronically to simplify entry into SPSS. The student information consisted of date of birth, ethnicity, gender, and grade, although age was not used as a demographic variable. Cognitive test scores from WJ-III COG were the Standard Scores for the seven cognitive ability clusters (*Ga, Gs, Gv, Gsm, Glr, Gf, and Gc*) as well as the subtest scores which comprise these clusters. Achievement scores were the Standard Scores from BRS cluster, the RC cluster, and the RF subtest. Occasionally, supplemental subtests of the cognitive assessment had been administered. Rationale for administration of additional subtests was not evident from the confidential report, but cluster scores were not differentiated based on the number of subtests. To further examine the interpretive possibilities, subtest data related to each cognitive area was extracted when presented as part of a student's report. Cluster and individual subtest scores were reported for reading achievement scores, but not for any additional achievement measures, such as math or written language, as this study did not extend to the interpretation of that data.

Research Design

An ex post facto correlational design that used a sample of convenience was utilized for the statistical analysis of this study. A correlation study indicates how a set of variables is related but does not imply a cause and effect relationship. A Pearson correlation was performed to assess whether standard scores attained by students on the WJ-III COG correlated with scores on the WJ-III ACH. This was used to determine whether a correlation existed, the strength of the correlation, and whether it was significant at either the $p < .01$ or $p < .05$ level. The first two research questions were designed to determine if cognitive profile scores are predictive of reading achievement scores. Research Question 1 was developed to examine the Cluster or Standard Scores associated with the seven processing abilities measured by the WJ-III COG, whereas Research Question 2 focused on the subtest scores. Therefore, for the current study, relationships between individual *(G)* factors and individual BRS, RC, and Rfl scores were examined with a Pearson Product Moment correlation. Furthermore, a multiple regression analysis was conducted to determine relationships between the seven *g* factors and the scores assigned to BRS, RC, and Rfl. Specifically, the analyses were conducted to determine which *g* factors were predictive of the reading scores. For the purposes of the analyses, the outcome measures were the reading scores, and the *Cognitive Cluster Scores* were the predictor variables.

The third research question was designed to discover if there was a gender difference in the CHC profile for students who were identified with a learning disability and a deficit in reading. To examine this relationship, several independent sample *t* tests were conducted to test the effect of gender on the seven *(G)* factor scores.

The fourth research question was developed to determine if there was a grade level difference between first and third grade students who were identified with a learning disability and deficit in reading. A one-way analysis of variance (ANOVA) was conducted to deduce the effect of grade level on each of the seven *(G)*factors.

Finally, the researcher was interested to see if there was a difference between ethnicity (i.e., Caucasian, Hispanic, and African American students) on their *g* factor scores. To examine this effect, several one-way ANOVAs were conducted. Due to the small sample size of African American students, the results of the additional analyses were confirmed with non-parametric tests (Kruskal-Wallis and Mann-Whitney *U*).

CHAPTER IV

RESULTS

Current regulations regarding the identification of students with learning disabilities provide for the utilization of a method of determining whether the student displays a cognitive pattern of strengths and weaknesses. This research questions whether those students who have been identified with a learning disability and deficits in reading display a specific cognitive pattern. Data were collected from 55 elementary-aged students in Grades 1 through 3 who were initially evaluated and determined to meet current criteria as a student with a learning disability. All students were administered the WJ-III COG and the WJ-III ACH. This chapter presents the results of the current study in terms of four research questions. There is also an additional analysis involving students' ethnicity. The presented results include all 55 participants. Analyses included independent sample *t* tests, one-way ANOVAs, multiple linear regressions, and Pearson Product Moment correlations.

Descriptive Analyses

A total of 55 students were included in the analyses. As shown in Table 4.1, a majority of students were male (54.5%). The grade levels were fairly equivalent; the greatest percentage of students was in the third grade (43.6%) whereas 25.5% of students were in the first grade and 30.9% were in the second grade. Finally, the greatest number of participants was Caucasian (49.1%). Due to the small number of students who were

Asian (5.5%) or did not specify an ethnicity (3.6%), only African Americans, Hispanics, and Caucasian were used for analysis purposes.

Table 4.1

Frequencies and Percentages of Gender, Grade, and Ethnicity

	Frequency	%
Gender		
Female	25	45.5
Male	30	54.5
Grade Level		
First Grade	14	25.5
Second Grade	17	30.9
Third Grade	24	43.6
Ethnicity		
African American	8	14.5
Hispanic	15	27.3
Caucasian	27	49.1
Asian	3	5.5
Not Specified	2	3.6

Note. Frequencies not equaling 55 reflect missing data.

As demonstrated in Table 4.2, the cluster scores were analyzed descriptively. Students' *Gc* scores ranged from 63 to 113, with an average score of 87.13 (SD = 11.16); *Glr* scores ranged from 51 to 106, with an average score of 78.29 (SD = 12.04); and *Gv* scores ranged from 75 to 125, with an average score of 101.51 (SD = 10.36). Furthermore, *Ga* scores ranged from 62 to 126, with an average score of 95.24 (SD = 14.21); *Gf* scores ranged from 61 to 118, with an average score of 91.06 (SD = 12.28); *Gs* scores ranged from 62 to 114, with an average score of 90.32 (*SD* = 12.94); and *Gsm* scores ranged from 54 to 114, with an average score of 80.81 (*SD* = 14.44). Also reported are the percentages for each cluster score below the standard score of 85.

Table 4.2

Means and Standard Deviations for Cluster Scores of the WJ-III Cognitive Test

	N	Mean	*SD*	Min	Max	% SS< 85
Gc	52	87.13	11.16	63	113	50
Glr	52	78.29	12.04	51	106	69
Gv	53	101.51	10.36	75	125	07
Ga	54	95.24	14.21	62	126	25
Gf	54	91.06	12.28	61	118	31
Gs	53	90.32	12.94	62	114	20
Gsm	53	80.81	14.44	54	114	70

Students' subtest scores are presented in Table 4.3. The results indicate that students' Verbal Comprehension scores ranged from 55 to 116, with an average Verbal Comprehension score of 88.55 (*SD* = 13.11); Visual Auditory scores ranged from 52 to 117, with an average Visual Auditory score of 82.34 (*SD* = 15.68); Spatial Visual scores ranged from 78 to 120, with an average Spatial Visual score of 99.02 (*SD* = 9.33); Sound Blending scores ranged from 69 to 129, with an average Sound Blending score of 100.09 (*SD* = 13.75); and Concept Formation scores ranged from 65 to 122, with an average Concept Formation score of 93.76 (*SD* = 13.29). Additionally, students' Numbers

Reversed scores ranged from 58 to 110, with an average Numbers Reversed score of 82.02 (*SD* = 12.67); General Information scores ranged from 69 to 113, with an average General Information score of 90.85 (*SD* = 9.42); Retrieval Fluency scores ranged from 59 to 115, with an average Retrieval Fluency of 84.00 (*SD* = 12.73); Picture Recognition scores ranged from 81 to 125, with an average Picture Recognition score of 104.61 (*SD* = 9.04); and Auditory Attention ranged from 53.00 to 121.00, with an average Auditory Attention score of 91.91 (*SD* = 15.22). Finally, students' Analysis Synthesis scores ranged from 69 to 122, with an Analysis Synthesis score of 91.91 (*SD* = 15.22); Decision Speed scores ranged from 75 to 118, with an average Decision Speed score of 96.09 (*SD* = 12.22); and Memory for Words scores ranged from 57 to 109, with an average Memory for Words score of 84.63 (*SD* = 11.24).

Students' ACH Reading Cluster scores were also descriptively analyzed with means and standard deviations. As shown in Table 4.4, students' BRS scores ranged from 60 to 100, with an average BRS score of 84.84 (*SD* = 9.22). Their RC scores ranged from 58 to 98, with an average reading comprehension score of 75.85 (*SD* = 8.72). Students' RF scores ranged from 59 to 105, with an average reading fluency score of 82.36 (*SD* = 10.41).

Table 4.3

Means and Standard Deviations for Reading Cluster Scores of the WJ-III ACH Test

	N	Mean	*SD*	Min	Max
Verbal Comprehension	44	88.55	13.11	55	116
Visual Auditory Learning	44	82.34	15.68	52	117
Spatial Relations	45	99.02	9.33	78	120
Sound Blending	45	100.09	13.75	69	129
Concept Formation	45	93.76	13.29	65	122
Visual Matching	44	85.77	14.13	52	109
Numbers Reversed	45	82.02	12.67	58	110
General Information	40	90.85	9.42	69	113
Retrieval Fluency	44	84.00	12.73	59	115
Picture Recognition	41	104.61	9.04	81	125
Auditory Attention	44	91.91	15.22	53	121
Analysis Synthesis	44	95.07	11.00	69	122
Decision Speed	45	96.09	12.22	75	118
Memory for Words	41	84.63	11.24	57	109

Table 4.4

Means and Standard Deviations for Cognitive Subtests

	N	Mean	*SD*	Min	Max
BRS	49	84.84	9.22	60	100
RC	48	75.85	8.72	58	98
RF	44	82.36	10.41	59	105

Note. BRS = Basic Reading Skills; RC = Reading Comprehension; RF = Reading Fluency.

Primary Analyses

Research Question 1

The first research question was designed to determine whether a cognitive profile, as identified through cluster scores, could be predictive of a specific learning disability in elementary-aged children who demonstrate reading deficits. To analyze the first research question, multiple linear regressions were conducted to predict students' BRS, RC, and RF scores from the cluster scores (*Gc, Glr, Gv, Ga, Gf, Gs*, and *Gsm*). As shown in Table 4.5, a multiple linear regression predicting students' BSR scores was not significant, $F(7, 22) = 1.80, p = .137$, and accounted for 16.2% of the variance ($R^2 = .162$). When examining the individual predictors, the results indicated that only *Gf* was a marginally significant predictor of students' BRS scores, *Beta* = .344, $p = .091$, indicating the students who had higher *Gf* scores were marginally more likely to have higher BRS scores compared those who had lower *Gf* scores.

A multiple linear regression was also conducted to examine the predictability of cluster scores on students' RC scores. As shown in Table 4.5, the overall model was significant, $F(7, 22) = 3.67, p = .009$, and explained 39.2% of the variance ($R^2 = .392$). A deeper examination of the results revealed that *Gf* was a significant predictor of students' RC scores (*Beta* = .503, $p = .006$), indicating that students with higher *Gf* scores were significantly more likely to have higher RC scores. Furthermore, students' *Gc* scores were a marginally significant predictor of students' RC scores (*Beta* = .317, $p = .081$), which indicates that students with higher *Gc* scores were marginally more likely to have higher RC scores, compared to those with lower *Gc* scores.

Table 4.5

Summary of Multiple Linear Regressions Predicting BRS, RC, and RF Reading Scores from Cluster Scores of the WJ-III Cognitive Scores

	BRS *Beta*	RC *Beta*	RF *Beta*
Gc	.208	.317 M	.288
Glr	-.163	-.229	.016
Gv	-.244	-.068	-.088
Ga	.186	.232	-.126
Gf	.344	.503 *	.209
Gs	-.300 M	-.219	-.168
Gsm	.022	.116	-.380 M

Note. Asterisk indicates significant predictor, M indicates marginally significant predictor; Summary of BRS model: $F(7, 22) = 1.80, p = .137, R^2 = .162$; RC model: $F(7, 22) = 3.67, p = .009, R^2 = .392$; RF model: $F(7, 22) = 1.14, p = .376, R^2 = .162$. BRS = Basic Reading Skills; RC = Reading Comprehension; RF = Reading Fluency.

Finally, a separate multiple linear regression was conducted to predict students' RF scores from their cluster scores. As shown in Table 4.5, the overall model was not significant, $F(7, 22) = 1.14, p = .376$ ($R^2 = .162$). The results did indicate that *Gsm* scores were a marginally significant predictor of students' RF scores (*Beta* = -.380, $p = .075$), indicating that students' with higher *Gsm* scores were marginally more likely to have lower RF scores.

Pearson Product Moment correlations were also conducted to test the relationships of each ACH reading score with the individual cluster scores. As shown in Table 4.6, students' BRS were significantly positively related to their *Gc, Gf,* and *Gsm* scores (*r*s ranging from .292 to .396, *p*s <.05), indicating that students with higher scores on the *Gc, Gf,* and *Gsm* tended to have higher BRS scores compared to those who had lower scores on these clusters. Students' RC scores were significantly positively related to their *Gc, Gf, Ga,* and *Gsm* scores (*r*s ranging from .339 to .561, *p*s <.05), indicating that students with higher scores on the *Gc, Gf, Ga,* and *Gsm* tended to have higher RC scores, compared to those who had lower scores on these clusters. Finally, students' RF scores were only marginally positively related to their *Gv* scores ($r = .277$, $p = .076$), indicating that students with higher *Gv* scores tended to have marginally higher RF scores than those with lower *Gv* scores.

The Pearson Product Moment correlations were also conducted with only students who scores below 85 on the individual cluster scores. As seen in Table 4.7, students' BRS scores were significantly positively related to their *Gf* scores ($r = .314$, $p = .030$), indicating that students with higher *Gf* scores tended to have higher BRS scores. Additionally, students' RC scores ($n = 13$) were significantly positively related to their *Gc, Gs, Gf,* and *Gsm* scores (*r*s ranging from .402 to .600, $p < .05$), indicating that students' with higher *Gc, Gs, Gf,* and *Gsm* scores tended to have higher RC scores.

Finally, there were no significant correlations between cluster scores and RF scores for students who scored below 85, all *ps* *ns*. It should also be noted that there were only two students who scored below 85 on the *Gv* test; therefore, a correlation was not meaningful.

Table 4.6

Pearson Product Moment Correlations between WJ-III Cognitive Scores and ACH Reading Scores

	BRS	RC	RF
Gc	.396**	.533**	.255
Glr	.142	.208	.092
Gv	.211	.265	.277 M
Ga	.195	.371**	.005
Gf	.314*	.561**	.118
Gs	-.042	-.002	.150
Gsm	.292*	.339*	.050

Note. *$p < .05$, ** $p < .01$. BRS = Basic Reading Skills; RC = Reading Comprehension; RF = Reading Fluency.

Table 4.7

Pearson Product Moment Correlations between WJ-III Cognitive Scores below 85 and ACH Reading Scores

	BRS	RC	RF
Gc	.354	.591 **	.362
Glr	-.029	.030	.083
Ga	-.089	.345	.571
Gf	.314*	.561 **	.118
Gs	-.106	.600*	.160
Gsm	.266	.402*	.357

Note. $*p < .05$, $**p < .01$. There was an insufficient number of participants with *Gv* scores who were below 85, therefore a correlation could not be conducted. BRS = Basic Reading Skills; RC = Reading Comprehension; RF = Reading Fluency.

Research Question 2

The second research question was developed to assess whether there was a CHC subtest pattern for elementary students identified as learning disabled who demonstrated reading deficits. Three multiple linear regressions were conducted to individually predict BRS, RC, and RF scores from the subtest scores. As seen Table 4.8, the overall model predicting students' BRS scores was not significant, $F(14, 14) = 1.63$, $p = .187$, and explained 23.9% of the variance ($R^2 = .239$). Both concept formation and auditory attention were marginally significant predictors (*Betas* = .581 and .410, respectively). Those with higher concept formation scores or auditory attention scores were marginally more likely to have higher BRS scores. There were, however, no other significant predictors of students' BRS scores, all *ps ns.* Additionally, the overall model predicting students' RC scores was not significant, $F(14, 13) = 1.39, p = .278$ and explained 16.9% of the variance ($R^2 = .169$). A deeper examination of the results revealed that were no significant predictors of students' reading comprehension scores, all *ps ns.* Finally, the overall model predicting RF scores from the subtest scores was not significant, $F(14,9) = 1.93, p = .161$, and explained 36.1% of the variance ($R^2 = .361$). A deeper examination of the results revealed that were no significant predictors of students' reading fluency scores, all *ps ns.*

Table 4.8

Summary of Multiple Linear Regressions Predicting the BSR, RC, and RF Scores from Subtest Scores of the WJ-III Cognitive Scores

	BRS	RC	RF
	Beta	*Beta*	*Beta*
Verbal Comprehension	.421	.478	.214
Visual Auditory Learning	-.271	-.370	.143
Spatial Relations	-.334	.176	-.322
Sound Blending	.060	.121	-.581
Concept Formation	.581	.213	.441
Visual Matching	-.085	.028	.424
Numbers Reversed	-.087	.155	-.095
General Information	.203	.343	.487
Retrieval Fluency	.044	.207	-.175
Picture Recognition	-.218	-.474	-.162
Auditory Attention	.410	.441	.139
Analysis Synthesis	-.162	.080	-.324
Decision Speed	-.003	-.284	.015
Memory for Words	-.035	.060	-.088

Note. Summary of BRS model: $F(14, 14) = 1.63, p = .187, R^2 = .239$; RC model: $F(14, 13) = 1.39, p = .278, R^2 = .169$; $F(14,9) = 1.93, p = .161, R^2 = .361$. BRS = Basic Reading Skills; RC = Reading Comprehension; RF = Reading Fluency.

Pearson Product Moment correlations were also conducted to test the relationships of each ACH reading score with the individual subtest scores. As shown in Table 4.9, students' BRS scores were significantly positively related to their Verbal Comprehension scores, Visual Auditory scores, Concept Formation scores, General Information scores, and Auditory Attention scores (*r*s ranging from .315 to .402, *p*s < .05), indicating that students with higher Verbal Comprehension scores, Visual Auditory scores, Concept Formation scores, General Information scores, and Auditory Attention scores tended to have higher BRS scores.

Additionally, students' RC scores were significantly related to higher Verbal Comprehension scores, Visual Auditory, Concept Formation scores, General Information scores, Auditory Attention scores, Analysis Synthesis scores, and Memory for Words scores (*r*s ranging from .339 to .485, *p*s < .05), indicating that students with higher Verbal Comprehension scores, , Concept Formation scores, General Information scores, Auditory Attention scores, Analysis Synthesis scores, and Memory for Words scores tended to have higher RC scores compared to those with lower Verbal Comprehension scores, , Concept Formation scores, General Information scores, Auditory Attention scores, Analysis Synthesis scores, and Memory for Words scores. Finally, students' RF scores were not significantly related to any of the subtest scores, all *p*s not significant.

Table 4.9

Pearson Product Moment Correlations between Subtest Scores of the WJ-III Cognitive Scores and the BRS, RC, and RF Reading Scores

	BRS	RC	RF
Verbal Comprehension	.358 *	.485 **	.224
Visual Auditory	.315 *	.361 *	.007
Spatial Visual	.088	.254	.163
Sound Blending	.195	.217	.019
Concept Formation	.392 *	.455 **	.122
Visual Matching	-.014	.160	.198
Numbers Reversed	.138	.237	.144
General Information	.402 *	.367 *	.232
Retrieval Fluency	.174	.244	.096
Picture Recognition	.012	.098	.174
Auditory Attention	.390 *	.339 *	.198
Analysis Synthesis	.181	.372 *	.111
Decision Speed	-.035	.012	.155
Memory for Words	.163	.386*	-.054

Note. $^{*}p < .05$, $^{**}p < .01$. BRS = Basic Reading Skills; RC = Reading Comprehension; RF = Reading Fluency.

Research Question 3

The third research question was designed to deduce whether there was a gender difference in CHC profile scores for students who were identified with a learning deficit and a deficit in reading score. To analyze this research question, a series of independent sample *t* tests were conducted to examine the potential difference between male and female students on the cluster scores. As seen in Table 4.10, there were no significant differences between males and females for each cluster score (i.e., *Gc, Glr, Gv, Ga, Gf, Gs,* and *Gsm*), all *p*s *ns.*

Research Question 4

The fourth and final research question was developed to determine whether there was a grade level difference (i.e., first, second, and third grade) in the CHC profile for students who were identified with a learning disability and a deficit in reading. To analyze the fourth research question, a series of one-way ANOVAs were conducted to demonstrate the effect of grade level on CHC profiles scores.

As shown in Table 4.11, there was a significant effect of grade level on *Glr* scores, $F(2, 49) = 3.60, p = .035$. A post hoc analysis revealed that students in third grade had significantly higher *Glr* scores ($M = 82.29, SD = 11.54$) than those in first grade ($M = 71.27, SD = 14.08$). Grade level did not have a significant effect on the other CHC profile scores, all *p*s *ns.*

Table 4.10

Means and Standard Deviation for Cluster Scores by Gender

	n	Mean	*SD*	*t*	*p*
Gc				-1.08	.285
Female	23	85.26	10.09		
Male	29	88.62	11.91		
Glr				-.93	.359
Female	25	76.68	13.53		
Male	27	79.78	10.51		
Gv				-1.13	.265
Female	24	99.75	7.61		
Male	29	102.97	12.13		
Ga				1.00	.323
Female	25	97.32	12.47		
Male	29	93.45	15.54		
Gf				-.76	.450
Female	25	89.68	10.79		
Male	29	92.24	13.50		
Gs				1.03	.308
Female	24	92.33	10.83		
Male	29	88.66	14.43		
Gsm				.20	.841
Female	25	81.24	15.05		
Male	28	80.43	14.15		

Table 4.11

Means and Standard Deviations for Cluster Scores by Grade Level

	n	Mean	*SD*	*F*	*p*
Gc				.01	.994
First Grade	14	87.14	13.08		
Second Grade	16	87.38	11.00		
Third Grade	22	86.95	10.49		
Glr				3.60	.035
First Grade	11	71.27[a]	14.08		
Second Grade	17	77.18[ab]	9.34		
Third Grade	24	82.29[b]	11.54		
Gv				1.64	.204
First Grade	14	97.50	13.99		
Second Grade	15	104.20	7.71		
Third Grade	24	102.17	9.00		
Ga				1.57	.218
First Grade	13	89.92	13.89		
Second Grade	17	94.76	17.15		
Third Grade	24	98.46	11.53		
Gf				1.30	.283
First Grade	14	89.64	13.29		
Second Grade	17	88.12	11.08		
Third Grade	23	94.09	12.33		
Gs				2.30	.111
First Grade	14	88.50	15.60		
Second Grade	16	86.00	12.08		
Third Grade	23	94.43	10.92		
Gsm				.23	.792
First Grade	14	78.71	17.52		
Second Grade	15	82.40	12.10		
Third Grade	24	81.04	14.31		

Note: Means with different superscripts indicate mean differences, $p < .05$.

Additional Analyses

To examine the differences in students' ethnicity, a series of one-way ANOVAs were conducted. As shown in Table 4.12, there was a significant effect of ethnicity on students' *Gc* scores, $F(2, 44) = 9.25, p < .001$. A post hoc analysis revealed that Caucasian students had significantly higher *Gc* scores ($M = 92.67$, $SD = 9.35$) than African American ($M = 80.50$, $SD = 6.46$) or Hispanic students ($M = 80.00$, $SD = 12.39$). There was also a significant effect of ethnicity on students' *Glr* scores, $F(2, 46) = 8.60, p = .001$. A separate post hoc analysis revealed that African American students had significantly lower *Glr* scores ($M = 65.50$, $SD = 8.45$) than Caucasian students ($M = 83.27$, $SD = 12.02$) or Hispanic students ($M = 77.40$, $SD = 9.01$). Additionally, there was a significant effect of ethnicity on students' *Gf* scores, $F(2, 46) = 5.27, p = .009$. Caucasian students had significantly higher *Gf* scores ($M = 96.27$, $SD = 11.91$) than Hispanic students ($M = 84.60$, $SD = 11.64$). Furthermore, there was a significant effect of ethnicity on students' *Gsm* scores, $F(2, 45) = 3.24, p = .049$. Caucasian students had marginally higher *Gsm* scores ($M = 85.62$, $SD = 13.48$) than Hispanic students ($M = 76.87$ $SD = 14.91$). Finally, ethnicity did not have a significant effect on the remaining CHC profile scores, all *ps ns*. Due to the low sample size of African American students, non-parametric analyses (i.e., Kruskal-Wallis and Mann-Whitney *U*) were conducted. The results of the non-parametric analyses confirmed the one-way ANOVA results.

Table 4.12

Means and Standard Deviations of Cluster Scores by Ethnicity

	n	Mean	*SD*	*F*	*p*
Gc				9.25	.000
African American	8	80.50 [a]	6.46		
Hispanic	12	80.00 [a]	12.39		
Caucasian	27	92.67 [b]	9.35		
Glr				8.60	.001
African American	8	65.50 [a]	8.45		
Hispanic	15	77.40 [b]	9.01		
Caucasian	26	83.27 [b]	12.02		
Gv				2.13	.131
African American	7	96.00	6.03		
Hispanic	15	100.73	10.51		
Caucasian	26	104.00	9.47		
Ga				.62	.542
African American	8	90.75	7.17		
Hispanic	14	96.71	16.56		
Caucasian	27	96.93	14.31		
Gf				5.27	.009
African American	8	88.88 [ab]	8.41		
Hispanic	15	84.60 [a]	11.64		
Caucasian	26	96.27 [b]	11.91		
Gs				.00	1.000
African American	8	89.75	10.66		
Hispanic	14	89.86	12.46		
Caucasian	26	89.73	13.64		
Gsm				3.24	.049
African American	7	72.43	16.03		
Hispanic	15	76.87	14.91		
Caucasian	26	85.62	13.48		

Note: Means with different superscripts indicate mean differences, $p < .05$.

CHAPTER V

DISCUSSION

"What CHC broad or narrow cognitive abilities hold promise either as early screening markers or collectively as pattern indicators of a potential LD process disorder?" (McGrew & Wendling, 2010, p. 652). This question summarizes the issue that has driven research in cognitive assessment to more accurately identify patterns of cognitive abilities. Now that educators have been granted the option to use a pattern of strengths and weaknesses in their identification of students with learning disabilities, a population of students exists with identified patterns. These patterns consist of both strengths which fall in the average range and weaknesses represented by a normative deficit. This study was designed to clarify whether the current LD identification method of using a pattern of strengths and weaknesses, would demonstrate that 55 first, second and third graders in a southwest school district, actually demonstrated similar patterns of cognitive deficits.

Based on a multiple regression model of analysis, only Fluid Reasoning, *Gf* was determined to be significantly predictive of reading. *Gf* was predictive of reading ability in the area of reading comprehension. Marginally predictive scores included: *Gf*, marginally significant (.091) in predicting BRS; *Gc*, marginally significant (.081) in predicting RC; *Gsm*, marginally significant (.075) in predicting Rf. Marginal scores indicated students with higher *G* scores were *marginally* more likely to have higher scores in the predicted areas of reading.

Correlational analysis was used in the first finding of this study to determine the strength of the relationships between cognitive cluster scores and the reading cluster scores. *Gf, Gc* and *Gsm* were identified as having a moderate, positive correlation with basic reading skills and with reading comprehension scores of the WJ-III ACH. *Ga,* also, had a positive correlation with reading comprehension. There were no significant correlations with RF.

The correlation of *Gc* with reading ability is consistent with previous studies (Vanderwood, et al., 2002; Evans, et al., 2001; Floyd, et al., 2007) that identified *Gc* as an element critical for acquiring meaning from reading (reading comprehension). The results of this study appear to confirm that students with deficits in reading often lack the necessary background knowledge, verbal skills, and language abilities required to progress in reading at the same rate as peers.

Gsm, Short-term memory, has been identified in students aged 6-8 years old and students aged 7-8 years old as a contributing factor to reading success (Evans et al., 2001; Floyd et al., 2007). These ages are consistent with the grade parameters of this study. Dehn (2006) states, that a deficit in one or more types of memory is the most common finding when students exhibit deficits in processing abilities. Short-term memory provides the cognitive ability to maintain information in immediate awareness. However, the narrow measures of Short-term memory on the WJ-III COG, Numbers Reversed and

Memory for Words, are both presented orally and would appear to measure auditory memory, or information that is present auditorally, as opposed to the visual-memory component required for reading.

In this study, *Ga,* Auditory Processing, was moderately correlated with reading comprehension. However, Vanderwood et al. (2002) using a prior version of the WJ-III COG, determined that there was a strong correlation of *Ga* with both basic reading skills and reading comprehension. Evans et al. (2001), Floyd, et.al. (2007) and Konold, et al. (1999) all reported that auditory processing was closely associated with reading skills. Shaywitz (2003) defines dyslexia as the struggle or inability to transform written symbols into sounds. As was noted in the limitations of this study, the state of Texas provides separate programs for students identified with dyslexia and includes when defining dyslexic characteristics; a lack of phonemic awareness. It is probable that students whose reading disabilities met the district criteria of 'dyslexic characteristics' were identified for a dyslexia program as the district alternative to a special education evaluation.

Gf's moderate correlation with both cluster scores of reading achievement was an unexpected finding for the author. The cognitive processing ability, *Gf,* while acknowledged by Wendling and Mather (2009) to correlate with scores of reading comprehension, has not consistently been identified in previous studies. In fact, in a research synthesis of all CHC-Basic Reading Skills Studies for students 6-8 years from the past twenty years, none identified *Gf* as a significant factor (McGrew & Wendling, 2010). The impact of Gf in the results of this study suggest that the narrow processing abilities of *Gf* identified as drawing inferences, concept formation, classification, generating and testing hypothesis, identifying relations, comprehending implications, problem solving, extrapolating, and transforming information (McGrew, 2004) may play a bigger part in reading acquisition than has previously been identified.

Gc, Gf, Gsm and *Ga* appear to correlate with the WJ-III ACH reading scores and would be expected to fall in the normative deficit range when BRS and RC are identified as reading deficits. However, *Glr* and *Gsm* had the lowest mean scores when compared to each of the seven cluster scores. In addition, *Glr* occurred as a normative deficit (standard score <85) 70 percent of the time and *Gsm* occurred 69 percent of the time as a normative deficit in the population studied. In this study, *Gv*, demonstrated no correlation with reading scores and fell below the standard score of 85 only 7% of the time; a finding consistent with studies from the literature review.

The frequency of cluster scores falling below 85, and therefore meeting the criteria in this study as a cognitive weakness, can be arranged in the following order: *Gsm* (70%), *Glr* (69%), *Gc*, (50%), *Gf* (31%), *Ga* (25%), *Gs* (20%) and *Gv* (7%). Based on these results, it is possible that students who met the criteria of a pattern with normative cognitive scores less that 85, had those weaknesses in the cognitive areas of *Gsm, Glr,* and/or *Gc*. These percentages also suggest that weaknesses in the cognitive areas of memory and comprehensive knowledge are greatly impeding the student's progress.

The second finding identified the cognitive subtest scores with the reading achievement scores. McGrew and Wendling (2010) state the most important focus for cognitive and achievement relationships is at the narrow (or subtest) level of abilities. The rationale for this focus is that while broad composites are the most predictive, narrow ability areas are best when applying that information to developing potential interventions.

There were no narrow or subtest scores that were predictive of a profile or pattern for the students in this study. Those students with high Concept Formation scores and Auditory Attention scores were marginally more like to have higher BRS Scores.

The correlation between the cognitive subtest scores of Verbal Comprehension, Concept Formation, General Information and Auditory Attention were significantly and positively related to the achievement areas of both basic reading skills and reading comprehension. Visual-Auditory Learning scores were significantly related to basic reading skills. Analysis Synthesis and Memory for Words were correlated with RC scores. Reading Fluency scores were not significantly correlated with any of the subtest scores. It was not surprising that subtest scores that were components of the cluster scores of *Gc*, *Gf*, and *Ga* had moderate correlations with the reading achievement tests.

The two narrow abilities of the cluster score *Gf* had moderate correlations with different reading skills as identified by BRS and RC. Analysis synthesis is a cognitive ability that uses deduction or the ability to start with the rule and draw conclusions from stated rules to solve more specific problems or puzzles. Analysis synthesis demonstrated a correlation with reading comprehension. Concept Formation had a moderate correlation with basic reading skills. A skill of inductive reasoning, concept formation involves the ability to discover the rule or underlying characteristic of a problem or use the rule from a previous problem. This skill may apply to basic reading skills in the application of phonics rules to decoding new and unknown words.

The third research question analyzed the possibility of gender differences. This study did not suggest any differences in cognitive processing abilities in relationship to gender. Keith, et al., (2007) reported a moderate mean difference favoring females in processing speed (Gs) and a small mean difference favoring males in comprehension-knowledge (Gc). Additional gender-cognitive related results reported by Keith (2007) and colleagues were not within with the age parameters of this study. While not discussed as part of this study, males, traditionally, have been more frequently identified with learning disabilities. However, there was no significant gender different in the number of participants who met the criteria for this investigation.

In answer to the final research question, a descriptive analysis identified *Glr*, Long-term Retrieval as the only cluster score to demonstrate a difference between grade levels. Students in third grade had a significantly higher *Glr* mean score than first grade students. Grade level did not have a significant effect on the other CHC profile scores. Studies by Floyd et al. (2007) also found that *Glr* was significant at 5 and 6 years old, but not at 7-8. Evans et al., (2001) suggest a significant effect for ages 6-8. *Glr* is the ability to store and consolidate new information in long-term memory and later fluently retrieve the storied information (McGrew, 2004).

The subtests of *Glr* on the WJ-III COG are associative memory (paired associative) and meaningful memory where there is a meaningful relationship between the bits of information (McGrew, 2004). In this study, associative memory, as measured by the task of Visual-Auditory Learning, demonstrated significant correlations with both BRS and RC. Meaningful memory, as measured by the timed retrieval fluency task, did not demonstrate a significant correlation. In many ways, the Visual-Auditory Learning subtest resembles a reading lesson, with symbols substituted for orthographic representations. It can be assumed that third graders would have had significantly more instruction and experience in this type of task.

Additional Findings

While ethnicity was not a research question for this study, ethnicity was included as part of the demographic data collected. Ethnicity had a significant effect on the cognitive ability scores of *Gc, Glr, Gf,* and a marginal effect on *Gsm*. Caucasian students had significantly higher *Gc* scores than African American or Hispanic students and significantly higher *Gf* scores than Hispanic students. There was also a significant effect of ethnicity on students' *Glr* scores. African American students had significantly lower *Glr* scores than Caucasian or Hispanic students. Caucasian students had marginally higher *Gsm* scores than Hispanic students. Finally, ethnicity did not have a significant effect on the remaining CHC profile scores.

Ethnicity must frequently be considered when determining eligibility for special education. Students being evaluated for a learning disability must meet the exclusionary clause which states, in part, that lack of academic achievement cannot be caused by: cultural factors, environmental or economic disadvantages, or limited English (IDEIA, 2004). The exclusionary clause can be difficult at times to interpret as cultural factors or economic disadvantages lack normative boundaries on which to make decisions.

This study did not access, from the student's evaluation information, possible language ability scores. Test administrators routinely consider possible cultural and linguist bias when selecting cognitive assessments. However information on whether a student speaks a second language, or whether a second language is used in the home is provided by the parents. It is possible that some students identified in this study may have been more accurately evaluated with a more appropriate assessment battery.

Implications for Practice

The results of this study suggest that when a pattern of cognitive strengths and weaknesses is used as a method of identification of students with learning disabilities, certain cognitive abilities are frequently correlated with a student's academic deficits in reading. In this study *Gf, Gc, Glr*, and *Gsm* appear to the cognitive skills most related to the acquisition of reading skills. Acknowledgment of the underlying skills represented by these cognitive abilities has the potential to promote increased accuracy in the assessment process as well as in the design of individualized education programs that tailor instruction for students with reading deficits.

Researchers consistently express the opinion that the purpose of identifying profiles or patterns of specific cognitive abilities should be to better define and construct instructional strategies and interventions which will meet the specific needs of students with learning disabilities. Diagnosticians frequently recommend instructional strategies that correlate with the cognitive processing abilities of the students they assess (Proctor and Stephens, 2010). These types of instructional strategies and interventions could also be applied to Response to Intervention (RtI),

Response to Intervention (RtI), while not examined in this study, is an additional method of interpretation for learning disabilities as provided by IDEIA 2004. The expectation for most Full Individual Evaluations, often required by LEA's when a learning disability is suspected, is that RtI has been provided as both an intervention and an assessment of skill acquisition. RtI is intended to offer diagnostic information as part of the identification process for students with learning disabilities. While each student is guided through a RtI process based on individual academic deficits, the knowledge that there are specific cognitive abilities that contribute to acquiring reading skills, may streamline the process of identifying what supports should be provided for the student (Hale, J. B., Kaufman, A., Naglieri, J. A., & Kavale, K. A., 2006).

Determining a pattern of abilities, using the scores of the subtests which provide a measurement of narrow abilities that compose each cluster score, may not be an applicable or a valid interpretive method of identifying a learning disability. However, skills that are measured by each narrow ability can provide information regarding how an individual student learns. This is especially true when one narrow score is significantly higher or lower than another of the same broad measure of cognitive ability. Metacognitive skills refer to an individual's ability to monitor and direct their own learning process. By incorporating cognitive strategy instruction based on an individual's abilities, the student has an opportunity to better understand his or her personal strengths and weaknesses and further develop metacognitive skills.

It was noted when evaluating the data for this research that, frequently, students had participated in the district's dyslexia program prior to being evaluated for a learning disability. Another factor noted was that many of the students who met eligibility for a learning disability had previously been retained. Knowledge of the abilities which are correlated with reading may aid in being able to provide students with interventions prior to considering a dyslexia program or retention.

Recommendations for Further Research

The total number of participants in this study (55) was limited by the number of students assessed using only the WJ-III COG and ACH. LEA's have access to numerous assessment batteries which are also based on the CHC Theory. To more precisely examine whether all students who are identified with LD and deficits in reading have similar patterns, research should be expanded to include all cognitive scores based on CHC theory.

In this study, the narrow measures of *Gsm* were both administered orally and both required oral responses. Because *Gsm* appears to influence the acquisition of reading skills, it may be appropriate to identify and use a non-verbal measure of those abilities to determine if similar results are obtained. Torgensen (2001a) and Dehn (2008) suggest that deficits in working memory are fundamental problems of children with LD. Additional information regarding memory abilities may more closely connect those abilities with reading acquisition.

Conclusion

The value of investigating cognitive processing abilities in an attempt to develop student profiles remains controversial. There does appear to be, however, a consensus that CHC theory identifies processing abilities that contribute to general intelligence and, factorial measurement of these abilities can be reported as standard scores. Whether these scores or combination of scores can or should be used to define specific populations has not been determined and was not conclusive in this study.

Educators are reminded by Keith and Reynolds (2010) that defining what is being measured by cognitive assessment is complex and that relying on a pattern of scores to understand a student's abilities may be an over-simplification. While certain cognitive skills do seem to be the weakest when a reading deficit is diagnosed, it would be unwise to try to exclusively identify a learning disability by these patterns. However, the knowledge that certain cognitive abilities are the most prevalent and linked with reading, behooves the educator to focus on the skills identified to develop instruction.

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APPENDIX A

Texas Education Agency Procedures for Evaluation of SLD

TEXAS Education Agency Evaluation of a Learning Disability

Pattern of strengths and weaknesses:

Schools may determine a pattern of strengths and weaknesses by evaluating specific areas of cognitive function, academic achievement or both and comparing those results against each other or in contrast to other measures of student performance.

This process may include significant discrepancies between intellectual ability and achievement. However, a discrepancy cannot be the sole determinant for specific learning disability identification. If a discrepancy is included in the identification process, it should be based on a standard regression procedure and not simple difference procedures. Current research fails to support the validity of simple difference procedures in determining the existence of a learning disability. Evaluation instrument manuals typically provide information specific to identifying a significant discrepancy between intellectual ability and academic achievement.

In conducting an evaluation, schools are encouraged to include criterion-referenced or curriculum-based measures to identify more accurately patterns of strengths and weaknesses and link eligibility determinations to instruction.

In evaluating specific areas of cognitive functioning to determine a pattern of strengths and weaknesses, schools must consider the federal definition of LD as "a disorder in one or more of the basic psychological processes involved in understanding or in using language" (34 CFR §300.8(c)(10). An identified pattern of strengths and weaknesses should be linked to the failure to achieve adequately as described above when used as a determination of LD. Students whose classroom achievement indicates a pervasive weakness that does not constitute a pattern of strengths and weaknesses should not be determined to have a LD. Students who meet the criteria as having mental retardation should not be determined to have a LD.

Professional Judgment:

The determination of LD must be made through the use of professional judgment, including consideration of multiple information/data sources to support the eligibility determination. Information/data sources may include statewide assessment results, formal evaluation test scores (IQ; achievement; cognitive function/processing), RtI progress monitoring data, informal data (e.g. rating scales, student work samples, interviews, parent input) and anecdotal reports. Such information/data sources must include an observation of the child in the child's learning environment as related to the area of LD

Reevaluation:

In conducting a reevaluation for LD eligibility, schools should continue to use a variety of data sources, possibly including an RtI process. During the reevaluation process, schools are encouraged to: 1) use caution in determining that a child is no longer eligible for special education services; 2) carefully consider the child's response to removal of such supports; and 3) examine whether the special education instruction has been appropriate and, if so, whether such evidence argues for a continuation of LD eligibility. A major consideration in the reevaluation process should be the student's ability to meet the instructional demands of grade-level standards without special education and related services.

Written documentation:

Written reports of LD eligibility should include: 1) the basis for making the determination; 2) relevant behavior and medical findings, if any, and; 3) whether the child fails to achieve adequately and does not make sufficient academic progress or exhibits a pattern of strengths and weaknesses. Any data collected as a result of RtI as well as the instructional strategies implemented should be incorporated in the report. The report should also include documentation that the child's parents were notified of: 1) the school policies regarding performance data collected and general education services provided; 2) strategies for increasing the child's rate of learning, and; 3) the parent's right to request an evaluation.

Texas Education Agency. Evaluation of Learning Disability (LD) Eligibility, Retrieved from: http://www.tea.state.tx.us/index2.aspx?id=2147500368

APPENDIX B

Cattell-Horn-Carroll Theory

Cattell-Horn-Carroll Theory of Cognitive Abilities (CHC theory)

CHC Theory is represented by three stratum that are different from each other in generality and extent of ability represented.

Stratum 3: The broadest ability: is representative of a global cognitive ability. Often represented by "g" (little g).

Stratum 2: Nine broad abilities at this level are each distinct from the others.

Stratum 1: Narrow abilities

Cattell-Horn-Carroll (CHC) Broad and Narrow Cognitive Ability Definitions
(3rd draft; 3-11-09; Kevin McGrew)

Fluid reasoning (*Gf*): The use of deliberate and controlled mental operations, often in a flexible manner, to solve novel problems that cannot be performed automatically. Mental operations often include drawing inferences, concept formation, classification, generalization, generating and testing hypothesis, identifying relations, comprehending implications, problem solving, extrapolating, and transforming information. Inductive and deductive reasoning are generally considered the hallmark indicators of *Gf*. *Gf* has been linked to cognitive complexity which is typically defined as the greater use of a wide and diverse array of elementary cognitive processes during performance. Historically is often referred to as fluid intelligence.

General Sequential (deductive) Reasoning (RG): Ability to start with stated assertions (rules, premises, or conditions) and to engage in one or more steps leading to a problem solution. The processes are deductive as evidenced in the ability to reason and draw conclusions from given general conditions or premises to the specific. Often known as hypothetical-deductive reasoning.

Induction (I): Ability to discover the underlying characteristic (e.g., rule, concept, principle, process, trend, class membership) that underlies a specific problem or a set of observations, or to apply a previously learned rule to the problem. Reasoning from specific cases or observations to general rules or broad generalizations. Often requires the ability to combine separate pieces of information in the formation of inferences, rules, hypotheses, or conclusions.

Quantitative Reasoning (RQ): Ability to inductively (I) and/or deductively (RG) reason with concepts involving mathematical relations and properties.

Piagetian Reasoning (RP): Ability to demonstrate the acquisition and application (in the form of logical thinking) of cognitive concepts as defined by Piaget's developmental cognitive theory. These concepts include seriation (organizing material into an orderly series that facilitates understanding of relations between events), conservation (awareness that physical quantities do not change in amount when altered in appearance), classification (ability to organize materials that possess similar characteristics into categories), etc.

Speed of Reasoning (RE): Speed or fluency in performing reasoning tasks (e.g., quickness in generating asmany possible rules, solutions, etc., to a problem) in a limited time. Also listed under *Gs*.

Comprehension-knowledge (*Gc*): The knowledge of the culture that is incorporated by individuals vis-a-vis a process of acculturation. *Gc* is typically described as a person's breadth and depth of acquired knowledge of the language, information and concepts of a specific culture, and/or the application of this knowledge. *Gc* is primarily a store of verbal or language-based declarative (knowing *what*) and procedural (knowing *how*) knowledge acquired through the investment of other abilities during formal and informal educational and general life experiences. Historically is often referred to as crystallized intelligence.

Language Development (LD): General development or understanding and application of words, sentences, and paragraphs (not requiring reading) in spoken native language skills to express or communicate a thought or feeling.

Lexical Knowledge (VL): Extent of vocabulary (nouns, verbs, or adjectives) that can be understood in terms of correct word (semantic) meanings. Although evidence indicates that vocabulary knowledge is a separable component from LD, it is often difficult to disentangle these two highly connected and corrected abilities in research studies.

Listening Ability (LS): Ability to listen and understand the meaning of oral communications (spoken words, phrases, sentences, and paragraphs). The ability to receive and understand spoken information.

General (verbal) Information (K0): Range of general stored knowledge (primarily verbal).

Information about Culture (K2): Range of stored general cultural knowledge (e.g., music, art, literature).

Communication Ability (CM): Ability to speak in "real life" situations (e.g., conversation, lecture, group participation) in a manner that transmits ideas, thoughts, or feelings to one or more individuals.

Oral Production and Fluency (OP): More specific or narrow oral communication skills than reflected by CM. Poorly defined by current research.

Grammatical Sensitivity (MY): Knowledge or awareness of the distinctive features and structural principles of a native language that allows for the construction of words (morphology) and sentences (syntax). Not the skill in applying this knowledge.

Foreign Language Proficiency (KL): Similar to Language Development but for a foreign language.

Foreign Language Aptitude (LA): Rate and ease of learning a new language.

General (domain-specific) knowledge (*Gkn*): The breadth, depth and mastery of a person's acquired knowledge in a specialized (demarcated) subject matter or discipline domains that typically do not represent the general universal experiences of individuals in a culture (*Gc*). *Gkn* reflects deep specialized knowledge domains developed through intensive systematic practice and training (over an extended period of time) and the maintenance of the knowledge base through regular practice and motivated effort (a.k.a., expertise).

Knowledge of English a Second Language (KE): Degree of knowledge of English as a second language.

Knowledge of Signing (KF): Knowledge of finger-spelling and signing (e.g., ASL) used in communication with the deaf or hard of hearing.

Skill in Lip-reading (LP): Competence in ability to understand communication from others by watching the movement of their mouths and expressions (lip reading). Also known as speech reading.

Geography Achievement (A5): Range of geography knowledge (e.g., capitals of countries).

General Science Information (K1): Range of stored scientific knowledge (e.g., biology, physics, engineering, mechanics, electronics).

Mechanical Knowledge (MK): Knowledge about the function, terminology and operation of ordinary tools, machines, and equipment. Since these factors were identified in research prior to the information/technology explosion, it is unknown if this ability generalizes to the use of modern technology (e.g., faxes, computers, internet).

Knowledge of Behavioral Content (BC): Knowledge or sensitivity to nonverbal human communication/interaction systems (beyond understanding sounds and words; e.g., facial expressions and gestures) that communicate feelings, emotions, and intentions, most likely in a culturally patterned style.

Visual processing (*Gv*): The ability to generate, store, retrieve, and transform visual images and sensations. *Gv* abilities are typically measured by tasks (viz., figural or geometric stimuli) that require the perception and transformation of visual shapes, forms, or images and/or tasks that require maintaining spatial orientation with regard to objects that may change or move through space.

Visualization (Vz): The ability to apprehend a spatial form, object, or scene and match it with another spatial object, form, or scene with the requirement to rotate it (one or more times) in two or three dimensions. Requires the ability to mentally imagine, manipulate or transform objects or visual patterns (without regard to speed of responding) and to "see" (predict) how they would appear under altered conditions (e.g., parts are moved or rearranged). Differs from Spatial Relations (SR) primarily by a deemphasis on fluency.

Spatial Relations (SR): Ability to rapidly perceive and manipulate (mental rotation, transformations,
reflection, etc.) visual patterns or to maintain orientation with respect to objects in space. SR may require the identification of an object when viewed from different angles or positions.

Closure Speed (CS): Ability to quickly identify a familiar meaningful visual object from incomplete (e.g., vague, partially obscured, disconnected) visual stimuli, without knowing in advance what the object is. The target object is assumed to be represented in the person's long-term memory store. The ability to "fill in" unseen or missing parts in a disparate perceptual field and form a single percept.

Flexibility of Closure (CF): Ability to identify a visual figure or pattern embedded in a complex distracting or disguised visual pattern or array, when knowing in advance what the pattern is. Recognition of, yet the ability to ignore, distracting background stimuli is part of the ability.

Visual Memory (MV): Ability to form and store a mental representation or image of a visual shape or configuration (typically during a brief study period), over at least a few seconds, and then recognize or recall it later (during the test phase).

Spatial Scanning (SS): Ability to quickly and accurately survey (visually explore) a wide or complicated spatial field or pattern and identify a particular configuration (path) through the visual field. Usually requires visually following the indicated route or path through the visual field.

Serial Perceptual Integration (PI): Ability to identify (and typically name) a pictorial or visual pattern when parts of the pattern are presented rapidly in serial order (e.g., portions of a line drawing of a dog are passed in sequence through a small "window").

Length Estimation (LE): Ability to accurately estimate or compare visual lengths or distances without the aid of measurement instruments.

Perceptual Illusions (IL): The ability to resist being affected by the illusory perceptual aspects of geometric figures (i.e., not forming a mistaken perception in response to some characteristic of the stimuli). May best be thought of as a person's "response tendency" to resist perceptual illusions.

Perceptual Alternations (PN): Consistency in the rate of alternating between different visual perceptions.

Imagery (IM): Ability to mentally depict (encode) and/or manipulate an object, idea, event or impression (that is not present) in the form of an abstract spatial form. Separate IM level and rate (fluency) factors have been suggested.

Auditory processing (*Ga*): Abilities that depend on sound as input and on the functioning of our hearing apparatus. A key characteristic is the extent an individual can cognitively control (i.e., handle the competition between signal and noise) the perception of auditory information. The *Ga* domain circumscribes a wide range of abilities involved in the interpretation and organization of sounds, such as discriminating patterns in sounds and musical structure (often under background noise and/or distorting conditions) and the ability to analyze, manipulate, comprehend and synthesize sound elements, groups of sounds, or sound patterns.

Phonetic Coding (PC): Ability to code, process, and be sensitive to nuances in phonemic information (speech sounds) in short-term memory. Includes the ability to identify, isolate, blend, or transform sounds of speech. Frequently referred to as phonological or phonemic awareness.

Speech Sound Discrimination (US): Ability to detect and discriminate differences in phonemes or speech sounds under conditions of little or no distraction or distortion. Resistance to Auditory Stimulus Distortion (UR): Ability to overcome the effects of distortion or distraction when listening to and understanding speech and language. It is often difficult to separate UR from US in research studies.

Memory for Sound Patterns (UM): Ability to retain (on a short-term basis) auditory events such as tones, tonal patterns, and voices.

General Sound Discrimination (U3): Ability to discriminate tones, tone patterns, or musical materials with regard to their fundamental attributes (i.e., pitch, intensity, duration, and rhythm).

Temporal Tracking (UK): Ability to mentally track auditory temporal (sequential) events so as to be able to count, anticipate or rearrange them (e.g., reorder a set of musical tones). According to Stankov (2000), UK may represent the first recognition of the ability (Stankov & Horn, 1980) that is now interpreted as working memory (MW).

Musical Discrimination and Judgment (U1 U9): Ability to discriminate and judge tonal patterns in music with respect to melodic, harmonic, and expressive aspects (phrasing, tempo, harmonic complexity, intensity variations).

Maintaining and Judging Rhythm (U8): Ability to recognize and maintain a musical beat.

Sound-Intensity/Duration Discrimination (U6): Ability to discriminate sound intensities and to be sensitive to the temporal/rhythmic aspects of tonal patterns.

Sound-Frequency Discrimination (U5): Ability to discriminate frequency attributes (pitch and timbre) of tones.

Hearing and Speech Threshold factors (UA UT UU): Ability to hear pitch and varying sound frequencies.

Absolute Pitch (UP): Ability to perfectly identify the pitch of tones.

Sound Localization (UL): Ability to localize heard sounds in space.

Short-term memory (*Gsm*): The ability to apprehend and maintain awareness of a limited number of elements of information in the immediate situation (events that occurred in the last minute or so). A limited-capacity system that loses information quickly through the decay of memory traces, unless an individual activates other cognitive resources to maintain the information in immediate awareness.

Memory Span (MS): Ability to attend to, register, and immediately recall (after only one presentation) temporally ordered elements and then reproduce the series of elements in correct order.

Working Memory (MW): Ability to temporarily store and perform a set of cognitive operations on information that requires divided attention and the management of the limited capacity resources of short term memory. Is largely recognized to be the mind's "scratchpad" and consists of up to four subcomponents. The *phonological or articulatory loop* processes auditory-linguistic information while the *visuo-spatial sketch/scratchpad* is the temporary buffer for visually processed information. The *central executive* mechanism coordinates and manages the activities and processes in working memory. The most recent component added to the model is the *episodic buffer*. Recent research (see McGrew, 2005) suggests that MW is *not* of the same nature as the other 60+ narrow factor-based trait-like individual difference constructs included in this table. MW is a theoretically developed construct (proposed to explain memory findings from experimental research) and not a label for an individual-differences type factor. MW is retained in the current CHC taxonomy table as a reminder of the importance of this construct in understanding new learning and performance of complex cognitive tasks (see McGrew, 2005).

Long-term storage and retrieval (*Glr*): The ability to store and consolidate new information in long-term memory and later fluently retrieve the stored information (e.g., concepts, ideas, items, names) through association. Memory consolidation and retrieval can be measured in terms of information stored for minutes, hours, weeks, or longer. Some *Glr* narrow abilities have been prominent in creativity research (e.g., production, ideational fluency, or associative fluency).

Associative Memory (MA): Ability to recall one part of a previously learned but unrelated pair of items (that may or may not be meaningfully linked) when the other part is presented (e.g., paired-associative learning).

Meaningful Memory (MM): Ability to note, retain, and recall information (set of items or ideas) where there is a meaningful relation between the bits of information, the information comprises a meaningful story or connected discourse, or the information relates to existing contents of memory.

Free Recall Memory (M6): Ability to recall (without associations) as many unrelated items as possible, in any order, after a large collection of items is presented (each item presented singly). Requires the ability to encode a "superspan collection of material" (Carroll, 1993, p. 277) that cannot be kept active in short-term or working memory.

Ideational Fluency (FI): Ability to rapidly produce a series of ideas, words, or phrases related to a specific condition or object. Quantity, not quality or response originality is emphasized. The ability to think of a large number of different responses when a prescribed task requires the generation of numerous responses. The ability to call up ideas.

Associational Fluency (FA): A highly specific ability to rapidly produce a series of words or phrases associated in meaning (semantically associated; or some other common semantic property) when given a word or concept with a restricted area of meaning. In contrast to Ideational Fluency (FI), quality rather quantity of production is emphasized.

Expressional Fluency (FE): Ability to rapidly think of and organize words or phrases into meaningful complex ideas under general or more specific cued conditions. Requires the production of connected discourse in contrast to the production of isolated words (e.g., FA FW). Differs from FI in the requirement to rephrase given ideas rather than generating new ideas. The ability to produce different ways of saying much the same thing.

Naming Facility (NA): Ability to rapidly produce accepted names for concepts or things when presented with the thing itself or a picture of it (or cued in some other appropriate way). The naming responses must be in an individual's long-term memory store (i.e., objects or things to be named have names that are very familiar to the individual). In contemporary reading research this ability is called *rapid automatic naming* (RAN).

Word Fluency (FW): Ability to rapidly produce isolated words that have specific phonemic, structural, or orthographic characteristics (independent of word meanings). Has been mentioned as possibly being related to the "tip-of-the-tongue" phenomenon (e.g., word finding difficulties) (Carroll, 1993). One of the first fluency abilities identified (Eckstrom et al., 1979).

Figural Fluency (FF): Ability to rapidly draw or sketch as many things (or elaborations) as possible when presented with a non-meaningful visual stimulus (e.g., set of unique visual elements). Quantity is emphasized over quality or uniqueness.

Figural Flexibility (FX): Ability to rapidly change set and try-out a variety of approaches to solutions for figural problems that have several stated criteria. Fluency in successfully dealing with figural tasks that require a variety of problem solving approaches.

Sensitivity to Problems (SP): Ability to rapidly think of a number of alternative solutions to practical problems (e.g., what can people do to stay healthy?). More broadly may be considered the "ability to imagine problems associated with function or change of function of objects and to suggest ways to deal with these problems" Royce (1973). Requires the recognition of the existence of a problem.

Originality/Creativity (FO): Ability to rapidly produce unusual, original, clever, divergent, or uncommon responses (expressions, interpretations) to a given topic, situation, or task. The ability to invent unique solutions to problems or to develop innovative methods for situations where a standard operating procedure does not apply. Following a new and unique path to a problem solution. FO differs from FI in that FO focuses on the quality of creative responses while FI focuses on an individual's ability to think of a large number of different responses.
Learning Abilities (L1): General learning ability rate. Poorly defined by existing research.

Processing Speed (*Gs*): The ability to automatically and fluently perform relatively easy or over-learned
elementary cognitive tasks, especially when high mental efficiency (i.e., attention and focused concentration) is
required

Perceptual Speed (P): Ability to rapidly and accurately search, compare (for visual similarities or differences) and identify visual elements presented side-by- side or separated in a visual field. Recent research (Ackerman et al., 2002; Ackerman & Cianciolo, 2000; Ackerman & Kanfer, 1993; see McGrew, 2005) suggests P may be an *intermediate* stratum ability (between narrow and broad) defined by four narrow sub-abilities: (1) *Pattern Recognition (Ppr)*—the ability to quickly recognize simple visual patterns; (2) *Scanning (Ps)*—ability to scan, compare, and look up visual stimuli; (3) *Memory (Pm)*--ability to perform visual perceptual speed tasks that place significant demands on immediate short-term memory, and (d) *Complex (Pc)*—ability to perform visual pattern recognition tasks that impose additional cognitive demands such as spatial visualization, estimating and interpolating, and heightened memory span loads.

Rate-of-Test-Taking (R9): Ability to rapidly perform tests which are relatively easy or over-learned (require very simple decisions). This ability is not associated with any particular type of test content or stimuli. May be similar to a higher-order "psychometric time" factor (Roberts & Stankov, 1998; Stankov, CHC broad and narrow cognitive ability definitions "working draft" 3-11-09; Kevin McGrew 2000). Recent research has suggested that R9 may better be classified as an *intermediate* (between narrow and broad strata) ability that subsumes most all psychometric speeded measures (see McGrew, 2005).

Number Facility (N): Ability to rapidly perform basic arithmetic (i.e., add, subtract, multiply, divide) and accurately manipulate numbers quickly. N does not involve understanding or organizing mathematical problems and is not a major component of mathematical/quantitative reasoning or higher mathematical skills.

Speed of Reasoning (RE): Speed or fluency in performing reasoning tasks (e.g., quickness in generating as many possible rules, solutions, etc., to a problem) in a limited time. Also listed under *Gf.*

Reading Speed (fluency) (RS): Ability to silently read and comprehend connected text (e.g., a series of short sentences; a passage) rapidly and automatically (with little conscious attention to the mechanics of reading). Also listed under *Grw*.

Writing Speed (fluency) (WS): Ability to correctly copy words or sentences repeatedly, or writing words, sentences, or paragraphs, as quickly as possible. Also listed under *Grw* and *Gps*.

Reaction and decision speed (*Gt*): The ability to make elementary decisions and/or responses (simple reaction time) or one of several elementary decisions and/or responses (complex reaction time) at the onset of simple stimuli. *Gt* is typically measured by chronometric measures of reaction and inspection time.

Simple Reaction Time (R1): Reaction time (in milliseconds) to the onset of a single stimulus (visual or auditory) that is presented at a particular point of time. R1 frequently is divided into the phases of decision time (DT; the time to decide to make a response and the finger leaves a home button) and movement time (MT; the time to move finger from the home button to another button where the response is physically made and recorded).

Choice Reaction Time (R2): Reaction time (in milliseconds) to the onset of one of two or more alternative stimuli, depending on which alternative is signaled. Similar to R1, can be decomposed into DT and MT. A frequently used experimental method for measuring R2 is the Hick paradigm.

Semantic Processing Speed (R4): Reaction time (in milliseconds) when a decision requires some encoding and mental manipulation of the stimulus content.

Mental Comparison Speed (R7): Reaction time (in milliseconds) where stimuli must be compared for a particular characteristic or attribute.

Inspection Time (IT): The ability to quickly (in milliseconds) detect change or discriminate between alternatives in a very briefly displayed stimulus (e.g., two different sized vertical lines joined horizontally across the top).

Psychomotor speed (*Gps*): The ability to rapidly and fluently perform physical body motor movements (e.g., movement of fingers, hands, legs, etc.) largely independent of cognitive control.

Speed of Limb Movement (R3): The ability to make rapid specific or discrete motor movements of the arms or legs (measured after the movement is initiated). Accuracy is not important.

Writing Speed (fluency) (WS): The ability to copy correctly words or sentences repeatedly, or writing words, sentences, or paragraphs, as quickly as possible. Also listed under *Grw* and *Gps*.

Speed of Articulation (PT): Ability to rapidly perform successive articulations with the speech musculature.

Movement Time (MT): Recent research (see summaries by Deary, 2003; Nettelbeck, 2003; also see McGrew, 2005) suggests MT may be an intermediate stratum ability (between narrow and broad strata) that represents the second phase of reaction time as measured by various elementary cognitive tasks (ECTs). The time taken to physically move a body part (e.g., a finger) to make the required response is movement time (MT). MT may also measure the speed of finger, limb, or multi-limb movements or vocal articulation (diadochokinesis; Greek for "successive movements") (Carroll, 1993; Stankov, 2000) and is also listed under *Gt*.

Quantitative knowledge (*Gq*): The breadth and depth of a person's acquired store of declarative and procedural quantitative or numerical knowledge. *Gq* is largely acquired through the investment of other abilities primarily during formal educational experiences. *Gq* represents an individual's store of acquired mathematical knowledge, not reasoning with this knowledge. Factor analysis research has been limited in this domain and other *Gq* narrow abilities most likely exist (e.g., dimensions of early number sense or literacy).

Mathematical Knowledge (KM): Range of general knowledge about mathematics. Not the performance of mathematical operations or the solving of math problems.

Mathematical Achievement (A3): Measured (tested) mathematics achievement.

Reading and writing (*Grw*): The breadth and depth of a person's acquired store of declarative and procedural reading and writing skills and knowledge. *Grw* includes both basic skills (e.g., reading and spelling of single words) and the ability to read and write complex connected discourse (e.g., reading comprehension and the ability to write a story).

Reading Decoding (RD): Ability to recognize and decode words or pseudowords in reading using a number of sub-abilities (e.g., grapheme encoding, perceiving multi-letter units, and phonemic contrasts, etc.)

Reading Comprehension (RC): Ability to attain meaning (comprehend and understand) connected discourse during reading. Verbal (printed) Language Comprehension (V): General development, or the understanding of words, sentences, and paragraphs in native language, as measured by reading vocabulary and reading comprehension tests. Does not involve writing, listening to, or understanding spoken information.

Cloze Ability (CZ): Ability to read and supply missing words (that have been systematically deleted) from prose passages. Correct answers can only be supplied if the person understands (comprehends) the meaning of the passage.

Spelling Ability (SG): Ability to form words with the correct letters in accepted order (spelling).

Writing Ability (WA): Ability to communicate information and ideas in written form so that others can understand (with clarity of thought, organization, and good sentence structure). Is a broad ability that involves a number of other writing sub-skills (e.g., knowledge of grammar, the meaning of words, and how to organize sentences or paragraphs).

English Usage Knowledge (EU): Knowledge of the "mechanics" (capitalization, punctuation, usage, and spelling) of written and spoken English language discourse. CHC broad and narrow cognitive ability definitions "working draft" 3-11-09; Kevin McGrew

Reading Speed (fluency) (RS): Ability to silently read and comprehend connected text (e.g., a series of short sentences; a passage) rapidly and automatically (with little conscious attention to the mechanics of reading). Also listed under *Gs*.

Writing Speed (fluency) (WS): Ability to copy words or sentences repeatedly, or writing words, sentences, or paragraphs, as quickly as possible. Also listed under *Gs* and *Gps*.

Psychomotor abilities (*Gp*): The ability to perform physical body motor movements (e.g., movement of fingers, hands, legs, etc) with precision, coordination, or strength. Movement or motor behaviors are typically the result of mental activity.

Static Strength (P3): The ability to exert muscular force to move (push, lift, pull) a relatively heavy or immobile object.

Multilimb Coordination (P6): The ability to make quick specific or discrete motor movements of the arms or legs (measured after the movement is initiated). Accuracy is not relevant.

Finger Dexterity (P2): The ability to make precisely coordinated movements of the fingers (with or without the manipulation of objects).

Manual Dexterity (P1): Ability to make precisely coordinated movements of a hand, or a hand and the attached arm.

Arm-hand Steadiness (P7): The ability to precisely and skillfully coordinate arm-hand positioning in space.

Control Precision (P8): The ability to exert precise control over muscle movements, typically in response to environmental feedback (e.g., changes in speed or position of object being manipulated).

Aiming (AI): The ability to precisely and fluently execute a sequence of eye-hand coordination movements for positioning purposes.

Gross Body Equilibrium (P4): The ability to maintain the body in an upright position in space or regain balance after balance has been disturbed.

Olfactory abilities (*Go*): Abilities that depend on sensory receptors of the main olfactory system (nasal chambers). The cognitive and perceptual aspects of this domain have not yet been widely investigated.

Olfactory Memory (OM): Memory for odors (smells).

Olfactory Sensitivity (OS): Sensitivity to different odors (smells).

Tactile abilities (*Gh*): Abilities involved in the perception and judging of sensations that are received through tactile (touch) sensory receptors. Includes abilities involved in the judgment of thermal stimulation, spatial stimulation, or patterns imposed on the skin. The cognitive and perceptual aspects of this domain have not yet been widely investigated.

Tactile Sensitivity (TS): The ability to detect and make fine discriminations of pressure on the surface of the skin.

Kinesthetic abilities (*Gk*): Abilities that depend on sensory receptors that detect bodily position, weight, or movement of the muscles, tendons, and joints. Abilities involved in the process of controlling and coordinating body movements, including walking, talking, facial expressions, gestures and posture. The cognitive and perceptual aspects of this domain have not yet been widely investigated.

Kinesthetic Sensitivity (KS): The ability to detect, or be aware, of movements of the body or body parts, including the movement of upper body limbs (arms) and the ability to recognize a path the body previously explored without the aid visual input (blindfolded).

(McGrew & Wendling, 2009).

APPENDIX C

Federal Determination of a Learning Disability

§ 300.309 Determining the existence of a specific learning disability

(a) The group described in §300.306 may determine that a child has a specific learning disability, as defined in §300.8(c)(10), if—

(1) The child does not achieve adequately for the child's age or to meet State-approved grade-level standards in one or more of the following areas, when provided with learning experiences and instruction appropriate for the child's age or State-approved grade-level standards:

(i) Oral expression.

(ii) Listening comprehension.

(iii) Written expression.

(iv) Basic reading skill.

(v) Reading fluency skills.

(vi) Reading comprehension.

(vii) Mathematics calculation.

(viii) Mathematics problem solving.

(2)(i) The child does not make sufficient progress to meet age or State-approved grade-level standards in one or more of the areas identified in paragraph (a)(1) of this section when using a process based on the child's response to scientific, research-based intervention; or

(ii) The child exhibits a pattern of strengths and weaknesses in performance, achievement, or both, relative to age, State-approved grade-level standards, or intellectual development, that is determined by the group to be relevant to the identification of a specific learning disability, using appropriate assessments, consistent with §§300.304 and 300.305; and

(3) The group determines that its findings under paragraphs (a)(1) and (2) of this section are not primarily the result of—

(i) A visual, hearing, or motor disability;

(ii) Mental retardation;

(iii) Emotional disturbance;

(iv) Cultural factors;

(v) Environmental or economic disadvantage; or

(vi) Limited English proficiency.

(b) To ensure that underachievement in a child suspected of having a specific learning disability is not due to lack of appropriate instruction in reading or math, the group must consider, as part of the evaluation described in §§300.304 through 300.306—

(1) Data that demonstrate that prior to, or as a part of, the referral process, the child was provided appropriate instruction in regular education settings, delivered by qualified personnel; and

(2) Data-based documentation of repeated assessments of achievement at reasonable intervals, reflecting formal assessment of student progress during instruction, which was provided to the child's parents.

(c) The public agency must promptly request parental consent to evaluate the child to determine if the child needs special education and related services, and must adhere to the timeframes described in §§300.301 and 300.303, unless extended by mutual written agreement of the child's parents and a group of qualified professionals, as described in §300.306(a)(1)—

(1) If, prior to a referral, a child has not made adequate progress after an appropriate period of time when provided instruction, as described in paragraphs (b)(1) and (b)(2) of this section; and

(2) Whenever a child is referred for an evaluation.

300.307 Specific learning disabilities.

(a) *General.* A State must adopt, consistent with §300.309, criteria for determining whether a child has a specific learning disability as defined in §300.8(c)(10). In addition, the criteria adopted by the State—

(1) Must not require the use of a severe discrepancy between intellectual ability and achievement for determining whether a child has a specific learning disability, as defined in §300.8(c)(10);

(2) Must permit the use of a process based on the child's response to scientific, research-based intervention; and

(3) May permit the use of other alternative research-based procedures for determining whether a child has a specific learning disability, as defined in §300.8(c)(10).

(b) *Consistency with State criteria.* A public agency must use the State criteria adopted pursuant to paragraph (a) of this section in determining whether a child has a specific learning disability. (Authority: 20 U.S.C. 1221e–3; 1401(30); 1414(b)(6))

(Assistance to States for the Education of Children with Disabilities, 2006).

APPENDIX D

Woodcock Johnson III Tests of Cognitive Ability

WOODCOCK-JOHNSON TEST OF COGNITIVE ABILITY, THIRD EDITION (WJ III COG; Woodcock, McGrew, & Mather, 2001)

Description of most commonly assessed cluster scores and the subtest scores which compose the cluster.

Comprehension-Knowledge includes the breadth and depth of a person's acquired knowledge, the ability to communicate one's knowledge, and the ability to reason using previously learned experiences or procedures. It is a store of primarily language-based knowledge. Tests included in this measure are Verbal Comprehension and General Information.

Verbal Comprehension is a measure of acquired knowledge. This test includes four subtests each measuring a different aspect of language development in spoken English language. Picture Vocabulary requires the subject to identify pictures of familiar and unfamiliar objects, measuring lexical knowledge. Synonyms and Antonyms measure separate aspects of vocabulary knowledge. Verbal Analogies measures the subject's ability to reason using lexical knowledge.

General Information measures the depth of one's general knowledge.

Long-Term Retrieval is the ability to store information and fluently retrieve it later in the process of thinking. The tests included in arriving at this score are Visual-Auditory Learning and Retrieval Fluency.

Visual-Auditory Learning is a test of associative and meaningful memory, requiring the subject to learn, store, and retrieve a series of visual-auditory associations.

Retrieval Fluency measures fluency of retrieval from stored knowledge.

Visual-Spatial Thinking is the ability to perceive, analyze, synthesize, and think with visual patterns, including the ability to store and recall visual representations. Tests included in this measure are Spatial Relations and Picture Recognition.

Spatial Relations measures visual-spatial thinking. The task requires that the subject identify the two or three pieces that form a complete target shape.

Picture Recognition measures visual memory of objects or pictures, an aspect of visual-spatial thinking.

Auditory Processing is the ability to analyze, synthesize, and discriminate auditory stimuli, including the ability to process and discriminate speech sounds that may be presented under distorted conditions. Tests included in this measure are Sound Blending and Auditory Attention.

Sound Blending is a test of auditory processing, measuring phonetic coding skills. It measures skill in synthesizing language sounds (phonemes).

Auditory Attention measures an aspect of speech-sound discrimination – the ability to overcome the effects of auditory distortion or masking in understanding oral language. This is a narrow auditory processing ability requiring selective attention.

Fluid Reasoning is a broad ability to reason, form concepts, and solve problems using unfamiliar information or novel procedures. Tests included in this measure are Concept Formation and Analysis-Synthesis.

Concept Formation is a test of fluid reasoning. The task involves categorical reasoning based on principles of inductive logic. This test also measures an aspect of executive processing – flexibility in thinking when required to shift one's mental set frequently.

Analysis-Synthesis is a test of fluid reasoning. It measures general sequential (deductive) reasoning, a thinking ability. The test is a controlled learning task and is designed to measure the ability to reason and draw conclusions from given conditions.

Processing Speed is an aspect of cognitive efficiency. It is the ability to perform automatic cognitive tasks, particularly when measured under pressure to maintain focused attention. Visual Matching and Decision Speed are used to arrive at this score.

Visual Matching is a measure of perceptual speed. It is a measure of the speed at which an individual can make visual symbol discriminations, an aspect of cognitive efficiency

Decision Speed measures the ability to make correct conceptual decisions quickly, an aspect of processing speed. It is a test of cognitive efficiency that measures the speed of processing simple concepts.

Short-Term Memory is an aspect of cognitive efficiency that is evident in the ability to apprehend and hold information in immediate awareness and then use it within a few seconds. Tests included in this measure are Numbers Reversed and Memory for Words.

Numbers Reversed is primarily a measure of short-term memory span, but it can also be classified as a measure of working memory or attentional capacity. The task requires the individual to hold a span of numbers in immediate awareness (memory) while performing a mental operation on it (reversing the sequence).

Memory for Words measures short-term auditory memory span, requiring the subject to repeat lists of unrelated words in the correct sequence.

Phonemic Awareness includes the knowledge and skills related to analyzing and synthesizing speech sounds. This cluster score encompasses the individual tests Sound Blending and Incomplete Words.

Incomplete Words measures auditory analysis and auditory closure, aspects of phonemic awareness and phonetic coding. Results provide information about auditory processing.

Sound Blending is a test of auditory processing, measuring phonetic coding skills. It measures skill in synthesizing language sounds (phonemes).

Working Memory refers to the ability to hold information in immediate awareness while performing a mental operation on the information. Test combined to produce this cluster score are Numbers Reversed and Auditory Working Memory.

Numbers Reversed is primarily a measure of short-term memory span, but it can also be classified as a measure of working memory or attentional capacity. The task requires the individual to hold a span of numbers in immediate awareness (memory) while performing a mental operation on it (reversing the sequence).

Auditory Working Memory measures short-term auditory memory span. It can also be classified as a measure of working memory or divided attention. The task requires the ability to hold information in immediate awareness, divide the information into two groups, and shift attentional resources to the two new ordered sequences.

Broad Attention consists of measures of selective attention, vigilance or sustained attention, divided attention, and attentional capacity. Tests combined to produce this cluster score are Numbers Reversed, Auditory Working Memory, Auditory Attention, and Pair Cancellation.

Numbers Reversed is primarily a measure of short-term memory span, but it can also be classified as a measure of working memory or attentional capacity. The task requires the individual to hold a span of numbers in immediate awareness (memory) while performing a mental operation on it (reversing the sequence).

Auditory Working Memory measures short-term auditory memory span. It can also be classified as a measure of working memory or divided attention. The task requires the ability to hold information in immediate awareness, divide the information into two groups, and shift attentional resources to the two new ordered sequences.

Auditory Attention measures an aspect of speech-sound discrimination – the ability to overcome the effects of auditory distortion or masking in understanding oral language. This is a narrow auditory processing ability requiring selective attention.

Pair Cancellation provides information about executive processing, attention/concentration, and processing speed. The task requires the capacity to stay on task in a vigilant manner. Because the test is timed, it also provides information about the subject's ability to perform a simple cognitive task under time pressure.

The Cognitive Fluency cluster measures the ease and speed by which an individual performs cognitive tasks. Tests combined to produce this cluster score are Retrieval Fluency, Decision Speed, and Rapid Picture Naming.

Retrieval Fluency measures fluency of retrieval from stored knowledge.

Decision Speed measures the ability to make correct conceptual decisions quickly, an aspect of processing speed. It is a test of cognitive efficiency that measures the speed of processing simple concepts.

Rapid Picture Naming measures the narrow ability of naming facility, or the speed of direct recall of information from acquired knowledge. It is a test of cognitive fluency, providing additional information about processing speed.

The Executive Processes cluster includes three aspects of executive functioning: strategic planning, proactive interference control, and the ability to shift repeatedly one's mental set. Tests combined to produce this cluster score are Concept Formation, Planning, and Pair Cancellation.

Concept Formation is a test of fluid reasoning. The task involves categorical reasoning based on principles of inductive logic. This test also measures an aspect of executive processing – flexibility in thinking when required to shift one's mental set frequently.

Planning is a test of executive processing, measuring the mental control process involved in determining, selecting, and applying solutions to problems using forethought. It is a complex task that draws upon fluid reasoning and visual processing abilities.

Pair Cancellation provides information about executive processing, attention/concentration, and processing speed. The task requires the capacity to stay on task in a vigilant manner. Because the test is timed, it also provides information about the subject's ability to perform a simple cognitive task under time pressure (Mather & Jaffe 2004).

APPENDIX E

Woodcock Johnson III Tests of Achievement

Table 1.3 Content and Uses of the WJ III Achievement Clusters (Reading)

Cluster	Tests Required	Uses
Reading Broad Reading	ACH Tests 1,2,9 (Letter-Word Identification, Reading Fluency, Passage comprehension)	Provides a broad measure of readind achievement.
Basic Reading Skills	ACH Tests 1, 13 (Letter-Word Identification, Word Attack)	Provides a measure of both sight and phonic skills
Reading Comprehension	ACH Testss 9, 17 (Passage comprehension, Reading Vocabulary)	Provides a measure of reading comprehension skills ranging from words inisolation to short passages.

(Mather, Wendling, & Woodcock, 2001, p. 11)

Table 1.2 Content and Task Demands of the 22 WJ Achievment Tests

Area	Test Name	Description	Task Demands
Reading	Test 1. Letter Word Identification	Measures an aspect of reading decoding.	Requires identifying and pronouncing isolated letters and words.
	Test 2. Reading Fluency	Measures reading speed.	Requires reading and comprehending simple sentences and then deciding if the statement was true or false by marking yes or no (3-minute time limit)
	Test 9. Passage Comprehension	Measure reading comprehension of contextual information.	Requires readin a short passage and supplying a key missing word.
	Test 13. Word Attack	Measures aspects of phonological and orthographic coding.	Requires applying phonic and strutual analysis skills in pronouncing phonically regular nonsense words.
	Test 17: Reading Vocabulary	Measures reading vocabulary and comprehension.	Requires reading and providing synonyms orantonyms or solving analogies
	Test 21: Sound Awareness	Measures four aspects of phonological awareness: rhyming, deletion, substitution, and reversal.	Requires analyzing and manipulating phonemes.

(Mather, Wendling, & Woodcock, 2001, p. 11)

APPENDIX F

District Testing Guidelines

[redacted]

SLD DETERMINATION: INITIAL

34 CFR 300.7 Children of disabilities. (10) Specific learning disability is defined as follows: (i) General. The term means a disorder in one or more of the basic psychological processes involved in understanding or in using language, (spoken/written), that may manifest itself in an imperfect ability to listen, think, speak, read, write, spell, or to do math calculations, including conditions such as perceptual disabilities, brain injury, minimal brain dysfunction, dyslexia, and developmental aphasia.

[redacted] **Determination of a Specific Learning Disability (SLD)** will be based on an integrated model approach combining Response to Intervention (RtI) and cognitive processing assessment.

FOUR QUESTIONS WILL GUIDE THE ASSESSMENT SPECIALIST IN THIS DETERMINATION

1. **Does the student exhibit a pattern of cognitive strengths and weaknesses?**
2. **Does the student have a normative deficit in academic achievement?**
3. **Is there a relationship between the cognitive deficits and academic deficits?**
4. **Is there evidence of functional impairment?**

1. **Does the student exhibit a pattern of cognitive strengths and weaknesses?**

Cognitive Strengths and Weaknesses: Assessment Specialist completes a full cognitive processing evaluation and determines processing abilities related to the referral question posed by the RtI Team. **Students considered having a condition of a SLD must have significant cognitive deficits that occur within an otherwise well-developed profile of cognitive abilities.** An otherwise well-developed profile must include defined strengths and weaknesses.

A student exhibiting a "flat" profile **must NOT be considered for SLD Eligibility** as they do not demonstrate a pattern of strengths and weaknesses as required in the federal definition. **(C.F.R. §300.311)**

Areas of cognitive processing to be evaluated include but not limited to the following:

- Fluid Reasoning **(Gf)**
- Crystallized intelligence **(Gc)**
- Short-Term Memory **(Gsm)**
- Visual Processing **(Gv)**
- Auditory Processing **(Ga)**
- Long Term Retrieval **(Glr)**
- Processing Speed **(Gs)**

- If administering the WJ III Test of Cognitive Abilities, the following subtests will be administered: 1-7 and 11-17. **It may be necessary to administer 18-20 for students exhibiting weaknesses with organization and/or attention.**
- When using the WJ III Cognitive, a cognitive pattern of strengths and weaknesses is illustrated by **3 or more areas of intra-cognitive discrepancy (utilize Compuscore report profile).** If the profile depicts 2 or less areas and academic deficits have been identified, additional cognitive testing must be administered.

<u>When using Compuscore – select Standard Deviation (SD) of 1.00, Low PR of 16 and High PR of 84. Confidence band should be 68%.</u>

- **If using the WISC-IV, administer Subtests 1-11 to obtain Index Scores and Gf, Gc, Gsm, Gv, Gs. Subtests 12-15 (Cancellation, Word Reasoning, Information and Arithmetic) and tests from the WISC-IV Integrated may also be necessary if subtests scores within the Broad G's are non-unitary. The Assessment Specialist must also supplement with additional cognitive measures to obtain Glr and Ga. For example, the CTOPP or WJ 3 Cog can be used to obtain Ga and the WJ to obtain Glr. See CHC Abilities of Intelligence Chart for specific G's and suggested tests.**

- A pattern of S/W using the WISC-IV is illustrated by a statistical difference between 2 index scores (Index Level Discrepancy) as indicated by a Base Rate of 10% or less.

2. Does the student have a normative deficit in academic achievement?

Academic Deficit: Determining a significant and normative deficit in academic achievement **must include a preponderance of evidence** from a variety of sources that will include **formal** academic achievement testing, a comprehensive review of educational history, **informal evaluation,** criterion-referenced and/or curriculum based data, which may include parent information, teacher input, student interviews/observations, grades and classroom performance (classroom performance MUST include data from more than one year and up to 3 years), and Response to Intervention (RtI) referral documentation.

- **For all Initial Evaluations, the Assessment Specialist will complete a global assessment of ALL academic areas (Basic Reading, Reading Comprehension, Reading Fluency, Written Expression, Math Reasoning, Math Calculations, Oral Expression, and Listening Comprehension) to determine current levels of functioning.**

  If administering the **WJ III Test of Achievement**, the following subtests will be administered: 1, 2, 5-11, 13, 17, and 18

  If administering the **WIAT II** give all subtests.

- **A student's scores will generally be compared to those in enrolled grade level making the use of grade norms, as opposed to age norms, the standard in examining test scores.**

If the student has Standard Scores (SS) of 84 or less in any cluster or subtest from initial global achievement testing **and** has a history of poor academic performance over time, or who has failed or was close to failing TAKS, additional achievement testing in that area(s) will be administered.

** CTOPP must be administered if the referral question suggests a reading disability.*

- **Basic Reading:** For verification of a deficit in basic reading, administer the WIAT-II (Basic Reading), KTEA-II (Letter Word Recognition), WJ-III ACH (Basic Reading Cluster) and/or Woodcock Reading Mastery (Word Identification and Word Attack).

- **Reading Comprehension**: For verification of a deficit in reading comprehension administer the WIAT-II (Reading Comprehension Subtest) KTEA-II (Reading Comprehension), WJ-III (Reading Comprehension Cluster), GORT 4 or Woodcock Reading Mastery Test (Word Comprehension and Passage Comprehension).

- **Reading Fluency**: For a verification of a deficit in reading fluency, WJ-III Reading Fluency subtest or GORT 4, or similar reading fluency test will be used.

- **Math Calculation:** For verification of a deficit in math calculation, all subtests representing the Operations Cluster from KeyMath3 will be used.

- **Math Reasoning:** For verification of a deficit in math reasoning, all subtests representing the Applications Cluster from KeyMath3 will be used.

- **Written Expression:** For verification of a deficit in written expression, the OWLS Written Expression or the TOWL-4 will be used.

- **Listening Comprehension and or Oral Expression):** For verification of a deficit in listening comprehension or oral expression, cluster scores from the OWLS must be used. A referral for a speech language evaluation is not required for a student to be identified as LD in either area of oral language unless the standard score obtained on the OWLS is 78 or less. If SS is 78 or less a referral is made for a speech language evaluation.

3. Is there a relationship between the cognitive deficits and academic deficits?

Determining Relationship between Cognitive Deficit and Academic Deficits

The Assessment Specialist is referred to the LINKING CHC TO INTERVENTION Worksheet Abilities in establishing a link between the cognitive deficit and academic deficit. The weakness **must be a normative weakness SS <84 in both a cognitive area and correlating academic area (giving consideration for the corresponding SEM at the 68% confidence interval).**

Additional testing may be necessary when non-unitary "G's" score are evident. **(Unitary related to cognitive processes =** When the highest & lowest subtest scores do not exceed 1.5 standard deviations).

For example, Standard Scores (SS) with a mean of 100 and Standard Deviation (SD) of 15, a factor would be considered non-unitary if there is a difference of 22 or more points between subtests administered. Scale Scores (ScS)with a mean of 10 and SD of 3, a factor would be considered non-unitary if there is a difference of 5 or more points between subtests administered.

The relationship between the specific cognitive and specific academic weaknesses and the impact the cognitive impairment has on learning must be described and interventions/recommendations provided.

When determining academic functioning, the Assessment Specialist reviews a variety of sources including, but not limited to: RTI data, parent information, teacher, student interviews, criterion-referenced measures, Curriculum Based Assessment (CBA), TAKS, Benchmarks, reading probes, and fluency probes.

*****Exclusionary factors** – The multi-disciplinary team has determined that the findings are not primarily the result of visual, hearing, or motor disability; mental retardation; emotional disturbance; cultural factors; environmental or economic disadvantage; or limited English proficiency; and is not due to lack of appropriate instruction in reading and mathematics.

4. Is there evidence of functional impairment?

Functional Impairment: The degree of deficit/impairment will be determined by the normative data gathered when answering questions 1-3. Whether the pattern of strengths and weaknesses is consistent with the condition of a SLD is determined by the assessment specialist (SLD Criteria is determined by the Assessment Specialist) and the recommendation is made to the ARD Committee to establish a SLD. The ARDC may accept the recommendation of SLD, or reject and ask for additional evaluation.

Cognitive Processing/Evaluation notes:

Assessment tools/procedures:

WECHSLER SCALES: WISC IV, WPPSI III, WAIS-III Administer subtests 1-11 to obtain Index Scores, **but must supplement to address all G's. Additional G's to obtain for WISC IV and WAIS III: Glr, Ga (WPPSI: Glr, Ga, Gsm)**

WISC- IV Integrated (refer to manual pg. 108) may be utilized when non-unitary index scores are revealed on the WISC IV for memory and processing speed domains, but the Assessment Specialist must supplement with other cognitive measures to obtain Ga and Glr.

WJ-COG III (standard battery + extended battery necessary to ID cognitive categories, CHC factors, or clinical clusters – must give subtests 1-20)

Stanford Binet; 5; may be utilized to determine cognitive processing abilities if used with other cognitive measurements to establish all 7 G's. **Additional G's to obtain: Glr, Ga, Gs**

KABC II (K or younger students only), may be utilized to determine cognitive processing abilities if used with other cognitive measurements to establish all 7 G's. **Additional G's to obtain: Ga and Gs**

CTOPP must be administered by Assessment Specialist if the referral question suggests a reading disability (provides Ga and Glr processing information).

When identifying a Specific Learning Disability, Nonverbal measures **(UNIT, Naglieri, WISC-Nonverbal, and/or Leiter-R)** may be used **only** after a complete measure of cognitive processing ability has been administered and the verbal scores are significantly below predicted index scores as these nonverbal measures do not identify all of the required elements of processing related to learning. Note: This applies to LD only evaluations.

Observation

The Assessment Specialist must ensure that the child is observed in the child's learning environment (including the regular classroom setting or natural environment if preschool aged) to document the child's academic performance and behavior in the areas of suspected difficulty. Best practice suggests the Assessment Specialist complete the observation. Federal regulations specify someone other than the general education teacher complete the observation.

Visual-Motor Integration

VMI or Bender may be used when appropriate as evidenced by referral data. For students **referred for academic/learning problems in mathematics or writing** a test of visual-motor integration **must be administered.**

Achievement Testing LD

Wechsler Individual Achievement Test-II **(WIAT-II)**
Woodcock Johnson Tests of Achievement III **(WJ Ach III)**
Gray Oral Reading Testing-4 **(GORT-4)**
Kaufman Test of Educational Achievement **(KTEA-II)**
Oral and Written Language Scales **(OWLS)**
Test of Written Language-4 **(TOWL-4)**
Woodcock Test of Reading Mastery, KeyMath-3 and other district approved assessment tools deemed necessary.

WJ-Ach III – Review Relative Proficiency Index **(RPI)**; RPI is considered to be significant when the ratio is 75/90 or below. See below.

Relative Processing Index (RPI): 20/90 means the individual has 20 percent mastery or proficiency on the task on which average age or grade peers have 90 percent mastery.

RPI	Instructional Level
96/90 to 100/90	Independent
76/90 to 95/90	Instructional
75/90 and below	Frustration

Appendix G

IRB Approval Letter

TWU
TEXAS WOMAN'S UNIVERSITY
DENTON DALLAS HOUSTON

Institutional Review Board
Office of Research and Sponsored Programs
P.O. Box [illegible] Denton, TX [illegible]
[illegible]
email: [illegible]

September 23, 2010

Ms. Lynda Nielsen
[redacted]

Dear Ms. Nielsen:

Re: *An Investigation of Cognitive Measures of Elementary Students Identified as Having a Specific Learning Disability (Protocol #: 16270)*

The above referenced study has been reviewed by the TWU Institutional Review Board (IRB) and was determined to be exempt from further review.

If applicable, agency approval letters must be submitted to the IRB upon receipt PRIOR to any data collection at that agency. Because a signed consent form is not required for exempt studies, the filing of signatures of participants with the TWU IRB is not necessary.

Any modifications to this study must be submitted for review to the IRB using the Modification Request Form. Additionally, the IRB must be notified immediately of any unanticipated incidents. If you have any questions, please contact the TWU IRB.

Sincerely,

Kathy DeOrnellas, Ph.D.

Dr. Kathy DeOrnellas, Chair
Institutional Review Board - Denton

cc. Dr. Jano Pemberton, Department of Teacher Education
Graduato School

APPENDIX H

Data Collection Sheet

Data Collection Form

Table #1.

Students		**Demographics**				**Cognitive Scores Cluster Scores**							**Achievement Scores**		
Students	DOB	Gender	Age	Gr	Eth	*Gc*	*Gf*	*Gs*	*Ga*	*Glr*	*Gsm*	*Gv*	BRS	RC	RF
Student #1															
Student #2															

	Cognitive Subtest Scores of Woodcock Johnson III Tests of Cognitive Ability													
Students	VC	VA	SV	SB	CF	VM	NM	GI	RF	PR	AA	AS	DS	MW
Student #1														
Student #2														