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Use of Cattell-Horn-Carroll Specific Cognitive Abilities to Enhance Prediction of Reading on the Third Grade Pennsylvania System of State Assessment

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USE OF CATTELL-HORN-CARROLL SPECIFIC COGNITIVE ABILITIES TO ENHANCE PREDICTION OF READING ON THE THIRD GRADE PENNSYLVANIA SYSTEM OF STATE ASSESSMENT

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Title: Use of Cattell-Horn-Carroll Specific Cognitive Abilities to Enhance Prediction of Reading on the Third Grade Pennsylvania System of State Assessment

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This correlational study examines three models of prediction with regard to 69 kindergarten and first grade students’ later reading achievement on a third grade state assessment.

The first model of prediction analyzed sex, age and maternal level of education as predictors of reading performance on the third grade Pennsylvania System of State Assessment (PSSA). The second model of prediction examined the ability of the Dynamic Indicators of Basic Early Literacy Skills (DIBELS) Phoneme Segmentation Fluency (PSF) measure to predict reading achievement on the PSSA. The third model analyzed the use of Cattell-Horn-Carroll (CHC) specific cognitive abilities to enhance the prediction of PSF of reading achievement.

The results from the analysis (Kendall’s Tau B) showed no significant correlation between the baseline predictor variables (sex, age, and maternal level of education) and student performance on the PSSA. Similarly, in the second model, student performance on the PSF measure of the DIBELS revealed no relationship with later reading achievement. In the third model, CHC specific cognitive abilities did not enhance the prediction of reading performance. Although there was one correlation of significance between fluid intelligence (Gf) and PSSA scores, the sample size was too low to allow for generalizability. Additionally, Gf is not one of the CHC factors linked to reading achievement in the literature.

Restriction of ranges may have affected the results in that the majority of the students were in special education, and half of the sample was not proficient on the PSSA.

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CHAPTER I

INTRODUCTION

The No Child Left Behind Act of 2001 (NCLB) implemented a nationwide mandate that all children read proficiently by third grade. Utilizing the National Reading Panel’s report as a guideline, children are expected to perform at or above grade level in the five areas of reading: phonemic awareness, phonics, fluency, vocabulary, and comprehension (National Reading Panel, 2000). Furthermore, NCLB mandated statewide accountability testing to gauge student progress. Because the state achievement test is administered only once during the school year, there is less information provided about student growth over shorter time periods. The impact of high stakes testing has encouraged school districts to implement more frequent monitoring of student academic outcomes to identify those students potentially at risk for not reaching proficiency levels (Shapiro, Solari, & Petscher, 2008). Consequently, schools are faced with the challenge of implementing assessment practices that satisfactorily measure progress and inform administrators and teachers when instructional methods need to be altered.

One commonly employed method for large-scale screening of student progress is curriculum based measurement (CBM). Curriculum-based measurement is an approach for assessing the growth of students in basic skills and involves repeated measurements on equivalent forms of the same task across extended periods of time. It involves short duration fluency measures and provides teachers with a method of evaluating the effectiveness of their instructional interventions (Deno, 1992; Shinn, 1992). Although CBM was originally intended to monitor progress of special education students, its use has expanded to decisions that include screening to identifying, evaluating prereferral interventions, determining eligibility for remedial and special education programs, evaluating instruction, and evaluating reintegration and inclusion of students in mainstream programs (Deno, 2003). More recently, research has been conducted on utilizing curriculum-based measurement to predict performance on high stakes assessment (Crawford, Tindal, & Stieber, 2001; Keller-Margulis, Shapiro, & Hintze, 2008; McGlinchey & Hixson, 2004; Shapiro, et al., 2008; Silberglitt, Burns, Madyun, & Lail, 2006; Stage & Jacobsen, 2001).

One such measure that has appeared consistently in the literature is the Dynamic Indicators of Basic Early Literacy Skills (DIBELS). The DIBELS can be administered to students in kindergarten through third grade and are comprised of five measures: Initial Sound Fluency, Phoneme Segmentation Fluency, Letter Naming Fluency, Nonsense Word Fluency, and Oral Reading Fluency. Initial Sound Fluency and Phoneme Segmentation Fluency are intended to assess phonological awareness while the remaining three measures tap into vocabulary, fluency and comprehension (Good & Kaminski, 2002). Students are not screened in all five areas; rather they are assessed with the developmentally appropriate measures based upon their grade level. Within the existing literature on DIBELS, the Oral Reading Fluency (ORF) measure in particular is utilized to predict later reading achievement.

Despite the plethora of research (Crawford et al., 2001; Keller-Margulis et al., 2008; McGlinchey & Hixson, 2004; Shapiro et al., 2008; Silberglitt et al., 2006; Stage & Jacobsen, 2001) that consistently links oral reading fluency to reading achievement, it is important to also examine students’ foundation skills by assessing phonemic awareness. Cunningham (1990) defines phonemic awareness as the ability to explicitly manipulate speech segments at the phoneme level. Similarly, Adams, Foorman, Lundberg, and Beeler (1998) define phonemic awareness as an awareness that language is composed of small units of speech that correspond to letters of an alphabetic writing system. These small units of speech are the actual phonemes within words. For example, the word pat consists of three distinct phonemes /p/, /a/, and /t/. The utility of phonemic awareness for early literacy skills is based on the idea that children must demonstrate an understanding of the sound structure of language prior to associating individual sounds with letters. Once sound awareness is established, the child progresses to sound-symbol correspondence and, ultimately, reading words. While a reading assessment can include measures of the broader, more general level of sound structure, phonological awareness, phonemic awareness has the strongest relationship to later reading and most tests focus on this level of sound awareness (Shaywitz, 2003) It is therefore important that schoolwide screening measures for reading include a measure of phonemic awareness such as that of the Phoneme Segmentation Fluency (PSF) measure of the DIBELS.

As a result of schoolwide screening, in conjunction with other available data, students at risk for reading difficulties are targeted for intervention, such as remedial reading programs. Students who encounter significant reading problems despite substantial intervention are typically referred to school psychologists for more in depth, comprehensive examination of their abilities. The traditional method of evaluating a student suspected of having a reading disability includes the administration of a cognitive measure. There are differing schools of thought on what specific cognitive abilities may contribute in explaining school achievement. Many school psychologists seek to establish a general ability level with which to predict academic outcomes. However, others favor the interpretation of specific intellectual constructs based on the belief that subtest scores yield useful diagnostic and treatment information (McGrew, Flanagan, Keith, & Vanderwood, 1997).

One particular theory of intelligence, the Cattell-Horn-Carroll (CHC) theory, supports the latter method of interpretation. CHC theory is perhaps the most well-researched framework of the structure of intelligence to date (Evans, Floyd, McGrew, & Leforgee, 2002; McGrew et al., 2008). Its thrust is that intelligence is best explained in terms of distinct ability and processing domains through the operationalization of broad and narrow cognitive abilities/processes. Based upon CHC theory and developed in the late 1990s, the Cross Battery Assessment (XBA) approach is a method by which more than one of the major intelligence tests can be administered to garner information on broad and narrow cognitive abilities. The cross-battery assessment method provides meaningful diagnostic data that affords the clinician insight into specific abilities that relate to academic skill areas (Flanagan, Ortiz, & Alfonso, 2007). Flanagan and colleagues stated “The XBA approach allows practitioners to reliably measure a wider range (or a more in-depth but selective range) of cognitive abilities/processes than that represented by a single intelligence battery.” In this regard, cross-battery assessment appears to be an essential tool for the school psychologist in identifying a student’s cognitive strengths and weaknesses and how they manifest in relation to acquisition of reading skills.

The Problem

Given the enormous impact of recent federal legislation on schools’ accountability for academic outcomes, there is substantial pressure on districts to identify and improve student performance, particularly in reading. School districts are in need of reading assessment that provides more frequent progress monitoring and is predictive of student performance on yearly state assessments. Curriculum-based measurement is becoming a more common practice for this purpose; however, additional research is needed to establish its predictive validity. This study will examine the utility of the DIBELS Phoneme Segmentation Fluency measure in predicting reading performance on the third grade Pennsylvania System of State Assessment (PSSA).

Simultaneously, it will measure the impact of children’s sex and age, as well as their mothers’ level of education on later reading performance. Because maternal level of education has been cited in the literature as being an influential factor on childhood reading development, it will be examined as a predictor in this study. According to the United States Department of Education (2001), having a mother with low education is one of the factors that may affect a child’s skills upon entering kindergarten. This is supported by other research that cites social and economic disadvantage as a negative factor in children’s development of letter knowledge and phonological awareness skills (Burt et al., 1999; Hale & Fiorello, 2004; McIntosh, Crosbie, Holm, & Dodd, 2007; Phillips et al., 2008). Because those children from low SES backgrounds tend to have less educated mothers, they receive less exposure to books and informal reading instruction.

Secondly, when students are referred to school psychologists for a psychoeducational evaluation, cognitive assessment is traditionally utilized to obtain a measure of ability for diagnostic purposes and decisions regarding educational programming. Historically, school psychologists differ in their practices regarding cognitive assessment. While some prefer to obtain a global measure of intelligence with which to diagnose reading problems, others subscribe to the theory that utilizing multiple specific cognitive abilities related to reading achievement is theoretically and technically a more sound practice. This study will examine the validity of specific cognitive abilities in predicting reading achievement on yearly state assessment. Additionally, it will measure the ability of specific cognitive abilities to enhance CBM’s predictive power of later reading achievement.

Research Questions

The following research questions will be addressed in this study.

1) Do sex, age, and maternal level of education predict third grade PSSA reading scores?
2) Does the DIBELS Phoneme Segmentation Fluency measure enhance the prediction of third grade PSSA reading scores?
3) Do CHC specific cognitive abilities enhance the prediction of PSF of third grade PSSA reading scores? Which of the CHC specific cognitive abilities are predictive of PSSA scores?

Hypotheses

To answer research questions 1 through 6, the following hypotheses were developed.

1) Do sex, age, and maternal level of education predict third grade PSSA reading scores? The research hypothesis is that sex will not be predictive of PSSA scores. Although there is a paucity of research in this area, recent studies indicate that sex is not a factor in performance on phonological awareness tasks (Burt, Holm, & Dodd, 1999; Nancollis, Lawrie, & Dodd, 2005). Pertaining to age, the hypothesis is that there will be a positive correlation between student age and performance on the third grade PSSA. Because phonological awareness has a developmental progression, older children should possess better phonological awareness skills. This hypothesis is based upon research stating that certain phonological skills are acquired earlier than others with a naturally occurring progression (Lane, Pullen, Eisele, & Jordan, 2002; Majsterek & Ellenwood, 1995; Shaywitz, 2003). The third hypothesis for this research question is that higher maternal level of education will correlate positively with higher student performance on the PSSA. Because educated parents tend to read to their children and promote the importance of reading more than less educated parents, their children are likely to possess stronger reading skills. This

hypothesis is supported by the research indicating that disadvantaged children enter school with lower levels of letter knowledge and phonemic awareness (Hale & Fiorello, 2004; Phillips, Clancy-Menchetti, & Lonigan, 2008).

2) Does the DIBELS Phoneme Segmentation Fluency measure enhance the prediction of third grade PSSA reading scores? The research hypothesis is that there will be a positive correlation between PSF scores and PSSA scores. It is well established that phonological awareness skills are a necessary predecessor to word reading and an excellent predictor of later reading success (Castle, 1999; Juel, 1988; McBride-Chang, Wagner, & Chang, 1997; Snider, 1997; Torgesen, Wagner, Bryant, & Pearson, 1992; Yopp, 1992). Additionally, research has consistently demonstrated a robust relationship between reading curriculum-based measurement and performance on the state high-stakes assessment (Crawford et al., 2001; Keller-Margulis et al., 2008; McGlinchey & Hixson, 2004; Shapiro et al., 2008; Silberglitt et al., 2006; Stage & Jacobsen, 2001).
3) Do CHC specific cognitive abilities enhance the prediction of PSF of third grade PSSA reading scores? Which of the CHC specific cognitive abilities are predictive of PSSA scores? The hypothesis is that Ga (auditory processing), Glr (long-term storage and retrieval), Gs (processing speed), Gc (language development), and Gsm (short-term memory) will each be predictive of reading achievement because they have each shown strong and consistent relationships with reading achievement (Flanagan, Ortiz, Alfonso, & Dynda, 2008; McGrew, 2005). There is no hypothesis as to which specific ability will demonstrate the strongest relation.

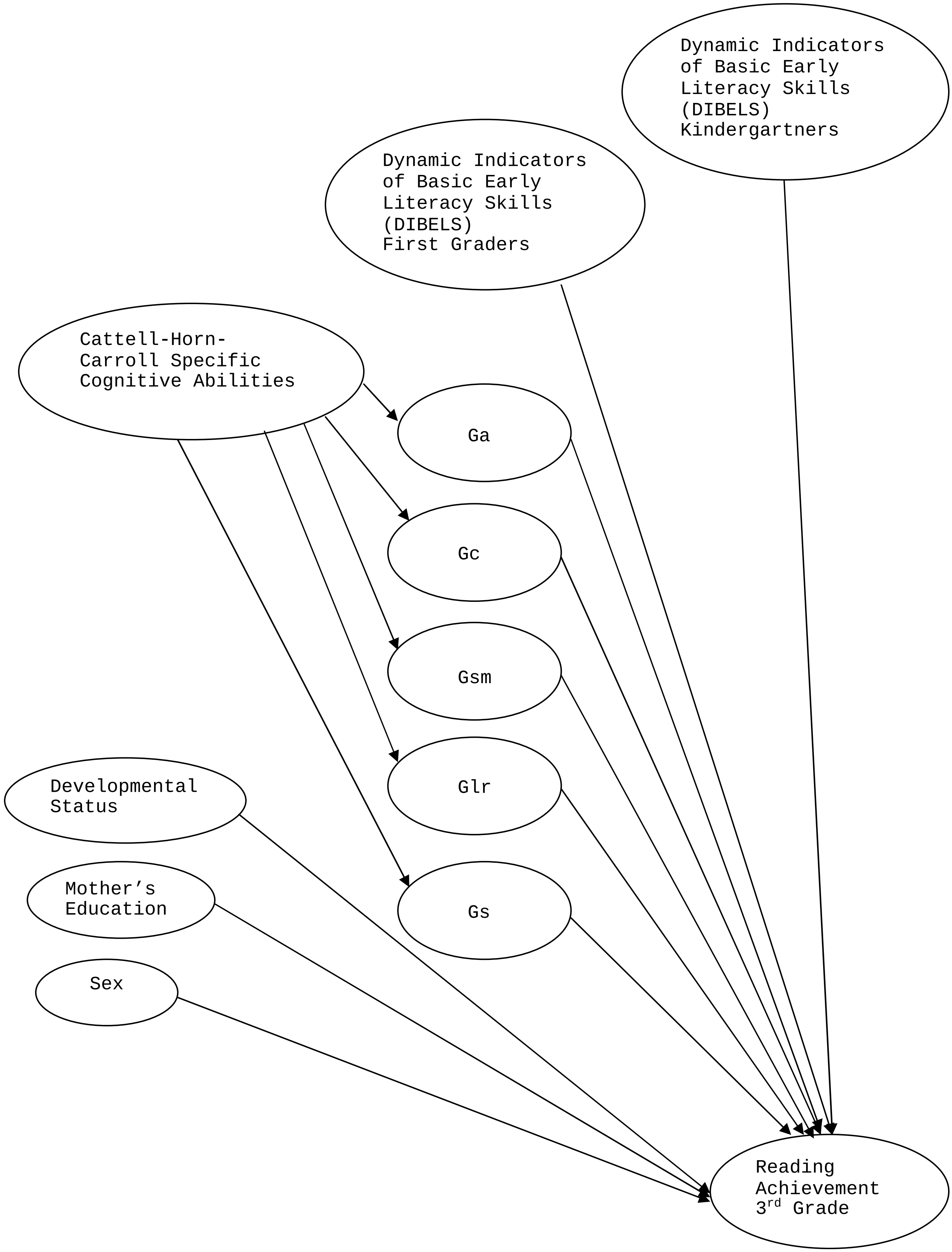

Figure 1. Research path diagram of the latent variables.

Problem Significance

Given the ever-increasing importance of reading assessment, it is vital that school districts secure a time efficient and accurate method of identifying struggling readers. Although psychoeducational evaluations have traditionally entailed both cognitive and curriculum-based measurement, it is necessary to determine if predictive power is enhanced by utilizing both types of assessment. This study will examine the ability of the DIBELS Phoneme Segmentation Fluency measure to predict future reading performance on the 3rd grade PSSA. Additionally, it will attempt to determine if predictive ability is enhanced by utilizing CHC specific cognitive abilities.

Definitions

Cattell-Horn-Carroll (CHC) theory: A multifactor theory of intelligence that integrates the Cattell-Horn Gf-Gc theory and the Carroll Three-Sratum theory. It is composed of 10 broad and more than 70 narrow cognitive abilities/processes (Flanagan et al., 2008; McGrew, 2005).

Auditory processing (Ga): Ga is a CHC ability that represents the extent to which an individual can cognitively “control” the perception of auditory information and includes a wide range of abilities involved in discriminating patterns in sounds and musical structure, as well as the abilities to analyze, manipulate, comprehend, and synthesize sound elements, groups of sounds, or sound patterns (McGrew, 2005).

Crystallized intelligence/knowledge (Gc): Gc is a CHC ability that represents a person’s wealth of acquired knowledge of the language, information and concepts of a specific culture, and/or the application of this knowledge (McGrew, 2005).

Fluid intelligence (Gf): Gf is a CHC ability that represents the ability to use deliberate and controlled mental operations to solve novel, “on-the-spot” problems (McGrew, 2005).

Long-term storage and retrieval (Glr): Glr is a CHC ability that represents the ability to store and consolidate new information in long-term memory, and later fluently retrieve the stored information through association (McGrew, 2005).

Processing speed (Gs): Gs is a CHC ability that represents the ability to automatically and fluently perform relatively easy or overlearned cognitive tasks, especially when high mental efficiency is required (McGrew, 2005).

Short-term memory (Gsm): Gsm is a CHC ability that represents the ability to apprehend and maintain awareness of elements of information in the immediate situation (McGrew, 2005).

Visual-spatial abilities (Gv): Gv is a CHC ability that represents a collection of different abilities emphasizing different processes involved in the generation, storage, retrieval, and transformation of visual images (McGrew, 2005).

Cross-battery assessment (XBA): A contemporary method of cognitive assessment that is grounded in CHC theory and research, and that utilizes a wider range of cognitive abilities/processes than that represented by a single intelligence battery (Flanagan et al., 2007).

Curriculum-based measurement (CBM): CBM is a method of monitoring student progress through direct assessment of academic skills. CBM is characterized by quick, easy to administer, and psychometrically solid measures that can be frequently administered to assess and monitor student performance (Deno, 1992).

Dynamic Indicators of Basic Early Literacy Skills (DIBELS): DIBELS are a set of quick measures for assessing the acquisition and progress of early literacy skills from kindergarten through third grade (Good & Kaminski, 2002).

Letter Naming Fluency (LNF): A DIBELS measure that assesses a child’s skill at identifying upper and lower case letters of the alphabet (Good & Kaminski, 2002).

Initial Sounds Fluency (ISF): A DIBELS measure that assesses a child’s skill at identifying and producing the initial sound of a given word (Good & Kaminski, 2002).

Nonsense Word Fluency (NWF): A DIBELS measure that assesses a child’s knowledge of letter-sound correspondence and ability to blend letters together to form unfamiliar “nonsense” words (Good & Kaminski, 2002).

Oral Reading Fluency (ORF): A DIBELS measures that assesses a child’s understanding of verbally read connected text (Good & Kaminski, 2002).

Phoneme Segmentation Fluency (PSF): A DIBELS measure that assesses a child’s skill at producing the individual sounds within a given word (Good & Kaminski, 2002).

Phoneme: A small unit of speech that corresponds to a letter of an alphabetic writing system (Adams et al., 1998).

Phonemic awareness: One aspect of phonological awareness; the ability to explicitly manipulate speech segments at the phoneme level (Cunningham, 1990).

Phonics: An instructional approach to assist children in making connections between sounds and letters (Lane et al., 2002).

Phonological awareness: One’s sensitivity to the sound structure of one’s own language and the ability to access and manipulate it (Bishop & Snowling, 2004; Havey, Story, & Buker, 2002; Kameenui, 1996; Lane et al.; McBride-Chang et al., 1997; Wagner, Torgesen, Laughon, Simmons, & Rashotte, 1993).

Assumptions

Reading assessment should be driven by data that will accurately identify deficits, inform instructional interventions, and predict later achievement.

Limitations

The race composition of this sample may not apply to most urban areas, in that those populations will likely be more diverse than the predominantly Caucasian sample in this study.

Summary

This chapter discussed the importance of early reading assessment as it relates to federal and state mandates involving student reading performance. The utility of curriculum-based measurement in predicting reading achievement on state assessment was discussed. One specific measure, the Dynamic Indicators of Basic Early Literacy Skills (DIBELS), was described. Cognitive assessment was discussed, as well as its relationship to reading outcomes. The Cattell-Horn-Carroll theory was highlighted followed by a description of the Cross-Battery method of cognitive assessment. Finally, research questions and their corresponding hypotheses were stated.

CHAPTER II

LITERATURE REVIEW

The following literature review will discuss the importance of reading assessment due to federal and state mandates and the accountability issue involved in annual high stakes testing. Assessment of reading via the Dynamic Indicators of Basic Early Literacy Skills (DIBELS) will be presented. Cognitive assessment and its relationship to reading achievement will be discussed. The Cattell-Horn-Carroll (CHC) theory will be presented, followed by a discussion of the factors that are linked to reading achievement. Concluding the chapter, the Cross Battery Assessment (XBA) approach to cognitive assessment will be addressed.

Reading Accountability

Never has there been a greater need for schools to implement an assessment process that accurately measures student progress in reading. Federal legislation mandates that all children read proficiently by third grade and states are required to administer high stakes testing as an accountability measure. Given the enormous pressure on school districts to produce capable readers, early progress monitoring has become vital. Crawford et al. (2001) stated four reasons that students' academic progress should be closely monitored through the use of other measurement systems:

1. Statewide testing programs often involve a format that is difficult for teachers to replicate at the classroom level.
2. Decisions being made are so important that other confirming information is needed to complement the data.
3. Teachers need other performance indicators, related to statewide tests that are available more frequently so that instructional programs can be improved in a timely fashion.

4. Statewide tests may be insensitive to change for low performing students.

Many districts have adopted the practice of large-scale screening to monitor student progress and identify those who are not progressing at expected levels. Once struggling readers are identified, teachers are better able to alter instructional strategies and more intensive intervention can be initiated through remedial reading programs if necessary and/or the building level student assistance team. A more recent but increasingly common practice is to utilize results of large-scale screening to predict performance on state-mandated assessment (Deno, 2003). Several studies have used an Oral Reading Fluency (ORF) measure to assess students' reading progress and predict later reading outcomes (Crawford et al., 2001; Keller-Margulis et al., 2008; McGlinchey & Hixson, 2004; Shapiro, et al., 2008; Silberglitt et al., 2006; Stage & Jacobsen, 2001).

Stage and Jacobsen (2001) conducted a study to determine the relationship between fourth grade students' skill in oral reading fluency and the state reading assessment conducted in May of the school year. The authors found that oral fluency rates improved the prediction of state assessment performance above that based on the base rates of students passing and failing the test. A subsequent study replicated the previous study with a different state fourth grade test across 8 years, a much larger sample, and a more diverse student population (McGlinchey & Hixson, 2004). Results indicated a moderately strong relationship between oral reading rates and performance on the state assessment. Similar to results from the Stage and Jacobsen study, oral reading fluency improved the prediction of performance on a state fourth-grade reading assessment above that based on the base rates of passing and failing. A different study completed by Keller-Margulis et al. (2008) examined the utility of oral reading fluency in predicting performance on a different statewide achievement test. The results demonstrated that ORF accurately predicted both reading and math achievement on the state-mandated test. Specifically, there was a significant relation between curriculum-based measurement (CBM) data in reading and math and performance on the third-grade state achievement test 1 and 2 years later. The results of this study strongly supported the long-term diagnostic accuracy of CBM scores and performance on state assessment in a different state than those of previous studies. Crawford et al., (2001) also examined the validity of an oral fluency measure in predicting performance on statewide achievement tests in reading and math. Consistent with the previous study, they found support for use of timed oral readings to predict students’ performance. Yet another study examined the diagnostic accuracy of two reading screening measures as well as the degree to which adding a reading comprehension screening measure enhanced the prediction of oral reading fluency to student reading performance on the yearly state assessment for grades 3 through 5 (Shapiro et al., 2008). The results demonstrated a strong relationship between ORF and overall reading outcomes and also that the addition of a reading comprehension measure enhanced the prediction of student performance. This study supports the previous research indicating a robust relationship between reading CBM scores and student performance on state high-stakes assessment in third and fourth grades. Last, a study by Roehrig, Petscher, Nettles, Hudson, & Torgesen (2008) evaluated the validity of the Dynamic Indicators of Basic Early Literacy Skills (DIBELS) Oral Reading Fluency measure for predicting performance on the state high stakes assessment as well as the Stanford Achievement Test (SAT-10) reading comprehension measures. The Oral Reading Fluency measure was found to be predictive of student performance on both the state assessment and the SAT, with the third administration of ORF having the strongest correlations. Additionally, the ORF scores predict performance on the state test equally well for students from different SES, language and race/ethnicity categories.

Dynamic Indicators of Basic Early Literacy Skills (DIBELS)

Curriculum-based measurement allows for ongoing assessment and prescriptive intervention of reading skills. One commonly used instrument is the Dynamic Indicators of Basic Early Literacy Skills. Based upon early literacy domains discussed by both the National Reading Panel and the National Research Council, the measures are designed to assess development of phonological awareness, alphabetic understanding, and automaticity and fluency. The DIBELS consist of five one minute fluency measures: Initial Sound Fluency, Phoneme Segmentation Fluency, Nonsense Word Fluency, Letter Naming Fluency, and Oral Reading Fluency. No student is administered all five measures. For instance, only kindergarten students would be administered Initial Sound Fluency because it is developmentally appropriate for this age level while first graders would be expected to have mastered this skill. Initial Sound Fluency and Phoneme Segmentation Fluency together are intended to assess phonological awareness, while the other measures are delineated into categories that reflect the alphabetic principle, vocabulary, and fluency and comprehension (Good & Kaminski, 2002).

In their validity study of the DIBELS with kindergartners in a large urban school district, Rouse and Fantuzzo (2006) revealed favorable results for the DIBELS as a psychometrically sound screening tool. Evidence for predictive validity was found in that Letter Naming Fluency, Nonsense Word Fluency, and Phoneme Segmentation Fluency correlated significantly to the outcomes of reading, vocabulary, and language constructs measured at the end of first grade. Convergent and discriminant validity were assessed for three literacy indicators of the DIBELS and found to have strong positive relationships with indicators of overall reading ability. The authors indicate that the predictive validity findings strongly support the utility of the DIBELS for identifying early reading deficits in kindergartners in urban public school settings.

Hintze, Ryan, and Stoner (2003) studied the degree to which the DIBELS correlated with the Comprehensive Test of Phonological Processing (CTOPP), another standardized measure of prereading skills. Their findings yielded a strong positive correlation between the DIBELS and the subtest and composite scores of the CTOPP that measure phonological awareness and memory. As would be anticipated, the Initial Sound Fluency task of the DIBELS correlated most strongly with the Elision, Blending Words, Sound Matching and NonWord Repetition subtests of the CTOPP. Additionally, Initial Sound Fluency was strongly linked with the Phonological Awareness Composite of the CTOPP and demonstrated a moderate relationship with the Phonological Memory Composite as well. Similar to Initial Sound Fluency, the Phoneme Segmentation Fluency task of the DIBELS also displayed moderate to strong correlations with the Elision, Blending Words, and Phonological Awareness Composite portions of the CTOPP. The authors concluded that there was sufficient evidence to assert that the two instruments are measuring a similar construct.

Elliott, Lee, and Tollefson (2001) completed a reliability and validity study of the DIBELS that was an extension of the authors' 1996 research. The study examined the DIBELS measures by including a larger, more diverse nationally representative sample of kindergarten children. The results supported the earlier findings, which found support for Letter Naming Fluency and Phoneme Segmentation Fluency as well as the experimental measure of Sound Naming Fluency. Also consistent with the preliminary study is that Initial Phoneme Ability emerged as the weakest measure and may not have sufficient reliability and validity for individual student assessments.

Phonological Awareness and Reading Achievement

Phonological awareness has been identified, when assessed prior to or during kindergarten, as an excellent predictor of reading success in first grade (Torgesen, Wagner, Bryant, et al., 1992). McBride-Chang et al. (1997) assert that phonological awareness is one of the two strongest longitudinal predictors of reading in children, along with knowledge of letter names and sounds of the alphabet. According to Castle (1999), phonological awareness is a more potent predictor of reading success than intelligence, vocabulary, or listening comprehension. Even when controlling for the effects of IQ and socioeconomic status, phonological skill predicts early reading success (Juel, 1988; Torgesen, Wagner, Bryant, et al.; Yopp, 1992). Preschool-age children's awareness of phonemes has been shown to hold singular predictive power, statistically accounting for as much as 50 percent of the variance in their reading proficiency at the end of first grade. This has been demonstrated not only among English students but also among Swedish, Norwegian, Spanish, French, Italian, Portuguese, and Russian students (Adams et al., 1998).

A study by Snider (1997) examined the predictive value of phonemic awareness to later reading achievement. She compared scores on a test of phonemic awareness given in kindergarten (50 item, informal test) with scores on a standardized reading achievement test given in second grade. Results indicated a significant correlation between performance on some phonemic awareness tasks and reading achievement in second grade. The author completed a second study as a three year follow up of the students who scored in the lowest quartile. She found that the majority of those students could not read fluently. Snider asserted that the results replicated previous research findings by confirming the predictive value of phonemic awareness to later reading achievement. Early identification of children who lack phonemic awareness is useful for providing appropriate instruction, but it should not be used to justify retention or identification of learning disabilities.

Development of Phonological Awareness

Researchers and theorists disagree about the developmental progression of phonological awareness. Babies become attuned to the phonemes of their native language in the first few months of life. This sensitivity is not conscious but rather is deeply embedded in the subattentional machinery of the language system (Adams et al., 1998). The acquisition of phonological awareness is developmental in that certain skills are acquired earlier than others (Majsterek & Ellenwood, 1995). Generally, a child will develop a sensitivity to sound awareness from a broader grouping such as a sentence, progressing to the other end of the spectrum, at the phoneme level. After sentences, in order of skill acquisition, are phrases, words, syllables, onset and rime, and finally, phonemes. Most children will enter kindergarten with a substantial vocabulary and adequate syntax, as well as a sufficient command of most of the phonemes that constitute their language. This means that they can pronounce most sounds clearly. However, they usually lack an understanding that speech is composed of a series of individual sounds (Adams et al.). Rhyming is typically the first phonological skill that children master (Lane et al., 2002). Students who learn to read well can rhyme at approximately age 4 (O’Connor, Jenkins, Leicester, & Slocum, 1993). The ability to generate rhymes is an excellent indicator of a child’s ability to apply phonological knowledge (Lane et al.). In order to determine how to assess their level of phonological awareness, Castle (1999) lists six identified levels:

1. A primitive ear for sounds of words, assessed with knowledge of nursery rhymes.

2. Rhyme and alliteration recognition, assessed by an odd-one-out task, for example, the child hears four words – “bat,” “rag,” “fat,” “sat” – and must identify the nonrhyming one.
3. Blending tasks in which the tester provides the segmented sounds of a word and the child must recompose the word, for example, “What does /b/ /a/ /g/ say?”
4. Onset-rime syllable splitting, where the child must remove the initial sound and say what is left, for example, “cat” without the /c/ says /at/.
5. Segmentation or phoneme counting tasks, for example, the child says the sounds of a word, /c/ /a/ /t/ for the heard word “cat.”
6. Manipulation of phonemes; reversing the sounds of words, for example, “pot” is “top” said backwards; or deleting a medial sound from a word, for example, “splat” without the /l/ is “spat,” as in the Bruce deletion task.

Onset is defined as the beginning consonant of a word whereas rime is the remainder of the syllable, which includes the vowel and optional consonants. Onset-rime awareness can also be explained as the recognition of alliteration, which is the onset, and rhyme, which is the rime portion of a syllable (Castle, 1999). The author also differentiates between sequential analysis which is segmenting with sound units and synthesis which is the equivalent of sound blending. A synonymous term for segmenting that is commonly found in the literature is analysis (Davidson & Jenkins, 1994; Torgesen, Morgan, et al., 1992).

In order to read fluently and with comprehension, children must learn to read familiar words as wholes by sight and to phonologically decode unfamiliar words. Decoding has been taught by utilizing phonics programs, which teach children the written symbols, or graphemes, that represent speech sounds (Busink, 1997). Phonemic awareness is necessary in learning to decode an alphabetic language, as print decoding depends on mapping phonemes to graphemes (Juel, 1988). The ability to read nonsense words is the best measure of phonologic decoding skill in children (Shaywitz, 2003). In order to benefit from phonics instruction, some basic level of phonological awareness is required. Good readers have the phonological skills necessary to benefit from phonics instruction. This ability does not come naturally to some children (Adams et al., 1998; Busink). In her study, Juel found that children who were classified as poor readers at the end of first grade had a .88 probability of receiving that same designation at the end of fourth grade. These children were distinguished by their lack of phonemic awareness at the beginning of first grade. Further, by the end of fourth grade, the poor readers had still not achieved the level of decoding skill that the good readers had achieved at the beginning of second grade. Phonemic awareness is difficult because people direct their attention to the meaning and force of an utterance as a whole, and they process the phonemes automatically. They do not attend to the sounds of the phonemes produced by themselves or others during speech (Adams et al.).

Synthesis (blending) tasks are less difficult than analysis (segmenting) tasks, are more likely to be mastered at an earlier level of reading development, and should be introduced prior to analysis tasks because children’s ability to segment phonemes develops later than blending (Torgesen & Davis, 1996; Torgesen, Morgan, et al. 1992). This idea is reinforced by Wagner et al. (1993), who report that the ability to combine individually presented phonological segments into words emerges earlier in development than ability to identify the individual segments within words presented as wholes. Although this may be the case, the training implications are in direct conflict with Castle’s (1999) recommendation that analysis skills should be taught before synthesis tasks. This is because the segmentation of slow, stretched pronunciation of words allows a child to perceive the separate sounds. A child must listen to the articulated sounds to identify all the auditory cues. Blending is subsequently taught once rhyming and segmenting have been mastered. There is disagreement regarding which auditory phonological skills are most directly related to the initial stages of reading and what the relationships might be among them (O'Connor et al., 1993) Part of the difficulty lies in the inconsistency among studies concerning which subskills, in which formats should be included within the larger categories of rhyming, blending, and segmenting. In other words, the importance of blending skills is debatable and when to introduce them into phonological awareness training is subject to further study.

Different Levels of Readers

There has not been extensive research completed on the effects of phonological awareness on varying levels of readers and prereaders. However, what has been reported is that children with severe problems and poor scores on pretest measures of phonological awareness may not necessarily benefit from training to the degree of students with average pretest scores (Torgesen & Davis, 1996). It is hypothesize that average effects of phonological awareness training on reading growth may be due to a "hothouse" effect for children who would learn to read normally without intervention, rather than a true measure of effects on reading growth of poor readers. It has been suggested that differences between disabled and below average readers may be differences of degree rather than of kind (Busincheck, 1997). The phonological factors associated with failure to learn to read in the disabled may also be responsible for the difficulties of below average readers. This argument indicates that phonological awareness training should benefit not only disabled readers but also those with poor, below average, and average skills.

The reverse is not necessarily true in that reading disabled children may not benefit from the same remediation as below average readers until they are provided with the groundwork for absorbing phonological awareness instruction (Busink).

There is considerable debate surrounding the issue of differentiating children who have reading disabilities from those who are poor readers, although the fact that almost 20% of all students have significant difficulty learning to read indicates that reading deficits are not specific to disability (Good, Simmons, et al., 1998). It is strongly recommended that phonological awareness training be included in any preventive or remedial program for children either at-risk for or identified with reading disabilities (Torgesen, Wagner, & Rashotte, 1994). Very explicit or intense training, more so than what is found in the literature, may be required to impact those students with severe reading disabilities.

According to O’Connor et al. (1993), students who learn to read well can rhyme at approximately age 4 and blend and segment orally presented words and sounds by the end of first grade. However, most poor readers, by the end of second grade, still cannot blend or segment words as well as normally reading younger children. These findings may have strong implications, not only for the scientific understanding of reading development, but also for early intervention for students at risk of reading failure because specific competencies are seemingly causally related to early reading success. The authors concluded that phonological awareness training can be taught to young children with learning disabilities before they acquire functional reading ability. However, overall, generalization did not occur among tasks. Training in blending did not improve segmentation skills and rhyming did not improve blending, for example. Blending words was easier to teach than segmenting those same words. Again, generalizing the tasks to novel items was difficult for the children. The study showed that because learning disabled children have difficulty developing phonological awareness independently, specific training is recommended. Short-term training did not result in appreciable generalization among tasks and settings. The authors suggest that future research focuses on the relationship among specific phonological manipulation skills and their contributions to reading for the student with a learning disability.

Influence of Parent Education Level on Reading

An analysis by the U.S. Department of Education indicated that 46% of children entering kindergarten came from family backgrounds with one or more factors that might affect their skills and knowledge. The factors include: living in a single-parent household, living in poverty, having a mother with low education, low familial literacy and poor nutrition (U.S. Department of Education, 2001). Social deprivation has been reported to delay children’s development of phonological awareness skills (Burt et al., 1999). Disadvantaged children enter kindergarten with lower levels of letter knowledge and phonemic awareness (Hale & Fiorello, 2004). Research has shown that preschool and early school-age children from lower income backgrounds and those whose parents have less education demonstrate lower phonological awareness skills than more affluent peers (Phillips et al., 2008). Children from socially disadvantaged backgrounds typically have a lack of informal experience with books and print prior to exposure to formal literacy instruction. Compared to their peers with average SES backgrounds, they have less extensive vocabularies, poorer letter knowledge and may struggle with knowledge of print and phonological awareness (McIntosh, Crosbie, Holm, & Dodd, 2007). However, explicit phonological awareness training in preschool and kindergarten may have the potential to mediate the effects of poverty (Joseph, 2006).

Gender as a Predictor of Phonological Awareness

Traditionally, girls have been considered to possess superior language and reading abilities to boys. The research on gender differences in phonological awareness is scant; however, there are studies that do not support this belief. Research by Burt et al. (1999) examined the phonological awareness skills of 57 normally developing preschool children. A total of eight tasks were utilized to assess three areas: spoken phonology, working memory, and phonological awareness. Five of the eight tasks tapped into phonological awareness and were labeled Syllable Segmentation, Rhyme Awareness, Alliteration Awareness, Phoneme Isolation, and Phoneme Segmentation. Results demonstrated no differences between males and females on any of the eight tasks; however, it was noted that the sample size may have been too small to reveal any trends toward gender differences.

In their 2005 study, Nancollis, Lawrie, and Dodd examined the effects of phonological awareness intervention on the acquisition of literacy and development of phonological awareness skills. The study focused on syllable and rhyme awareness and assessed the outcome of ninety-nine children at 2 years post intervention. The children underwent a 9-week phonological awareness program during the summer semester of their final preschool year and were then assessed with measures of language and phonological awareness at the beginning of their first year at school. Two years later, they were again assessed on measures of phonological awareness and literacy. A control group of 114 children from the same schools was used; they received no phonological awareness intervention. Results of the longitudinal study showed that gender was not a significant influence on performance.

Cognitive Assessment

The concept of individual differences in human performance can be traced back to great thinkers such as Socrates, Plato, Mohammedan rulers, and

Charles Darwin (French & Hale, 1990). Formal measurement of human intelligence was documented as long ago as 1534 when Sir Anthony Fitzherbert published an intelligence test. This test was intended to differentiate between the “idiot” and the “lunatic” for those experts interested in the humane treatment of individuals with mental retardation (Kamphaus, 2009). Nearly 400 years later, Binet and Simon broke through with their 1905 intelligence scale which later evolved into the Stanford-Binet Intelligence Scale, now in its fifth edition. The principle of standardized assessment procedure is a concept that was borrowed from Wundt by James McKeen Cattell when he sought to create his first intelligence test at Columbia College (Kamphaus). The research and development surrounding intelligence testing continues to impact psychological practice and scientific work more than a century later.

Keith (1999) stated “Among the most enduring – and, at times, most acrimonious – debates in the field of intelligence is that of the viability of measurement of specific versus general intelligence.” Intelligence tests are the most frequently used measures by school psychologists and yet heated debate over their use and interpretation continues (Hale et al., 2001). Learning disability evaluations have traditionally involved a test of intelligence that provided the examiner with an overall measure of general ability or g. The student’s g score was then compared to scores on tests of academic achievement to determine if a severe discrepancy existed between overall ability and any of the obtained achievement scores. While this practice continues to be the norm for many school psychologists, there is a different school of thought that recognizes the assessment of specific cognitive abilities as the theoretical and statistical best practice for measuring intelligence (Flanagan et al., 2008; Floyd et al., 2007). Concurrently, because of the professional movement to eliminate the discrepancy formula, there are many practitioners who seek to eliminate IQ testing from learning disability identification altogether. However, “a great deal of research has identified cognitive processing deficits that are linked to learning disabilities, and if cognitive assessment can be used to identify cognitive processing strengths and weaknesses, elimination of testing would be a mistake.” (Fiorello & Primerano, 2005).

Cattell-Horn-Carroll Theory of Intelligence

The origin of CHC theory dates back to Raymond Cattell’s work in the 1940s. Cattell’s premise was that fluid intelligence (Gf) included inductive and deductive reasoning whereas crystallized intelligence (Gc) consisted primarily of acquired stores of knowledge. In 1965, John Horn expanded this model to include four additional abilities: visual perception or processing (Gv), short-term memory (Gsm), long-term storage and retrieval (Glr), and speed of processing (Gs). In subsequent years, Horn added factors to his original model, including a factor representing reaction time and decision speed (Gt). He later added auditory processing ability (Ga) to the model and refined the definitions of Gv, Gs, and Glr. Quantitative knowledge (Gz) and a broad reading and writing factor (Grw) were the final factors to be integrated, resulting in a ten-factor model that became known as the Cattell-Horn Gf-Gc theory (Flanagan et al., 2008).

In the early 1990s, John Carroll proposed a theory that delineated cognitive abilities into three strata. The broadest and most general level is denoted by stratum III. This level represents an overall level of g and encompasses both broad (stratum II) and narrow (stratum I) abilities. There are eight broad abilities in Carroll’s theory with many narrow abilities within stratum I. This model became known as Carroll’s Three-Stratum Theory (Flanagan et al., 2008).

The marriage of Cattell-Horn Gf-Gc theory and Carroll's Three Stratum theory was brought about by McGrew's attempt to resolve some of the differences between the two theories, which ultimately resulted in Cattell-Horn-Carroll (CHC) theory (McGrew, 2005). This integrated theory is composed of 10 broad and more than 70 narrow cognitive abilities and processes. However, there is no representation of *g*, since general ability is not supported in CHC theory as useful to understanding individual abilities. Rather the theory asserts that abilities are best understood through operationalizing broad and narrow cognitive abilities and processes. The Gf-Gc constructs underlying the Horn and Cattell models have been supported extensively through many forms of validity evidence, including achievement in relation to predictions of academic capability and occupational success (McGrew et al., 1997). A number of researchers have used composite scores representing CHC broad abilities to better understand their contributions to reading and mathematics (Floyd, McGrew, & Evans, 2008).

CHC Factors Related to Reading Achievement

The CHC model establishes that reading difficulties are linked to deficiencies in five broad areas: Crystallized intelligence (Gc), Short-term memory (Gsm), Auditory processing (Ga), Long-term storage and retrieval (Glr), and Processing speed (Gs) (McGrew, 2005). A description of each of these broad abilities as well as those narrow abilities encompassed by the broad abilities follows:

Crystallized Intelligence (Gc) can be described as "a person's wealth of acquired knowledge of the language, information and concepts of a specific culture, and/or the application of this knowledge" (McGrew, 2005). The information stored in Gc is primarily verbal or language-based. The specific narrow abilities subsumed by Gc that are related to reading achievement are Language Development (LD), Lexical Knowledge (VL), and Listening Ability

(LS). Language development encompasses the ability to understand and apply language. Lexical knowledge is an individual's vocabulary knowledge and Listening ability is the ability to understand spoken language (McGrew, 2005).

Short-Term Memory (Gsm) is defined as "the ability to apprehend and maintain awareness of elements of information in the immediate situation" (McGrew, 2005). Memory Span is the only Gsm narrow ability that is linked to reading achievement (Flanagan et al., 2008). Memory Span is referred to as "the ability to attend to, register, and immediately recall temporally ordered elements and then reproduce the series of elements in correct order" (McGrew).

Auditory Processing (Ga) involves "a wide range of abilities involved in discriminating patterns in sounds and musical structure as well as the abilities to analyze, manipulate, comprehend, and synthesize sound elements, groups of sounds, or sound patterns" (McGrew, 2005). Phonetic coding, also known as phonological awareness/processing, is extremely important to the acquisition of early literacy skills (Flanagan et al., 2008). Generally speaking, phonological awareness is defined as one's sensitivity to the sound structure of one's own language and the ability to access and manipulate it (Bishop & Snowling, 2004; Havey, Story, & Buker, 2002; Kameenui, 1996; Lane et al., 2002; McBride-Chang et al., 1997; Wagner, Torgesen, Laughon, Simmons, & Rashotte, 1993). Researchers have found repeatedly that phonological awareness, not I.Q., is the most robust predictor of early reading performance (Anthony et al., 2007; Castle, 1999; McBride-Chang et al.). Anthony, Williams, McDonald, & Francis (2007) examined the intercorrelations of phonological awareness, phonological memory, and rapid naming and the effect of general cognitive ability on each of them. They found that children's phonological processing abilities were related to their general cognitive ability; however, children’s general cognitive ability did not directly predict their emergent literacy skills. Their findings further support the theory that children’s early literacy skills are better predicted by assessments of their phonological processing abilities than by measuring their general cognitive ability.

Long-Term Storage and Retrieval (Glr) is described as “the ability to store and consolidate new information in long-term memory, and later fluently retrieve the stored information through association” (McGrew, 2005). Naming Facility (NA), also referred to as Rapid Automatic Naming, is very important to reading acquisition. It is defined as “the ability to rapidly produce accepted names for concepts or things when presented with the thing itself or a picture of it”. Associative Memory (MA) is “the ability to recall one part of a previously learned but unrelated pair of items when the other part is presented, e.g., paired associate learning”. Associative Memory is thought to be somewhat important to reading achievement at certain ages (Flanagan et al., 2008).

Processing Speed (Gs) is “the ability to automatically and fluently perform relatively easy or overlearned cognitive tasks, especially when high mental efficiency is required” (McGrew, 2005). The narrow ability subsumed by Gs is Perceptual Speed (P) which is considered to be essential to reading, particularly during the elementary years (Flanagan et al., 2008). Perceptual speed is defined as “the ability to rapidly and accurately search, compare and identify visual elements presented side by side or separated in a visual field.”

CHC Studies of Reading Achievement

Floyd et al. (2007) investigated the effects of CHC specific cognitive abilities on reading decoding skills. They found that five broad abilities demonstrated significant effects on reading decoding skills: Auditory

Processing, Short-Term Memory, Long-Term Storage and Retrieval, Crystallized Intelligence, and Processing Speed. An earlier study that examined the relations between CHC cognitive abilities and reading achievement found the same five broad abilities as significant to reading (Evans et al., 2002). Crystallized Intelligence (Gc) demonstrated moderate to strong relations with the components of reading achievement across childhood and adolescence whereas Short-term Memory (Gsm) showed a moderate relationship during this period. The other three abilities, Auditory Processing (Ga), Long-term Retrieval (Glr), and Processing Speed (Gs) were moderately related with reading achievement during the elementary years. Demonstrating no consistent pattern of relationship with reading achievement throughout childhood and adolescence were Fluid Reasoning (Gf) and Visual-Spatial Thinking (Gv). Garcia and Stafford (2000) completed a similar study that examined the ability of Ga and Gc specific cognitive abilities to predict reading; however, the study targeted low-SES English-speaking White and Hispanic students. Their findings indicated that race does not affect the predictive ability of Ga and Gc for reading decoding and reading comprehension of these students. Additionally, they found that due to the invariance of relations across race among the predictor variables and reading achievement, SES was a more robust predictor of academic achievement than race. A different study examined the effects of specific and general abilities on the reading and mathematics achievement of African American, Hispanic, and Caucasian students (Keith, 1999). Results demonstrated that, for all grade levels and all ethnic groups, specific cognitive abilities had significant effects on reading achievement above and beyond the effects of general cognitive ability on reading achievement. The findings suggest that race is generally not an important consideration in understanding the effects of abilities on achievement.

Cross Battery Assessment

The Cross-Battery Assessment (XBA) approach is rooted in contemporary theory based on the Cattell-Horn-Carroll (CHC) theory of cognitive abilities. There are three basic tenets of the XBA approach. The first tenet entails a relatively thorough framework for describing the organization of cognitive abilities. The second tenet is the CHC broad (stratum II) classification of cognitive and achievement tests. The CHC broad level consists of the following abilities: fluid intelligence (Gf), crystallized intelligence (Gc), visual processing (Gv), auditory processing (Ga), short-term memory (Gsm), long-term storage and retrieval (Glr), processing speed (Gs), quantitative knowledge (Gq), reading and writing (Grw), and decision/reaction time/speed (Gt). The third pillar is the CHC narrow (stratum I) classifications of both cognitive and achievement tests (Flanagan et al., 2007). This classification system minimizes the effects of “construct-irrelevance variance”. Construct-irrelevance variance occurs when an “assessment is too broad, containing excess reliable variance associated with other distinct constructs. . . that affects responses in a manner irrelevant to the interpreted constructs” (Messick, 1995, p. 742). For example, the WAIS Verbal I.Q. contains measures of Gc, Gq, and Gsm and is therefore considered a mixed measure of abilities. The cross-battery approach also controls for “construct underrepresentation” which occurs “when an assessment is too narrow and fails to include important dimensions or facets of a construct (p.742). For instance, the Woodcock-Johnson III Concept Formation subtest is an example of construct underrepresentation because it measures only one narrow aspect of Gf. The cross-battery assessment approach can be utilized with all subtests of the major intelligence and achievement batteries. The subtest categorization was “based on the results of a series of cross-battery confirmatory factor analysis studies of the major intelligence batteries” (Flanagan et al., 2007). The cross-battery assessment method focuses on specific cognitive abilities that are related to learning deficits rather than obtaining a general measure of intelligence. It is important for school psychologists to identify the role that measures of specific cognitive abilities have in identification and treatment of learning difficulties (Floyd et al., 2007). Given its psychometrically sound theoretical framework as well as its pragmatic offering to school psychologists, cross-battery assessment may soon become the norm among practitioners.

Summary

This chapter discussed the No Child Left Behind Act and its ramifications for school districts. Literature related to the utilization of curriculum-based measurement to predict students' reading performance on high-stakes assessment was reviewed. The Dynamic Indicators of Basic Early Literacy Skills were presented, including a review of validation studies. Factors influencing development of phonological awareness and, ultimately, reading achievement were discussed. Different levels of readers and their response to intervention techniques were detailed. Cognitive assessment was presented with a focus on the Cattell-Horn-Carroll theory of intelligence, followed by a discussion of the CHC factors that are related to reading achievement. Last, cross-battery assessment and its utility for cognitive assessment of reading problems were outlined.

CHAPTER III

METHODS

Introduction

The purpose of this study was to determine if the use of Cattell-Horn-Carroll (CHC) specific cognitive abilities enhances prediction of reading scores on the third grade Pennsylvania System of State Assessment (PSSA). Within this chapter, methodology procedures are outlined followed by descriptions of the population and sample. The instruments utilized in this study are reviewed in detail. Procedures for data collection are discussed and statistical analyses are described.

Design

This correlational study examined five CHC specific cognitive abilities and how well they predict third grade PSSA reading scores. The specific cognitive abilities were analyzed to determine if they predicted PSSA scores as well as enhanced the ability of the Dynamic Indicators of Basic Early Literacy Skills (DIBELS) Phoneme Segmentation Fluency (PSF) measure to predict PSSA scores. The predictor variables included age, mother's education level, sex, and scores on the Dynamic Indicators of Basic Early Literacy Skills (DIBELS) Phoneme Segmentation Fluency measure. Specific cognitive abilities were assessed with selected subtests from the Wechsler Intelligence Scale for Children – Fourth Edition (WISC-IV), Woodcock-Johnson Tests of Cognitive Abilities – Third Edition (WJ-III), Stanford-Binet Intelligence Scale – Fifth Edition (SB-V), and Wechsler Preschool and Primary Scale of Intelligence – Third Edition (WPPSI-III). The results were intended to determine if utilizing Cattell-Horn-Carroll specific cognitive abilities adds to the prediction of the DIBELS Phoneme Segmentation Fluency measure for third grade reading scores on the PSSA.

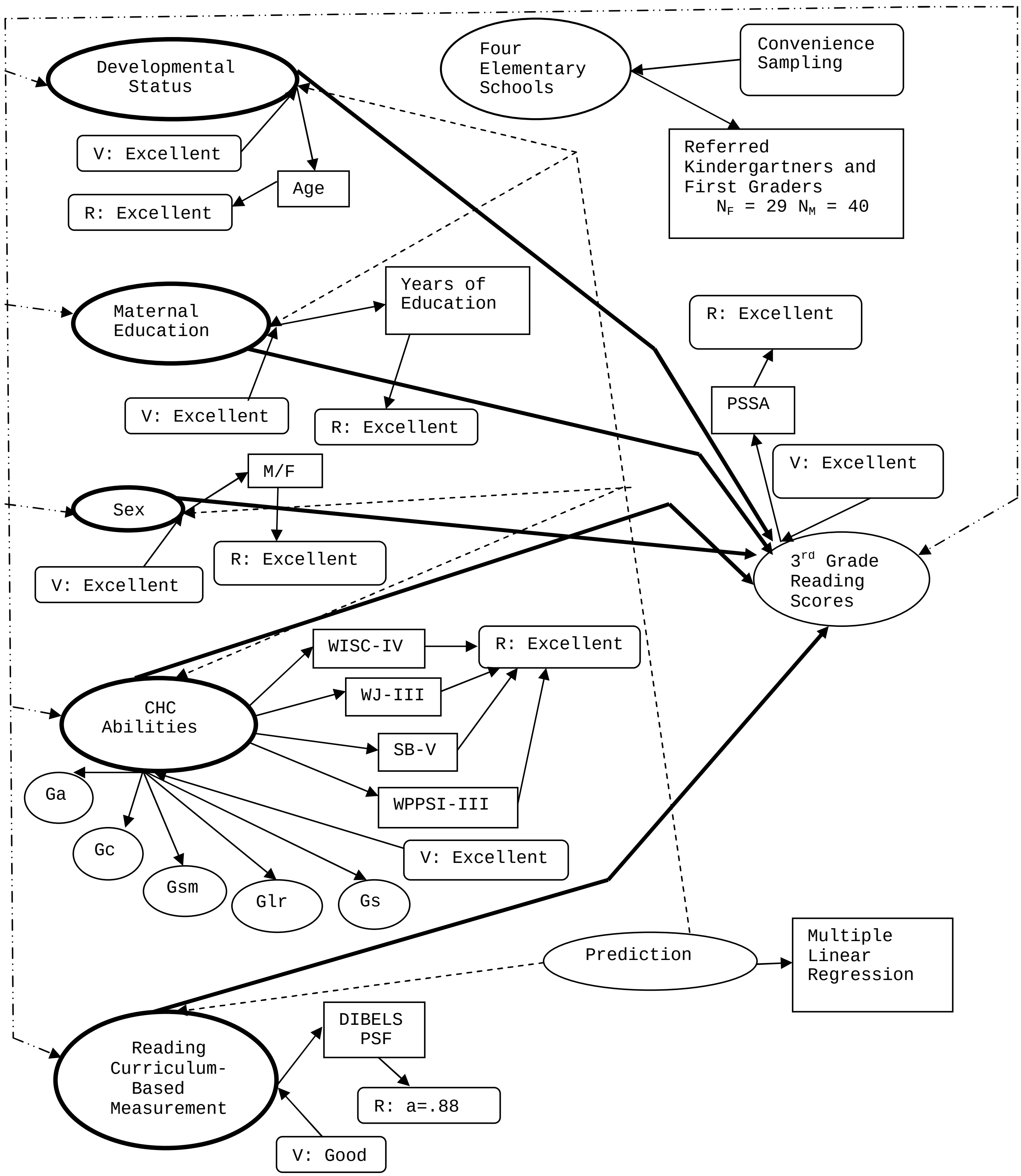

Figure 2. Research path diagram of the Cattell-Horn-Carroll Specific Cognitive Abilities Study.

Population

Participants for the present study were 69 students from a suburban school district located approximately 25 miles north of Pittsburgh, Pennsylvania. The school district's student enrollment is currently 7,579, which does not include students who are home-schooled or enrolled in private schools. The race distribution is 96 percent Caucasian, <1 percent African-American, <1 percent Asian, <1 percent Hispanic, <1 percent Indian, and <1 percent Multi-racial.

Sample

Participants were kindergarten and first grade students from the 2003-2004, 2004-2005, and 2005-2006 school years. The students were referred for psychoeducational evaluations to determine special education eligibility. Some students were already placed in a special education program (Speech/Language Support) for speech or language impairments whereas others were placed in the Learning Support program based on the psychoeducational evaluation recommendations.

Assignment

There was no ability to assign subjects.

Table 1

Demographic Distribution of Sample

Year	2003-2004	2004-2005	2005-2006	Total
Age				
5	0	2	0	2
6	4	22	4	30
7	5	18	12	35
8	1	1	0	2
Grade				
K	3	18	0	21
1	7	25	16	48
Sex				
Female	4	17	8	29
Male	6	26	8	40
Mother's Education				
High School	3	17	1	21
Some College	1	7	4	12
College Graduate	3	11	8	22
Graduate Degree	2	1	2	5

Measurement

The participants were assessed with a combination of subtests from the Dynamic Indicators of Basic Early Literacy Skills and the Wechsler Intelligence Scale for Children – Fourth Edition. Fifteen students were administered the Woodcock-Johnson Tests of Cognitive Abilities – Third Edition, the Stanford-Binet Intelligence Scale – Fifth Edition, or the Wechsler Preschool and Primary Scale of Intelligence – Third Edition instead of the WISC-IV, due to test age limitations or specific diagnostic purposes.

Cattell-Horn-Cattell specific cognitive abilities scores were interpreted via the Cross-Battery Assessment Data Management and Interpretive Assistant (Flanagan, Ortiz, & Alfonso, 2007). This software program includes the subtests for the seven major intelligence batteries and converts scores for each of the broad CHC abilities/processes. All subtest scores from the

WISC-IV, WJ-III, SB-V, and WPPSI-III were entered under their respective CHC factors. For example, the WISC-IV subtests of Similarities, Vocabulary, and Comprehension are subsumed by the CHC factor Crystallized Knowledge. The three subtest scores were converted to standard scores and, subsequently, an average standard score was derived. If the individual scores were too disparate and not within the same normative range, the scoring program deemed the average standard score as uninterpretable. In cases when the factor scores were uninterpretable, subtest scores were calculated according to the factor scores of their respective tests. As an example, there were several instances in which discrepant Coding and Symbol Search scores on the WISC-IV could not be interpreted as a CHC Processing Speed score via the Cross-Battery scoring program. Therefore, in order to derive a single score for the Processing Speed factor, the Processing Speed Index of the WISC-IV was utilized instead. The seven converted CHC factor scores of Gc, Gf, Gsm, Gv, Glr, Ga, and Gs were then utilized for statistical analyses.

The DIBELS are targeted for assessing kindergarten through third grade students to assess and monitor their progress in early reading skills. The measures include Initial Sound Fluency, Phoneme Segmentation Fluency, Letter Naming Fluency, Nonsense Word Fluency, and Oral Reading Fluency. All but Oral Reading Fluency can be administered to kindergarten and first graders; however, the only measure that will be utilized for this study is Phoneme Segmentation Fluency. The Phoneme Segmentation Fluency measure requires the student to produce the individual sounds (phonemes) within a given word. It assesses a student’s ability to segment three- and four-phoneme words into their individual phonemes fluently.

The Wechsler Intelligence Scale for Children – Fourth Edition is a widely used intelligence test for children ages 6 through 16. In addition to providing a Full Scale I.Q. that represents a child’s general intellectual ability, it yields four composites scores that represent specified cognitive domains: Verbal Comprehension, Perceptual Reasoning, Working Memory, and Processing Speed. Ten subtests comprise the core battery with an additional five subtests that can be utilized to obtain supplemental data. The WISC-IV taps into three of the CHC broad abilities that are linked to reading: crystallized intelligence (Gc), working memory (Gsm), and processing speed (Gs).

The Woodcock-Johnson Tests of Cognitive Abilities – Third Edition is an individually administered instrument that is appropriate for ages 2 to 90 (Woodcock, McGrew, & Mather, 2001, 2007). The standard cognitive battery is comprised of 10 subtests and the extended battery contains an additional 10 subtests. The WJ-III is firmly rooted in CHC theory and is designed to assess abilities that factor into all CHC broad categories. Each of the five broad abilities that are related to reading achievement is assessed by the WJ-III.

The Stanford-Binet Intelligence Scale – Fifth Edition is an individually administered intelligence test that is appropriate for ages 2 through 89 (Roid, 2003). Ten subtests factor into the Full Scale I.Q. score, with five verbal subtests contributing to a Verbal I.Q. score and five subtests comprising a Nonverbal I.Q. score. In addition to the three I.Q. scores are five factor index scores: Fluid Reasoning, Knowledge, Quantitative Reasoning, Visual-Spatial Processing, and Working Memory. The SB-V was redesigned to integrate CHC theory as a basis for assessing specific cognitive abilities. Of those broad factors represented on the SB-V, crystallized intelligence (Gc) and Working Memory (Gsm) are those connected to reading achievement.

The Wechsler Preschool and Primary Scale of Intelligence – Third Edition (WPPSI-III) is an individually administered instrument for assessing the intelligence of children ages 2 years 6 months through 7 years 3 months

(Wechsler, 2002). The child’s general intellectual functioning is represented using a Full Scale I.Q. with two additional composites, the Verbal I.Q. and the Performance I.Q. Supplemental subtests are included to obtain an optional General Language Composite and, at older ages, a Processing Speed Quotient. The WPPSI-III measures two CHC broad abilities linked to reading: crystallized intelligence (Gc) and processing speed (Gs).

The Pennsylvania System of State Assessment (PSSA) is administered annually as the measure intended for educational accountability. The reading portion of the PSSA assesses the two broad skill areas that are based on Pennsylvania Assessment standards: Comprehension and Reading Skills, and Analysis of Fiction and Nonfiction Text (DRC, 2007). Students’ performance falls into one of four classification categories: Advanced, Proficient, Basic, or Below Basic.

Reliability and Validity

Dynamic Indicators of Basic Early Literacy Skills: The two-week alternate-form reliability for the Phoneme Segmentation Fluency measure is .88 and the one-month, alternate-form reliability is .79 in May of kindergarten. The predictive validity of a spring-of-kindergarten administration with winter-of-first-grade Nonsense Word Fluency is .62 and with spring-of-first-grade Oral Reading Fluency it is also .62 (Good & Kaminski, 2002).

Wechsler Intelligence Scale for Children – Fourth Edition: Reliability for the Full Scale score is measured at .97 (Wechsler, 2003). Reliability coefficients for the individual subtests range from .79 on Symbol Search to .90 on Letter-Number Sequencing, with all other core battery subtests at .81 or above. The test manual documents content validity while stating that the subtests tap a broad range of cognitive domains, including verbal reasoning, perceptual reasoning, concept formation, sequential processing, auditory comprehension, cognitive flexibility, working memory, perceptual organization, and psychomotor processing speed (Wechsler, 2003). Criterion-related validity was reported on studies with several different instruments, including the Wechsler Intelligence Scale for Children – Third Edition, Wechsler Preschool and Primary Scale of Intelligence – Third Edition, Wechsler Adult Intelligence Scale – Third Edition, Wechsler Abbreviated Scale of Intelligence, Wechsler Individual Achievement Test – Second Edition, Children's Memory Scale, Gifted Rating Scale, BarOn Emotional Quotient Inventory, and Adaptive Behavior Assessment System – Second Edition. Construct validity was documented via exploratory factor analysis and confirmatory factor analysis. According to the standards set forth by Rosenthal and Rosnow (1991), recommending a reliability coefficient of .85 or above and well-documented content, criterion-related, and construct validity, WISC-IV reliability and validity well exceed the acceptable level.

Woodcock-Johnson Tests of Cognitive Abilities – Third Edition: Internal consistency reliability estimates are generally in the .80s and .90s for individual tests and in the .90s for clusters. Validity evidence is provided via test content, correlational analysis and confirmatory factor analyses. Reliability and validity are well within the acceptable range, based upon the standards established by Rosenthal and Rosnow (1991).

Stanford-Binet Intelligence Scale – Fifth Edition: The composite I.Q. scores have reliabilities that average from .95 to .98 for the Full Scale I.Q., Nonverbal I.Q. and Verbal I.Q. The five factor indexes have average reliabilities of .90 to .92. Validity for the SB-V is established via extensive validity studies, including confirmatory factor analyses showing the presence of the five factors. Based upon the standards for acceptable reliability and validity established by Rosenthal and Rosnow (1991), both properties are well-represented.

Wechsler Preschool and Primary Scale of Intelligence – Third Edition: Reliability estimates at the subtest level across ages are .83 to .95 with a few subtests less than .80 at specific ages. The average Full Scale internal consistency coefficient is .96 with the three additional composites showing coefficients between .89 and .95. Validity evidence is presented via internal structure, correlations with other measures, and special group studies. According to the standards set forth by Rosenthal and Rosnow (1991), reliability coefficients are generally above the recommended range of .85 and validity data are acceptable as well.

Pennsylvania System of State Assessment: The technical analysis manual for the PSSA reading indicated that all forms had reliability coefficients (Cronbach's Alpha) close to or above .90. Extensive evaluation of content validity, construct validity, item fit, and calibration were described in the technical analysis manual.

Table 2

Cattell-Horn-Carroll Specific Cognitive Abilities Study Measurement Characteristics: Research Questions, Latent Variable Names, Observed Categories, Instrument/Source, Validity, and Reliability

Research Question	Latent Variable Name	Observed Categories	Instrument/ Source	Validity	Reliability
1. Do sex, age, and maternal level of education predict third grade PSSA reading scores?	Sex	Males-females	School records	Excellent	Excellent
	Developmental status	5 years 6 years 7 years 8 years	School records	Excellent	Excellent
	Mother's education	High school Some college College graduate Graduate degree	School records	Excellent	Excellent
	Reading Achievement	Below Basic Basic Proficient Advanced	PSSA	Excellent	Excellent
2. Does the DIBELS PSF measure enhance the prediction of third grade PSSA reading scores?	PSF	Deficit Emerging Established	DIBELS	Excellent	Good
	Reading achievement	Below Basic Basic Proficient Advanced	PSSA	Excellent	Excellent
3. Do CHC specific cognitive abilities enhance the prediction of PSF of third grade PSSA	Specific cognitive abilities	Gf Gsm Ga Glr Gs	WISC-IV WJ-III SB-V WPPSI-III	Excellent Excellent Excellent Excellent	Excellent Excellent Excellent Good/Excellent
	Reading achievement	Below Basic Basic Proficient	PSSA	Excellent	Excellent

reading scores? Which of the CHC specific cognitive abilities are predictive of PSSA scores?	Advanced

PSSA: Pennsylvania System of State Assessment
DIBELS: Dynamic Indicators of Basic Early Literacy Skills
PSF: Phoneme Segmentation Fluency
CHC: Cattell-Horn-Carroll

Procedures

Archival data were gathered from psychoeducational evaluations conducted within a school district during the 2003-2004, 2004-2005, and 2005-2006 school years. Psychoeducational evaluations were conducted by district school psychologists. Assessment data were examined for 69 kindergarten and first grade students who were evaluated by school psychologists due to reading difficulties.

The researcher’s interest in reading assessment prompted the project idea in Spring 2007. The WISC-IV was already being utilized as part of the examiner’s typical assessment battery for those students with reading difficulties. In some cases, the WJ-III, SB-V, and WPPSI-III were administered in lieu of the WISC-IV, due to age requirements or diagnostic purposes.

Four school psychologists, employed by the same school district, were involved in administration of the psychoeducational evaluations from which the research data was collected. All school psychologists involved in data collection were state certified by the Pennsylvania Department of Education. Their years of experience ranged from two to seventeen.

Upon completion of the 2007-2008 school year, deidentified student data was obtained from the special education database via the Special Education Department Secretary. The data was examined to determine if it met the assumptions for analyses used. Following the statistical analyses, results were interpreted.

Based upon the methods and procedures reviewed, the following research questions were answered:

1. Do sex, age, and maternal level of education predict third grade PSSA reading scores?
2. Does the DIBELS Phoneme Segmentation Fluency measure enhance the prediction of third grade PSSA reading scores?

3. Do CHC specific cognitive abilities enhance the prediction of PSF of third grade PSSA reading scores? Which of the CHC specific cognitive abilities are predictive of PSSA scores?

Table 3

Cattell-Horn-Carroll Specific Cognitive Abilities Study Task Table

#	Name	Description	Begin	End	Person
1	Project Idea	Based upon use of the cognitive assessment in regular practice, conduct a study to examine its effectiveness in identifying reading deficits and predicting outcomes.	03-07	04-07	School Psychologist
2	Administer DIBELS	The Dynamic Indicators of Basic Early Literacy Skills are administered to all kindergarten and first grade students three times per school year.	09-03	06-06	Reading Specialists
3	Administer Cognitive Test	Administer measure of cognitive ability within context of psychoeducational evaluations.	09-03	06-06	School Psychologists
4	Administer PSSA	The Pennsylvania System of State Assessment is administered yearly to third grade students.	03-06	03-08	Regular and Special Education Teachers
5	Data Collection	Obtain de-identified student data from the special education database.	08-08	08-08	School Psychologist
6	Data Analysis	Examine data to determine if it meets the assumptions for analysis to be used. Run the analysis. Interpret analysis results.	09-08	09-08	School Psychologist

Sample Size

The sample was a sample of convenience because any student who met the criteria was included. Any kindergarten or first grade student who was referred for a psychoeducational evaluation due to reading difficulty was included in the study.

Statistical Analyses

This study examined the use of CHC specific cognitive abilities for enhancing the prediction of third grade PSSA reading scores. It is a correlational study that analyzed the association between students' performance on the DIBELS Phoneme Segmentation Fluency measure and later performance on the reading portion of the third grade PSSA. It also determined if utilizing CHC specific cognitive abilities enhanced the predictive ability of PSF of reading achievement on the PSSA. They were also examined with respect to the other variables.

The following statistical analyses were proposed to answer the research questions:

1. *Do sex, age, and maternal level of education predict third grade PSSA reading scores?* The research hypothesis was that sex would not be predictive of PSSA scores. Pertaining to age, the hypothesis was that there would be a positive correlation between student age and performance on the third grade PSSA. The third hypothesis for this research question was that higher maternal level of education would correlate positively with higher student performance on the PSSA. A multiple linear regression was proposed to answer this research question. The assumptions necessary for this procedure were 1) Interval or ratio data; 2) Normality of error term; 3) Linearity; 4) Non-multicollinearity. Assumptions appropriateness was examined by 1) Examining the instrument; 2) Histograms with normal curves; 3)Bi-

variate plots with straight lines; 4) The correlation matrix of predictors.

2. *Does the DIBELS Phoneme Segmentation Fluency measure enhance the prediction of third grade PSSA reading scores?* The research hypothesis was that there would be a positive correlation between PSF scores and PSSA scores. A multiple linear regression was proposed to answer this research question. The assumptions for this statistical procedure were 1) Interval or ratio data; 2) Normality of error term; 3) Linearity; 4) Non-multicollinearity. Assumptions appropriateness was examined by 1) Examining the instrument; 2) Histograms with normal curves; 3) Bi-variate plots with straight lines; 4) The correlation matrix of predictors.

3. *Do CHC specific cognitive abilities enhance the prediction of PSF of third grade PSSA reading scores? Which of the specific cognitive abilities are predictive of PSSA scores?* The research hypothesis was that Ga (auditory processing), Glr (long-term storage and retrieval), Gs (processing speed), Gc (language development), and Gsm (short-term memory) would each be predictive of reading achievement. A multiple linear regression was proposed to answer this research question. The assumptions for this statistical procedure were 1) Interval or ratio data; 2) Normality of error term; 3) Linearity; 4) Non-multicollinearity. Assumptions appropriateness were examined by 1) Examining the instrument; 2) Histograms with normal curves; 3) Bi-variate plots with straight lines; 4) The correlation matrix of predictors.

Table 4

Research Questions, Hypotheses, Variables, Statistical Analyses, and Statistical Assumptions for the Cattell-Horn-Carroll Specific Cognitive Abilities Study

Research Questions	Hypotheses	Variables	Statistic	Assumptions	Assumptions Appropriateness
1. Do sex, age, and maternal level of education predict third grade PSSA reading scores?	Sex will not be predictive of PSSA scores. Age will be predictive of PSSA scores. Maternal education will be predictive of PSSA scores.	Sex Age Maternal education PSSA scores	Multiple linear regression	1. Interval or Ratio data 2. Normality of error term 3. Linearity 4. Non-multi-collinearity	1. Examine the instrument 2. Histograms with normal curves 3. Bivariate plots with straight lines 4. Correlation matrix of predictors
2. Does the DIBELS PSF measure enhance the prediction of third grade PSSA reading scores?	PSF will enhance the prediction of PSSA scores.	PSF scores PSSA scores	Multiple linear regression	1. Interval or Ratio data 2. Normality of error term 3. Linearity 4. Non-multi-collinearity	1. Examine the instrument 2. Histograms with normal curves 3. Bivariate plots with straight lines 4. Correlation matrix of predictors
3. Do CHC specific cognitive abilities enhance the prediction of PSF of third grade PSSA reading scores?	Ga, Glr, Gs Gc, and Gsm will predict PSSA scores.	CHC specific cognitive abilities PSSA scores	Multiple linear regression	1. Interval or ratio data 2. Normality of error term 3. Linearity	1. Examine the instrument 2. Histograms with normal curves 3. Bivariate plots with straight lines

Which of the CHC specific cognitive abilities are predictive of PSSA scores?	4. Non-multi-collinearity	4. Correlation matrix of predictors

PSSA: Pennsylvania System of State Assessment
DIBELS: Dynamic Indicators of Basic Early Literacy Skills
PSF: Phoneme Segmentation Fluency
CHC: Cattell-Horn-Carroll

Summary

No Child Left Behind dictates that all children must read proficiently by the end of third grade. At the core of reading is phonological awareness. School psychologists are challenged with the task of assessing students accurately by employing psychometrically solid instruments that lend the best diagnostic utility and tap into those areas most related to reading achievement.

This research entailed a correlational study that examined the efficacy of using CHC specific cognitive abilities to enhance prediction of third grade reading scores on the PSSA. Data gathered over a three year time period was analyzed. This study sought to establish the value of utilizing cognitive assessment in addition to reading curriculum-based measurement for identifying reading deficits and predicting outcomes on state high-stakes tests. Participant selection, research design, instrumentation, data collection and statistical analyses were described.

CHAPTER IV

RESULTS

This study sought to determine if utilizing Cattell-Horn-Carroll (CHC) specific cognitive abilities enhances the prediction of reading achievement on the third grade Pennsylvania System of State Assessment (PSSA). The baseline model of prediction examined the predictive ability of sex, age, and maternal level of education of PSSA scores. The second model analyzed the increase in prediction by adding the Phoneme Segmentation Fluency measure of the Dynamic Indicators of Basic Early Literacy Skills to the predictor variables. The third model incorporated the CHC specific abilities to determine if predictive power was enhanced by their addition.

Complications

The predominant complication encountered during this study was sample size. First, the total number of participants was lower than originally anticipated due to students moving out-of-district and variability in implementation of DIBELS administration among elementary schools. Furthermore, because four different intelligence tests were utilized to garner data on CHC specific cognitive abilities, there were inconsistencies in the representation of each ability. With the exception of the Woodcock-Johnson Tests of Cognitive Ability – Third Edition (WJ-III), none of the intelligence tests taps into all seven of the CHC specific cognitive abilities. WJ-III data were obtained on only 5 students and subsequently Ga and Glr, which are not measured by the other instruments used in this study, are represented by the performance of only those 5 students. To further compound the issue, Ga and Glr are two of the five CHC specific cognitive abilities that are linked to reading achievement (Flanagan et al., 2008; McGrew, 2005), and their lacking representation in the analysis weakened the power of CHC abilities in predicting later reading achievement on the PSSA.

Subject size is viewed as the major impediment to this research; subsequently, generalizability is severely limited.

Computer Program

The Statistical Package for the Social Sciences (SPSS) computer program was utilized to calculate the data for this study.

Table 5

Means and Standard Deviations of the Predictor and Outcome Variables

	Valid	Missing	Mean	Std. Dev.	Min.	Max.
Sex	69	0	.6	.5	0	1
Age	69	0	6.5	.6	5	8
Mother's Education	60	9	1.2	1.0	0	3
DIBELS	69	0	1.4	.7	0	2
Gc	69	0	96.9	10.0	65	123
Gf	69	0	103.5	13.0	69	135
Gsm	64	5	92.9	11.4	65	120
Gv	69	0	95.8	11.6	70	125
Glr	5	64	94.6	5.5	85	99
Ga	5	64	100.6	8.4	91	112
Gs	64	5	96.9	12.1	62	128
PSSA	69	0	1.2	1.0	0	3

Table 6
Pennsylvania System of State Assessment (PSSA) Proficiency Level Categorization of the Sample

	Regular Education	Special Education
Below Basic	1	21
Basic	4	10
Proficient	7	22
Advanced	1	3

Analyses

1. *Do sex, age, and maternal level of education predict third grade PSSA reading scores?* The research hypothesis was that sex would not be predictive of PSSA scores. Pertaining to age, the hypothesis was that there would be a positive correlation between student age and performance on the third grade PSSA. The third hypothesis for this research questions was that higher maternal level of education would correlate positively with higher student performance on the PSSA. A multiple linear regression was proposed to determine this relationship. The assumptions necessary for this procedure were 1) Interval or ratio data; 2) Normality of error term; 3) Linearity; 4) Non-multicollinearity. Assumptions appropriateness was examined by 1) Examining the instrument; 2) Histograms with normal curves; 3) Bi-variate plots with straight lines; 4) The correlation matrix of predictors. After examining the assumptions for multiple linear regression, the data did not meet the assumptions for linearity; therefore, a linear relationship could not be established. This determination was made due to the lack of a normal curve within the histograms as well as the absence of a straight line on the bivariate plots. Subsequently, a Kendall's Tau B was calculated to answer the research question and test the hypothesis. Kendall's Tau B is used as a test of association for ordinal data when there are tied pairs. It can

be utilized with a small sample size when there is a high degree of overlapping numbers. It examines the degree to which the rank ordering of the second variables correspond to the rank ordering of the first variables (concordance rates) and provides a measure of significance between rankings.

Results: The Kendall's Tau B analysis yielded no statistically significant values among the variables (See Appendix C). Consequently, these are not meaningful findings.

2. *Does the DIBELS Phoneme Segmentation Fluency measure enhance the prediction of third grade PSSA reading scores?* The research hypothesis was that there would be a positive correlation between PSF scores and PSSA scores. A multiple linear regression using variables from research question 1 and adding Phoneme Segmentation Fluency scores was proposed to determine this relationship. The assumptions for this statistical procedure were 1) Interval or ratio data; 2) Normality of error term; 3) Linearity; 4) Non-multicollinearity. Assumptions appropriateness was examined by 1) Examining the instrument; 2) Histograms with normal curves; 3) Bi-variate plots with straight lines; 4) The correlation matrix of predictors. After examining the assumptions for multiple linear regression, the data did not meet the assumptions for linearity; therefore a linear relationship could not be established. This determination was made due to the lack of a normal curve within the histogram as well as the absence of a straight line on the bivariate plot. Subsequently, a Kendall's Tau B was utilized to answer the research question and test the hypothesis.

   Results: No statistically significant values were identified among the variables (See Appendix C). Consequently, these are not meaningful findings.

3. *Do CHC specific cognitive abilities enhance the prediction of PSF of third grade PSSA reading scores? Which of the specific cognitive abilities are predictive of* PSSA scores? The hypothesis was that Ga (auditory processing), Glr (long-term storage and retrieval), Gs (processing speed), Gc (language development), and Gsm (short-term memory) would each be predictive of reading achievement. A multiple linear regression was proposed using all variables from research question 2 and adding the Cattell-Horn-Carroll scores to determine this relationship. The assumptions for this statistical procedure were 1) Interval or ratio data; 2) Normality of error term; 3) Linearity; 4) Non-multicollinearity. Assumptions appropriateness was examined by 1) Examining the instrument; 2) Histograms with normal curves; 3) Bi-variate plots with straight lines; 4) The correlation matrix of predictors. After examining the assumptions for multiple linear regression, the data did not meet the assumptions for linearity; therefore, a linear relationship could not be established. This determination was made due to the lack of normal curves within the histograms as well as the absence of a straight line on the bivariate plots. Subsequently, a Kendall's Tau B was calculated to answer the research question and test the hypothesis.

Results: Of the seven CHC specific cognitive abilities, only Gf demonstrated a statistically significant relationship with PSSA scores. However, the correlation between Gf and PSSA was .20, indicating a very small effect size and, consequently, a weak link between the two variables. Statistically significant correlations among predictor variables were found between age and Gv (.24, $p = .05$); Gf and Gsm (.18, $p = .05$); Gf and DIBELS PSF (.21, $p = .05$); Gsm and DIBELS PSF (.24, $p = .05$); Gv and Gs (.21, $p = .05$); and Gv and DIBELS PSF (.26, $p = .01$). As with the relationship between Gf and PSSA, all of the above correlations are considered to have very small to small effect sizes, with at least a .50 necessary to be considered moderate (Cohen, 1977). There was a statistically significant relationship between Gf and Ga (.95, p = 05); however, the sample size for this particular correlation was only 5, thus preventing generalization of the result.

Summary

This chapter presented the complications encountered during the course of this research study. Small sample size profoundly affected the results and reduced generalizability. Inadequate representation of each CHC ability, particularly two of the well-established predictors of reading achievement, was a complicating factor as well. Statistical analysis revealed that multiple linear regression was not an appropriate analysis as originally thought, due to a lack of data linearity. Subsequently, the nonparametric measure of Kendall’s Tau B was utilized. Although statistically significant relationships were found, only one correlation was determined to be strong. Due to an extremely low sample size, however, the generalizability of that particular relationship is poor.

CHAPTER V

DISCUSSION

Introduction

The following chapter will discuss the results of this research study and ramifications of the findings. The predictor variables within each research question and the outcomes of each prediction model will be analyzed. Internal and external threats to validity will be presented. Finally, direction for future research will be discussed.

Baseline Prediction Model

The baseline model of prediction for this study examined the ability of sex, age, and maternal level of education to predict later reading achievement on the third grade Pennsylvania System of State Assessment (PSSA). Sex was not found to have a significant relationship with PSSA scores and, in fact, had a negative correlation (-.02, $p = .05$). This finding supports the research that sex is not a factor in performance on phonological awareness tasks (Burt et al., 1999; Nancollis et al., 2005). Age demonstrated no significance in relation to PSSA scores (-.05, $p = .05$), which does not support the literature on the developmental progression of reading. Certain phonological skills are acquired earlier than others and older children are expected to possess more advanced phonological awareness skills (Lane et al., 2002; Majsterek & Ellenwood, 1995; Shaywitz, 2003). The third component of the baseline model is maternal education. As with the previous two predictor variables, there was no significant relationship between mothers' years of education and children's performance on the third grade PSSA (.09, $p = .05$). This finding is not consistent with the current literature. Disadvantaged children typically enter school with lower levels of letter knowledge and phonemic awareness (Hale & Fiorello, 2004; Phillips et al., 2008). Compared to peers from average SES homes, socially disadvantaged children have less extensive vocabularies and poorer letter knowledge because they typically have a lack of experience with books prior to entering school (McIntosh et al., 2007). However, there is evidence that explicit phonological awareness instruction in preschool and kindergarten may mediate the effects of poverty (Joseph, 2006). Therefore, the possibility exists that direct instruction upon entering kindergarten, paired with remedial programs such as Title 1, could have altered in a positive manner the reading skills of those students with less proficiency. Additionally, many of the students were placed in special education programs following evaluation and had been receiving intensive, specially designed instruction for two to three years by the time they took the third grade PSSA.

DIBELS Phoneme Segmentation Fluency as a Predictor

The second model of prediction addressed the ability of the Phoneme Segmentation Fluency (PSF) measure of the Dynamic Indicators of Basic Early Literacy Skills (DIBELS) to predict PSSA scores. Not only was there no significant relationship between the two variables, a negative correlation resulted (.07, $p = .05$). This outcome was unexpected and at odds with the existing literature. Several studies have found strong connections between curriculum-based measurement (CBM) and performance on later state assessments (Crawford et al., 2001; Keller-Margulis et al., 2008; McGlinchey & Hixson, 2004; Shapiro et al., 2008; Silberglitt et al., 2006; Stage & Jacobsen, 2001). In particular, oral reading fluency was typically utilized as the CBM predictor variable in these studies. One explanation for the present study’s findings is that Phoneme Segmentation Fluency was used rather than oral reading fluency. Developmentally, PSF is a much less advanced reading skill, assessing students’ ability to segment at the sound level. Oral reading fluency, which assesses accuracy and speed when reading words, may be more likely to effectively predict later reading skill; however, it was not utilized in this study because it is not assessed at the kindergarten level.

CHC Specific Cognitive Abilities as Predictors

The third prediction model utilized Cattell-Horn-Carroll (CHC) specific cognitive abilities to determine if their addition would enhance the prediction of PSSA scores. Fluid intelligence (Gf) is the only specific cognitive ability that demonstrated a statistically significant relationship with PSSA scores (.20, $p = .05$). Gf is the ability to use deliberate and controlled mental operations to solve novel, “on-the-spot” problems (McGrew, 2005). Given that Gf is not one of the five factors cited in the literature as being strongly linked to reading achievement, this finding does not reflect the research. However, it should be noted that because the correlation between Gf and PSSA was very low, it was not indicative of a strong link between the two.

Crystallized intelligence (Gc) is a person’s acquired knowledge of the language, information and concepts of a specific culture, and/or the application of this knowledge (McGrew, 2005). Gc was not found to have a significant connection to PSSA scores (.19, $p = .05$). This finding is in contrast to the literature indicating that Gc has the strongest effect on passage comprehension (McGrew et al., 1997).

Auditory processing (Ga) is an ability that represents the extent to which an individual can cognitively control the perception of auditory information including the abilities to analyze, manipulate, comprehend, and synthesize sound elements (McGrew, 2005). Auditory processing, specifically phonological awareness, plays a significant role in reading development (McGrew; Snider, 1997). The results of the current study did not demonstrate a relationship between Ga and PSSA scores (.12, $p = .05$) and do not support the literature; however, the extremely limited sample size of 5 prevents any conclusions from being drawn. Auditory processing is not adequately represented on the Wechsler Intelligence Scale for Children – Fourth Edition (WISC-IV), the intelligence battery used to assess the majority of the subjects. Only those subjects who were administered the Woodcock-Johnson Test of Cognitive Abilities – Third Edition (WJ-III) were factored into the representation of Ga.

Short-term memory (Gsm) is the ability to apprehend and maintain awareness of elements of information in the immediate situation (McGrew, 2005). It is one of the CHC abilities that is connected to reading achievement, according to the literature (Flanagan et al., 2008). Gsm showed no link to PSSA scores in this study (-.05, $p = .05$).

Visual-spatial abilities (Gv) are involved in the generation, storage, retrieval, and transformation of visual images (McGrew, 2005) and are not known to play a significant role in reading (Flanagan et al., 2008). Within this study, Gv showed no relationship with PSSA scores (.08, $p = .05$), which is consistent with the research.

Long-term storage and retrieval (Glr) involves the storage and consolidation of new information in long-term memory, and the ability to later fluently retrieve the stored information through association (McGrew, 2005). Glr is one of the five CHC abilities that is related to reading achievement. More specifically, skill on tasks of rapid automatic naming is considered to be very important during the elementary years (Flanagan et al., 2008). There was not a significant relationship between Glr and PSSA scores (.13, $p = .05$); however, similar to Ga, the subject size was only 5, preventing any ability to generalize results. As mentioned previously for Ga, the WISC-IV does not tap into Glr and, subsequently, those subjects who were administered the WJ-III provided the only data for this factor.

Processing speed (Gs) represents the ability to automatically and fluently perform relatively easy or overlearned cognitive tasks, especially when high mental efficiency is required (McGrew, 2005). Gs did not reveal any significance with relation to PSSA scores (.04, $p = .05$). This result is contrary to what is indicated in the literature because Gs has repeatedly been found to be linked with reading achievement and is particularly important during the elementary school years (Flanagan et al., 2008).

Internal Threats to Validity

There may have been a history effect that influenced the results of this research study. Explicit instruction in the regular education curriculum, as well as through Title 1 or special education may have improved the reading skills of some students, particularly those who were poor readers at the time of DIBELS administration in kindergarten or first grade.

External Threats to Validity

The generalizability of this study is significantly affected for different reasons. First, the subject size of 69 is small. Second, the sample was geographically restricted to a large, suburban school district in Southwestern Pennsylvania which restricts generalizability of the results to urban or rural school districts.

Restriction of Ranges

The unusual findings of this study may also be due to effects from restriction of ranges. Of the 56 students who were in special education, 31 scored Below Basic or Basic on the third grade PSSA, indicating that despite specially designed instruction, the students were not at a level of proficiency in reading. Add to that number the five regular education students who scored in the Below Basic or Basic ranges, which results in one half of the total sample unable to read proficiently. Because the sample was limited to those students referred for psychoeducational evaluation due to reading problems, the range of reading skills was already limited at the outset of the study. It may be that those students who were initially poor readers were subsequently unable to develop the necessary skills to become proficient readers, even with intensive remediation (Matthew effect).

Implications for Future Research

Given that there are several recent studies that consistently found CBM to be an accurate predictor of later reading achievement, there is a fair amount of evidence that utilizing CBM is an effective method of prediction. Future studies should continue to expound upon the existing literature since the early prediction of later reading skills is an invaluable tool for school districts attempting to remediate struggling readers. This practice is especially useful given the pressure to produce proficient readers that has been incurred by districts as a result of No Child Left Behind.

Despite the sparse findings of this research study, it would be beneficial for future studies to examine CHC abilities as possible predictors of later reading achievement. A larger sample size and adequate representation of the broad CHC abilities may produce different results than those of the present study. If future research deems that CHC abilities are an accurate means of identifying reading deficits and predicting later progress, it may be prudent to apply the same methodology to math.

Summary

The preceding chapter discussed three different models of predicting reading achievement on the third grade PSSA. First, sex, age, and maternal level of education were examined as predictors, none of which was determined to be linked to third grade PSSA scores. The second model added the DIBELS Phoneme Segmentation Fluency measure as a predictor variable and also found no connection with PSSA scores. The third prediction model involved the addition of Cattell-Horn-Carroll specific cognitive abilities to determine if they enhanced the prediction of PSSA scores. Results indicated that CHC abilities did not predict PSSA scores. History was an internal threat to validity due to the instruction that students received between the time of psychoeducational evaluation and DIBELS in kindergarten or first grade, and the PSSA in third grade. Generalizability of results is an external threat to validity because of the small sample size and restricted geographic location of the sample. Restriction of ranges was a probable factor in the outcome, in that the majority of the students were in special education, and half of the sample was not proficient on the PSSA. Suggestions for future research include the same type of study with a larger sample size and better representation of CHC abilities. As well, a similar study could be completed to predict math outcomes.

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APPENDICES

APPENDIX A

Letter from Dr. Donald J. Tylinski

Seneca Valley School District

Donald J. Tylinski, Ed.D.
Superintendent

Administration Center
124 Seneca School Road
Harmony, PA 16037-9134
PHONE: (724) 452-6040
FAX: (724) 452-6105

November 12, 2008

Ms. Kathleen Nicholson
7109 Cresswyck Court
Wexford, PA 15090

Dear Ms. Nicholson:

I have reviewed your request to utilize archived student information/data in the completion of your doctoral work and dissertation study at Indiana University of Pennsylvania. I understand that the data to be collected will include DIBELS and I.Q. scores of kindergarten and first grade students, as well as their PSSA reading scores from third grade. The information to be obtained will involve kindergarten and first grade students from the 2003-04, 2004-05, and 2005-06 school years.

Because the data that you are requesting is archival in nature and not new data that will be collected from students, I grant you permission to utilize this data under the condition that no Seneca Valley School District student will be identifiable as a result of your use of this data.

I am confident that the results of your study will assist the Seneca Valley School District in providing an improved educational program for our students. I may ask you to present your findings to members of the administrative team once your study has been completed.

Good luck with your project. I look forward to reviewing your results.

Sincerely,

Donald J. Tylinski

Donald J. Tylinski, Ed.D.
Superintendent

APPENDIX B

Correlation Matrix of the Variables

Variable	PSSA Score	Sex	Age	Gc	Gf	Gsm	Gv	Glr	Ga	Gs	Mother's Educ.	DIBELS Score
PSSA Score	1.000	-.020	.052	.185	.197*	-.047	.082	.126	.120	.039	.086	-.072
p	.	.856	.636	.052	.039	.640	.400	.776	.782	.692	.446	.511
n	69	69	69	69	69	64	69	5	5	64	60	69
Sex	-.020	1.000	.081	.077	.007	-.231*	.008	.333	.632	.066	-.048	.067
p	.856	.	.493	.446	.947	.030	.941	.468	.157	.535	.690	.566
n	69	69	69	69	69	64	69	5	5	64	60	69
Age	-.052	.081	1.000	.001	.132	.126	.242*	.667	-.316	.036	.215	.420**
p	.636	.493	.	.995	.185	.227	.018	.147	.480	.726	.067	.000
n	69	69	69	69	69	64	69	5	5	64	60	69
Gc	.185	.077	.001	1.000	.252**	.282**	.157	.105	.600	.058	.071	.278**
p	.052	.446	.995	.	.003	.002	.073	.801	.142	.518	.486	.005
n	69	69	69	69	69	64	69	5	5	64	60	69
Gf	.197*	.007	.132	.252**	1.000	.182*	.242**	.222	.949*	.244**	.058	.211*
P	.039	.947	.185	.003	.	.042	.006	.603	.023	.006	.566	.031
n	69	69	69	69	69	64	69	5	5	64	60	69
Gsm	-.047	-.231*	.126	.282**	.182*	1.000	.060	.105	.000	.087	.171	.243*
P	.640	.030	.227	.002	.042	.	.511	.801	1.000	.352	.107	.017
n	64	64	64	64	64	64	64	5	5	59	56	64
Gv	.082	.008	.242*	.157	.242**	.060	1.000	-.105	.400	.212*	.179	.258*
P	.400	.941	.018	.073	.006	.511	.	.801	.327	.021	.085	.010
n	69	69	69	69	69	64	69	5	5	64	60	69
Glr	.126	.333	.667	.105	.222	.105	-.105	1.000	.105	-.316	.000	-.252
P	.776	.468	.147	.801	.603	.801	.801	.	.801	.448	1.000	.568
n	5	5	5	5	5	5	5	5	5	5	5	5
Ga	.120	.632	-.316	.600	.949*	.000	.400	.105	1.000	-.400	-.120	.598
P	.782	.157	.480	.142	.023	1.000	.327	.801	.	.327	.782	.166
n	5	5	5	5	5	5	5	5	5	5	5	5

Gs	.039	.066	.036	.058	.244**	.087	.212*	-.316	-.400	1.000	.000	.122
P	.692	.535	.726	.518	.006	.352	.021	.448	.327		.994	.233
n	64	64	64	64	64	59	64	5	5	64	55	64
Mother’s Educ.	.086	-.048	.215	.071	.058	.171	.179	.000	-.120	.000	1.000	.162
P	.446	.690	.067	.486	.566	.107	.085	1.000	.782	.994	.	.164
n	60	60	60	60	60	56	60	5	5	55	60	60
DIBELS Score	-.072	.067	.420**	.278**	.211*	.243*	.258*	-.252	.598	.122	.162	1.000
P	.511	.566	.000	.005	.031	.017	.010	.568	.166	.233	.164	.
n	69	69	69	69	69	64	69	5	5	64	60	69