RELATIONSHIP BETWEEN CATTELL-HORN-CARROLL (CHC) COGNITIVE ABILITIES AND EARLY ACADEMIC ABILITIES IN PRESCHOOL CHILDREN

by

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ABSTRACT

RELATIONSHIP BETWEEN CATTELL-HORN-CARROLL (CHC) COGNITIVE ABILITIES AND EARLY ACADEMIC ABILITIES IN PRESCHOOL CHILDREN

Interest in the assessment of preschool children has grown considerably over the past few decades due to federal legislation in special education in the US, national goals on early school preparedness in both the US and Canada, and research on the importance of early preschool experiences. This increase of interest in early assessment has lead to a need for evaluation of cognitive factors important to understanding early academic achievement in young children. Previous research exploring the role of specific cognitive abilities in academic performance or achievement has historically focused on school-age and adult populations, and has neglected to consider early academic abilities in preschool children, despite the recognized importance of the use of intelligence tests with this population. The purpose of this study was to explore the relationship between cognitive abilities as defined by the Cattell-Horn-Carroll (CHC) theory and early academic abilities in preschool age children using the Woodcock-Johnson - Third Edition Tests of Cognitive Abilities (WJ III COG), Tests of Achievement (WJ III ACH), and Diagnostic Supplement (WJ III DS) (Woodcock, McGrew, and Mather, 2001). Participants included 179 children, ages 3 years, 0 months to 6 years, 3 months. Pearson correlations were used to examine the relationships between the overall General Intellectual Ability (GIA) scores from the WJ III COG and DS, and the achievement clusters from the WJ III ACH. Additionally, individual stepwise regression equations were used to determine the cognitive abilities most important for early academic achievement in preschool-age children.

The GIA – Early Development score demonstrated overall higher correlations with the achievement clusters than the GIA Standard and GIA Extended scores, providing support for the use of the GIA – Early Development score as an appropriate measure of general intellectual functioning for preschool children. Individual regression equations revealed that Comprehension-Knowledge, Processing Speed, Fluid Reasoning, and memory abilities were identified most consistently as important predictors of the WJ III ACH clusters: Pre-Academic Skills (Std), Pre-Academic Skills and Knowledge (Ext), Basic Reading Skills, Basic Writing Skills, and Math Reasoning. Limitations of the study, contributions to the field, and future avenues for research are discussed.

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CHAPTER ONE

Introduction

The study of cognitive abilities and academic achievement in preschool age children has grown considerably over the last few decades, and its importance is well recognized in the school psychology field. The introduction of special education legislation in the United States in the 1980's, knowledge of the impact of early education for later development, research on the effectiveness of preschool and daycare programs, and goals to improve school readiness have all lead to this growth (Nagle, 2000). Although the use of standardized assessment techniques with preschool-age children has been criticized by some due to their inadequate psychometric properties, lack of treatment utility, and instability in evaluation procedures (Bagnato & Neisworth, 1994; McLean, Wolery, & Bailey, 2004; Nagle, 2000; Neisworth & Bagnato, 2004), norm-referenced instruments can be useful for identifying young children in need of early intervention and educational services and for program planning, with more recent instruments showing considerable improvement in their psychometric characteristics (Bracken, 1987; Flanagan & Alfonzo, 1995; Ford & Dahinten, 2005). In addition, a better understanding of the structure of intellectual abilities in preschool children and how these cognitive functions relate to early academic abilities or achievement is essential for detecting learning difficulties and developing meaningful early interventions.

Definition of Key Terms

Intelligence and Cognitive Abilities

Despite the prevalence of the terms intelligence and intelligence testing in assessment practice with school-age children and adults, their definitions are commonly misunderstood and often disagreed upon by professionals and scholars in the field. Prominent definitions range from intelligence as a sign of adaptive behavior (Anastasi, 1986), the ability to resolve problems during everyday encounters (Gardner, 1983), a survival skill (Sattler, 2001), or as planning ability and coding of information (Das, 1986). Thus, many professionals working with children tend to prefer the term cognitive ability to intelligence. However, a consistent definition of cognitive ability is difficult to identify and often not agreed upon. In his book, Human Cognitive Abilities, Carroll (1993) proposes a definition of "cognitive abilities", which first requires an understanding of the term "ability" as referring to:

> *the possible variations over individuals in the liminal [threshold] levels of task difficulty (or in derived measurements based on such liminal levels) at which, on any given occasion in which all conditions appear favorable, individuals perform successfully on a defined class of tasks* (p. 8).

In his connection of this definition to the term "cognitive ability", Carroll (1993) first defines a "cognitive task" as "*any task in which correct or appropriate processing of mental information is critical to successful performance*" (p. 10). It is this focus on the mental information that must be processed or operated on, which leads to Carroll's final definition of "cognitive ability" as "*any ability that concerns some class of cognitive tasks, so defined*" (p.10). Carroll further explains that many cognitive tasks appear complex but can often be dissected into separate components or processes. Despite such a detailed description and definition as to what constitutes a cognitive ability, many scholars and theorists define this concept in different ways, and there has not been a universal acceptance of the term "cognitive ability" over "intelligence", or vice versa. As the test authors for the WJ III have embraced the term "cognitive abilities", and given that the term is perceived by the researcher to be more contemporary and inclusive, for the purposes of this study, the terms "cognitive abilities" and "cognitive functioning" will be used to refer to the construct often called "intelligence" or "intellectual functioning".

Early Academic Abilities or Achievement

While the definition of what constitutes academic achievement for school-age children and adolescents is well established, and literature on this topic is readily available, defining and examining academic achievement for preschoolers has just begun. Because little research has explored the question of what early achievement looks like for preschool children, the present study will be charting somewhat undiscovered territory while adding to this gap in the literature. Academic achievements have traditionally and historically been conceptualized as those abilities that develop as a function of more school-related, formal educational experiences (Flanagan, Ortiz, Alfonzo, & Mascolo, 2002). Therefore, it seems counter-intuitive to discuss the notion of academic achievement in preschool children, who have not yet had an opportunity to participate in formal schooling. However, many preschool-age children gain exposure to achievement abilities such as pre-reading skills, early writing skills (including formation of lines and letters), and early number concepts and counting, prior to entering a formal education institution in grade 1. The achievement tests appropriate for preschool children on the WJ III, which comprise the early development achievement clusters, are designed to measure pre-academic content thought to be important for preparing young children for the academic challenges of the classroom, and are therefore appropriately conceptualized as achievements. As stated by Schrank, Mather, McGrew, and Woodcock (2003), "in early childhood assessment, an understanding of the child's levels of early- or pre-academic skills often aids in interpreting the impact that any disabling condition or developmental delay might have on the ability to perform in school" (p.9). For the purpose of this study, the terms "early academic abilities" and "early academic achievement" will be used interchangeably.

Preschool Children

There is often debate over the ages covered by the preschool years. Traditionally, when referring to cognitive assessment, the preschool years has been defined as beginning between two and three years of age, and continuing through approximately age seven or eight (Ford & Dahinten, 2005; Tideman & Gustafsson, 2003). For the purpose of this study, the term preschool children will be used to define those children who are between the ages of 3 years, 0 months, and 6 years, 3 months, as this is the range of ages corresponding to the children who participated in this study and it is consistent with the age before which students begin to receive more traditional classroom based primary instruction.

Purpose of the Study

The purpose of the present study was to examine the relationship between the Cattell-Horn-Carroll (CHC) cognitive abilities and early academic abilities or achievement in preschool age children. Very little is known about the structure of preschool cognitive abilities from a CHC theoretical perspective, as much of the research with this model has focused on school-age and adult populations. Specifically, this study explored the cognitive measures from the Woodcock-Johnson Tests of Cognitive Abilities – Third Edition (WJ III COG; Woodcock, McGrew & Mather, 2001) and the Woodcock-Johnson III Diagnostic Supplement to the Tests of Cognitive Abilities (WJ III DS; Woodcock, McGrew, Mather & Schrank, 2003) that play a role in achievement for young children as measured by the Woodcock-Johnson Tests of Achievement – Third Edition (WJ III ACH; Woodcock, McGrew & Mather, 2001). In addition, an attempt was made to discover the predictive ability of different cognitive cluster scores from the WJ III COG and WJ III DS with WJ III ACH clusters and tests in preschool-age children. Because the same norm sample of participants were used in the standardization of all three instruments being utilized in this study, an accurate investigation of validity is possible. One goal of the current study is to better understand the nature of cognitive abilities at the preschool level and to investigate how these abilities relate to early academic achievement within this population. A second goal is to further examine the utility of the WJ III with young children by accumulating knowledge on how this test battery functions differently for preschool children than for their school-age and adult counterparts.

Research conducted with the Woodcock-Johnson – Third Edition (WJ III; Woodcock, McGrew, and Mather, 2001) and preschool children is necessary given the following: 1) preschool assessment using standardized, norm-referenced tools is necessary (at least in part) for receiving special education services in both Canada and the United States; 2) many of the commonly used preschool assessment measures have been criticized for their weak psychometric properties and their lack of procedures appropriate to young children with limited language skills and difficult behavior; 3) the WJ-R received favorable reviews in terms of technical characteristics, but a major revision of this measure, the WJ III is now available and includes an additional diagnostic supplement for further interpretation and diagnosis; and 4) few independent studies have investigated the nature of preschool cognitive abilities as measured by the WJ III, and the utility of this tool with young children. The following research questions were addressed:

1. What are the relationships between the WJ III COG General Intellectual Ability (GIA) score, the WJ III General Intellectual Ability - Early Development (GIA-EDev) score, and the WJ III ACH clusters: Basic Reading Skills, Basic Writing

Skills, Math Reasoning, Pre-Academic Skills (Std), and Pre-Academic Skills and Knowledge (Ext)?

2. Which CHC abilities, as measured by the WJ III COG [specifically, Comprehension-Knowledge (Gc), Long-Term Retreival (Glr), Short-Term Memory (Gsm), Fluid Reasoning (Gf), Processing Speed (Gs), Auditory Processing (Ga), and Visual-Spatial Processing (Gv)], and additional clusters, as measured jointly by the WJ III COG and DS [specifically, Associative Memory (Glr), Auditory Memory Span (Gsm), and Visual-Spatial Thinking 3 (Gv3)] are the best predictors of Basic Reading Skills, Basic Writing Skills, Math Reasoning, Pre-academic Skills (Std), and Pre-academic Skills and Knowledge (Ext)?

CHAPTER TWO

Review of Relevant Literature

For the past few decades, research relating to the assessment of preschool children has grown considerably. Factors affecting this increase include the effectiveness of preschool programs, national goals to enhance school readiness, an increase in research on the importance of early educational experiences for later development, and most importantly, federal legislation in the United States, which required states to provide special services to preschool children under the same disability categories as older children (Nagle, 2000). With this increase of interest in preschool assessment leading to early intervention comes a need to evaluate the cognitive factors that are important to understanding early academic achievement in young children.

Issues in Preschool Assessment

Brief History of Preschool Assessment. Current trends in preschool assessment have been shaped by many of the early research developments and events that had major influences on assessment with school-age populations (for example, the work of Binet, Goddard, Terman, and Cattell) (Ford & Dahinten, 2005; Kelley & Surbeck, 2000). Until the early 20th century, intelligence was thought to be a fixed trait that was dependent on sensory functions. Binet was the first to shift this paradigm by proposing that intellectual functioning involves reasoning, comprehension and judgment rather than perceptual abilities (Bracken & Walker, 1997). Along with this shift, an aim of the Child Study Movement of the early 1900s was to discover the characteristics of normally developing young children, determine the influences of heredity versus environment on intelligence, and an attempt to improve tools for assessment of young children. The Wellman-Goodenough controversy in the 1930s and 1940s of modifiable as opposed to fixed intelligence sparked a need for reevaluation of the influences cognitive functioning, and for the development of well-standardized, psychometrically strong measurement devices for assessing young children's abilities (Kelley & Surbeck, 2000).

During the 1960s, attention towards early child development and education further increased (Bracken & Walker, 1997). At the same time, federally funded, educational intervention projects such as Head Start were initiated as an attempt to enhance early experiences for children raised in poverty. These interventions led to a greater need for preschool assessment tools as a means of evaluating program efficacy, and paved the way for federal legislation designed to ensure that children with disabilities were provided with an appropriate education (Bracken & Walker, 1997; Paget & Nagle, 1986). Arguably, one of the most influential events for preschool assessment in the United States was the Education for All Handicapped Children Act (Public Law 94-142) developed in 1975, which mandated that states provide all school-age children with disabilities free and appropriate education in the least restrictive environment possible. In 1986, an amendment to this act (Public Law 99-457) mandated an extension of this law that required educational services to be provided to children between the ages of 3 and 5, and included incentives for providing programs to children from birth to two years (Bracken & Walker, 1997; Ford & Dahinten, 2005). Together, these two laws represented key steps toward conceptualizing preschool assessment as a means for providing appropriate instructional planning rather than merely as a tool for diagnosis and identification for special education services (Paget & Nagle, 1986). While these laws apply in the US, their impact on the development of new assessment tools for young children is experienced by those in English speaking countries throughout the world.

Use of Standardized Measures with Young Children. Traditional, norm-referenced assessment tools designed for use with preschool-age children have been both criticized and supported for several reasons. In a survey of 185 preschool psychologists from the National Association of School Psychologists (NASP) and the American Psychological Association (APA) who together reported that they had assessed 7,223 infants and preschool children, Bagnato and Neisworth (1994) found that early intelligence tests failed to be acceptable tools 43% of the time for these psychologists, and that many preschool children were "untestable" with standardized measures due to limited language abilities and difficult behavior. Bagnato and Neisworth concluded that their survey provided sound evidence for the invalidity and lack of treatment utility of early intelligence tests, and contended that norm-referenced, standardized intelligence tests should be abandoned in favor of multidisciplinary, ecological, and curriculum-based approaches to assessment.

In a response to Bagnato and Neisworth (1994), Bracken (1994) argued that, rather than reject the use of traditional intelligent tests, psychologists should use standardized approaches to intellectual assessment as a complement to alternative procedures that "promote meaningful interventions, enhance child development, improve the alliance between parents, educators, professionals and children, and are worthy of adoption and widespread implementation" (p. 104). In addition, Gyurke (1994) argued that many of the problems of using intelligence tests with young children outlined by Bagnato and Neisworth (1994) can be avoided if these assessment measures are used intelligently by psychologists. Gyurke further states that assessment with standardized, norm-referenced instruments does have a role in helping to identify and provide services for preschool-age children with special needs. Additionally, standardized assessment continues to be a requirement for special education both within the United States and Canada (Flanagan & Alfonzo, 1995).

In a more current examination of the preschool assessment debate, Neisworth and Bagnato (2004) stress that measurement using norm-referenced tests is detrimental to young children, and that these tests have not been developed for nor validated on children with developmental disabilities. The authors continue to assert that conventional norm-referenced testing practices be abandoned for all purposes (e.g., screening, program planning and monitoring, eligibility) and replaced by authentic assessment, which "refers to the systematic collection of information about the naturally occurring behaviors of young children and families in their daily routines" (p. 204). Neisworth and Bagnato further outline 8 standards they believe are necessary in guiding developmentally appropriate assessment: Utility, Acceptability, Authenticity, Equity, Sensitivity, Convergence, Collaboration, and Congruence.

Although Neisworth and Bagnato's (2004) claims are well organized and supported by other educators and professionals (e.g., McLean, Wolery, & Bailey, 2004; Meisels & Atkins-Burnett, 2000), several points of argument are necessary. First, many newer traditional, norm-referenced instruments used for assessment of young children *have* been validated on a sample of children with developmental disabilities, and they provide modification or accommodation procedures for children with disabilities that should be followed during administration. Secondly, often assessment in early education is conducted for the express purpose of diagnosis and establishing eligibility for services (McLean, Wolery, & Bailey, 2004). For this type of assessment, it is necessary to compare a child's performance with typically developing children of the same age (referred to as norm-referenced testing), in order to understand the possible severity of delays. Although standardized tools do not generally provide information about children's potential or classroom performance, they are nevertheless very useful for diagnostic purposes and currently absolutely necessary for meeting eligibility requirements in both Canada and the United States. Lastly, it is possible to use standardized assessment instruments in combination with other methods as part of the authentic assessment approach, while still adhering to the 8 standards of appropriate assessment outlined above, rather than abandoning these tools altogether.

Technical Characteristics of Preschool Intelligence Tests. In addition to the argument for the abandonment of intelligence tests supported by Bagnato and Neisworth (1994), Meisels and Atkins-Burnett (2000), and Neisworth and Bagnato (2004), many researchers have criticized the use of standardized assessment tools with young children because of their limited technical characteristics and properties. In a review of 10 common assessment instruments designed for their use with preschool children, Bracken (1987) examined the technical adequacy and delineated minimal standards of acceptability for several technical properties, including reliability (both test-retest and internal consistency), validity, item gradients, and test floors. Item gradients refer to "how rapidly standard scores increase as a function of a child's success or failure on a single test item" (Bracken, 1987, p. 322), and tests with adequate floors allow for differentiation between children who are functioning in the low range of abilities and those with average skills. Bracken's review of preschool tests revealed psychometric properties that were severely limited in their test floors, reliability and item gradients, especially for children below 4 years of age.

In a similar examination of standardized tests designed for use with children from birth through two years of age, Bradley-Johnson (2001) found concerns with the technical adequacy of all six of the measures reviewed (the Battelle Developmental Inventory, the Bayley Scales of Infant Development – Second Edition, the Cognitive Abilities Scale, the Leiter International Performance Scale – Revised, the Mullen Scales of Early Learning, and the Stanford Binet –

Fourth Edition). In particular, many of these measures did not include samples of children with developmental delays, had inadequate test-retest reliability and test floors, and lacked information on predictive validity. Bradley-Johnson concluded that "test limitations warrant careful thought so that test selection is appropriate and results are interpreted accurately" (p. 41). Both Bracken's (1987) and Bradley-Johnson's (2001) reviews were detailed and careful in their methodology and revealed several serious concerns with the technical adequacy of standardized tests used with infants, toddlers and preschoolers. However, many of the tests that Bracken reviewed, and a few of the tests that Bradley-Johnson examined (e.g., the Stanford-Binet – Fourth Edition) are currently outdated and would therefore be inappropriate for use with any children. Additionally, many of these assessment tools have since been updated and revised with the technical limitations identified by Bracken (1987) and Bradley-Johnson (2001) in mind.

In an attempt to address this issue and determine whether the psychometric limitations of certain tests identified by Bracken (1987) were improved with the publication of new or recently revised intelligence tests for preschool-age children, Flanagan and Alfonzo (1995) reviewed several updated tests, including: The Wechsler Preschool and Primary Scale of Intelligence – Revised (WPPSI-R), the Differential Ability Scales (DAS), the Stanford-Binet Intelligence Scale – Fourth Edition (S-B:IV), the Woodcock-Johnson Psychoeducational Battery – Revised: Tests of Cognitive Ability (WJ-R COG), and the Bayley Scales of Infant Development – Second Edition (BSID-II). Similar to results by Bracken (1987), Flanagan and Alfonzo found that standardization samples and internal consistency of all measures under study were good, although several of the tests reviewed had inadequate technical properties at the youngest age ranges, with test floors and item gradients being especially problematic for children below the age of 4. Two tests, however, were found to be psychometrically sound, even at the lower preschool age ranges: the BSID-II and the WJ-R COG. In particular, the WJ-R COG was indentified as "the only instrument that has good floors and item gradients across the entire preschool age range for all but one of its recommended tests" (p. 85). Therefore, despite certain technical characteristics that continue to be problematic even with test revision, improvements have been made. An investigation of the psychometric properties from the most recent edition of the Woodcock-Johnson Tests of Cognitive Abilities (WJ III COG) and preliminary investigations using additional recently revised preschool cognitive measures suggests that the trend for improved technical characteristics may well continue (Tusing, Maricle, & Ford, 2002; Kozey, Merkel, Morgan, Swart, Ford & Tusing, 2005). In a brief review of several contemporary revisions of assessment measures for infants/toddlers and preschool children, Tusing, et al (2002) and Ford and Dahinten (2005) report that some tests from the WJ III COG are appropriate for children as young as 2:0, and suggest that its utility is enhanced by using the WJ III Diagnostic Supplement in conjunction with the main cognitive battery (WJ III COG). In addition, Ford and Dahinten (2005) state that "the WJ III has an interpretive advantage that may be particularly useful for determining the presence and severity of developmental delay in assessment of young children" (p. 497) due to the use of the Relative Proficiency Index (RPI) score, which describes a child's quality of performance rather than merely their status compared to same-age or same-grade peers.

Challenges of Preschool Assessment. Several unique characteristics of preschool children make the task of reliable and valid assessment challenging when compared to the assessment of school-age children, adolescents, and adults. Young children's development is characterized by rapid growth and change, which makes it difficult to assess skills that may be emerging and unstable (Nagle, 2000). In addition, preschool children exhibit behaviors that examiners must take into account, including short attention spans, distractibility and high activity levels, need for frequent breaks, lack of motivation for responding correctly and pleasing the examiner, and separation issues (Ford & Dahinten, 2005; Greenspan & Meisels, 1996; Nagle, 2000). Because of these differences, the stability of standardized test results with preschool children may be somewhat compromised.

Importance of Standardized Assessment in Early Intervention. Despite the criticisms and psychometric limitations of using intellectual tests with preschool children, and the developmental and behavioral challenges unique to children in this age range, several benefits of early assessment with standardized cognitive instruments have been identified. First, early assessment allows educational professionals to identify children with delays in order to provide immediate interventions. Often these additional experiences or services are essential for decreasing the gap between the typical expected level of performance and the child's current skills. Second, standardized assessment can provide professionals with knowledge of which cognitive skills are important for predicting early social, behavioral, or academic development. Therefore, assessment tools for preschool children must be designed to measure skills that are important for predicting future development, but first we need to discover what those skills actually *are.* In other words, interventions based on assessment results can only be justified if the tests used to conduct the evaluation have been shown to predict these important areas of functioning (Bracken & Walker, 1997). If we do not understand what cognitive abilities are important to the prediction of academic achievement in young children, assessments that rely on the measurement of those cognitive abilities will not be useful for developing meaningful interventions.

Using Cognitive Abilities to Predict Achievement

Cattell-Horn-Carroll (CHC) Theory. Different theories, models, and approaches have been proposed by researchers in an attempt to provide a framework through which the cognitive processes most central to achievement may be examined. One prominent and well-validated theory of cognitive abilities that has been used to understand and predict reading, math, writing, and oral language acquisition and achievement is the Cattell-Horn-Carroll (CHC) theory of cognitive abilities (Evans et al., 2001; Floyd et al., 2003; McGrew, Keith, Vanderwood & Flanagan, 1997). CHC theory evolved from the psychometric approach to studying intelligence (McGrew, Woodcock, & Ford, 2002), and as the name suggests, is a synthesis of the Cattell-Horn *Gf-Gc* theory of several kinds of intelligences (for a detailed description, see McGrew, 2005), and the Carroll three-stratum theory of cognitive abilities (Carroll, 1993). The theory proposes three hierarchical levels (or strata) of abilities: *g*, or general intelligence at the top (Stratum III), broad cognitive abilities in the middle (Stratum II), and narrow cognitive abilities, which are subsumed by the broad abilities (Stratum I). The broad cognitive abilities include: Fluid Reasoning (Gf), a measure of problem solving ability using unfamiliar information or stimuli, Comprehension-Knowledge or Crystallized Ability (Gc), a measure of culturally acquired verbal and procedural knowledge, Short-term Memory (Gsm), the ability to hold information in memory while working on another task, Visual Processing (Gv), the ability to think with and mentally manipulate visual patterns and stimuli, Auditory Processing (Ga), a measure of the ability to manipulate and analyze sounds, Processing Speed (Gs), the ability to perform mental tasks with ease and speed, Long-term Retrieval (Glr), the ability to store information in long-term memory and then retrieve it later, Reading and Writing (Grw), a measure of the breadth and depth of acquired reading and writing skills and knowledge, and

Quantitative Knowledge (Gq), the ability to apply and understand mathematical concepts (Evans et al., 2001; Mather & Woodcock, 2001; Sattler, 2001).

Extensive empirical evidence exists to support the validity of contemporary CHC theory. Many factor-analytic studies using large, nationally representative samples of participants have demonstrated that the hierarchical structure of cognitive abilities (a higher-order g factor that is subsumed by eight broad abilities) as defined by the CHC model holds across the lifespan, from childhood through adulthood (McGrew, 2005). Several small-sample studies, using data from commonly used cognitive measures, provide additional support for the CHC framework (for details, see McGrew, 2005, and McGrew & Flanagan, 1998). McGrew and Flanagan (1998) also provide structural evidence, which is based on individual differences, to demonstrate that the CHC model is invariant across ages, gender, and cultural and racial differences. In addition, the validity of the CHC framework is supported by developmental growth curve evidence showing that different broad abilities follow differing developmental trajectories as individuals age (Horn & Noll, 1997; McGrew & Flanagan, 1998; McGrew & Woodcock, 2001).

Relationship Between Cognitive Abilities and Achievement.

Generally, cognitive abilities and academic achievements are thought to lie on the same continuum of human mental abilities. However, these two concepts "can be differentiated to some extent by the manner in which their development is influenced by different types of learning (e.g., formal school-based instruction versus informal real-life experience), achievements (e.g., level of education, opportunities to cultivate unique strengths), and experiences (e.g., cultural, linguistic)" (Flanagan, Ortiz, Alfonzo & Mascolo, 2002, p. 49).

A number of previous research studies have examined the relationship between CHC broad cognitive abilities and the curricular areas of reading, math, and writing achievement, including skills related to basic reading development, reading comprehension, math calculation, math reasoning, basic writing development, and written expression. Major findings for each curricular area are discussed separately below.

Reading Achievement. In order to examine the relationship between CHC abilities and academic achievement, Flanagan, Ortiz, Alfonzo, and Mascolo (2002) reviewed and summarized a large number of studies grouped into three categories: 1) key studies designed to specifically to investigate the relations between the different CHC abilities [e.g., Fluid Reasoning (Gf), Long-Term Retreival (Glr)] and areas of academic achievement, 2) narrative and meta-analytic reviews of the literature, and 3) individual research studies that did not specifically investigate abilities from a CHC framework, but that nevertheless contribute to our understanding of CHC cognitive abilities as they relate to achievement. In terms of reading achievement, Flanangan, Ortiz, Alfonzo, and Mascolo discovered that the narrow abilities that showed the most consistent significant relations with this curricular area where those subsumed by the broad abilities of Ga, Gc, Glr, Gsm, and Gs. In a summary of several studies designed to examine the relationship between overall general functioning, seven Gf-Gc specific abilities, and reading achievement, McGrew, Keith, Vanderwood, and Flanagan (1997) found that Gc, Gsm (especially the working memory component), and Ga were most consistently related to reading achievement throughout the school years, even after controlling for overall intellectual ability (*g*), and that Gf is also important for reading comprehension. In addition, Catts, Gillispie, Leonard, Kail, and Miller (2002) found that Gsm explained unique variance in reading achievement, over and above IQ and phonological awareness. Similarly, Evans, Floyd, McGrew, and Leforgee (2001) found that Gc was consistently and strongly related to basic reading skills and reading comprehension, and that Gsm demonstrated consistent moderate relations with basic reading skills, throughout childhood and adolescence. They also showed that Ga is moderately related to both basic reading skills and reading comprehension during the early elementary years (ages 6 through 8). This particular study was unique in that the authors included a large number of participants drawn from the standardization sample of the WJ III (*n* greater than 3,300), provided separate information on abilities important for more basic reading skills (such as decoding) and reading comprehension, and examined which cognitive abilities are most important to reading achievement across 14 different age groups (from 6 to 19 years of age).

Mathematics Achievement. In their comprehensive review of several studies exploring the relationship between CHC abilities and achievement described in the previous section, Flanagan, Ortiz, Alfonzo, and Mascolo (2002) found support for the importance of Gc, Gsm (especially working memory), and Gs to math achievement, as well as significance for Gf and Gv. In their investigation of the relationship between general intellectual ability, specific Gf-Gc abilities, and mathematics skills, McGrew, Keith, Vanderwood, and Flanagan (1997) found that Gs abilities are increasingly important to general mathematics achievement as children age, and that both Gf and Gc are important to math achievement, especially in the early grades.

In an examination of the cognitive abilities important to predicting math calculation skills and math reasoning throughout childhood and adolescence (ages 6 to 19), Floyd, Evans, and McGrew (2003) demonstrated that Gc, Gf, Gsm, Glr and working memory demonstrated moderate relations to both math calculation and math reasoning achievement. In addition, the authors found that Gs demonstrated moderate with math calculation skills (throughout childhood and adolescence) and math reasoning (up to age 14), and that Ga showed moderate relations with math calculation skills during the early elementary school years. These results were based on information drawn from a large number of participants in the standardization sample of the WJ

III (*n* greater than 3,000), and were found to be representative of 6- to 19-year-olds in the United States population, leading to confidence in the generalization of results. In a recent study which extends prior research of Floyd, Evans, and McGrew (2003) by examining the cognitive ability profiles of low math achievers, Proctor, Floyd, and Shaver (2005), found that children low in math reasoning skills scored lower than their average-achieving peers on Gf and Gc, providing further support for the strong relationship between these two cognitive abilities and math reasoning and problem solving.

Writing Achievement. Although the relationship between broad CHC abilities and writing achievement has not been as well researched as that found for reading and math achievement, McGrew and Knopik (1993) examined the relationship between seven Gf-Gc abilities and writing achievement across the lifespan (5 through 79 years of age), using participants drawn from the Woodcock-Johnson – Revised standardization sample. The authors found that Gs and Gc demonstrated the most consistent relationship with writing achievement across the lifespan (from age 6 onwards), with Ga being important earlier on, and Gf showing importance for basic writing skills primarily during the elementary age range, and for written expression across all ages. Memory abilities (Glr and Gsm) and Visual Processing (Gv) were not found to significantly or consistently related to writing achievement at any age. In a more recent review by Flanagan, Ortiz, Alfonzo, and Mascolo (2002), described earlier, Ga, Gsm, and Gs showed the most consistent relations with overall writing achievement, with Gc showing importance for basic writing skills and written expression during the school years, although more research is clearly needed. Some evidence is present for the relation between Gf and Gv and writing achievement, but the research supporting this finding is extremely sparse, suggesting that these broad abilities may not play a very significant role.

Cognitive Abilities and Achievement for Preschool Children. The focus of the research to date on the connection between CHC abilities and academic achievement has historically focused on school-age and adults, and has neglected to consider preschool children, despite the recognized importance of the use of intelligence tests with this population and the need to understand those children most at-risk for early school difficulties. Indeed, even Carroll himself in his landmark book provided little exploration of the application of his theory to children below age 5 years. Previous research has shown that the specific broad abilities that are important for achievement change as children get older and advance through the school years (Floyd et al. 2003; McGrew & Flanagan, 1998), suggesting that the CHC cognitive abilities important to early achievement with preschool-age children may look quite different than those abilities significant for achievement in school-age, adolescent, and adult populations.

In a study utilizing a series of joint factor analyses to investigate the nature of CHC cognitive measures for children between the ages of 4 and 5 using the Woodcock-Johnson – Revised and the Differential Ability Scales, Tusing and Ford (2004) found that five broad abilities were reliably identified for these children (Gc, Glr, Gsm, Ga, and Nonverbal Ability), rather than the seven factors identified for school-age children and adolescents. In two confirmatory factor analysis studies investigating the cognitive structure of young children (under 6 years of age) using the updated WJ III, a Gf-Gc model using seven broad cognitive abilities was found to be an inappropriate fit for preschool children, as was a two-factor Verbal/Nonverbal model (League, 2000; Teague, 1999). Teague (1999) determined that a five-factor model including Gc, Ga, Gv, Gsm, and Glr, best fit the WJ III data for young children, with separate factors for Gf and Gs not emerging. It appears that a model containing between two and seven factors may best explain the structure of cognitive abilities for preschool-age children, with crystallized ability, auditory processing, visual-spatial ability and memory abilities emerging most reliably as essential factors (League, 2000; Teague, 1999; Tusing & Ford, 2004; Tusing, Maricle & Ford, 2003).

In one study that did focus on the CHC cognitive abilities that are most central to understanding academic achievement in young children (aged 3:6 to 5:11), McCullough (2001) found that Gc from the Woodcock-Johnson Tests of Cognitive Abilities (WJ III COG) had significant predictive validity for several achievement areas, including Oral Language, Oral Expression, Listening Comprehension, Academic Knowledge, and Applied Problems. In addition, McCullough identified Glr and Gsm as the best predictors for Basic Reading Skills. However, more research is clearly warranted in order to better understand the role that these broad cognitive abilities play in young children's academic achievement. As stated by Ford and Dahinten (2005), "the CHC model holds great promise as a framework for interpreting preschool measures of intelligence but more work is needed to understand the nuances of the model with preschool children" (p. 499).

Purpose of the Study

Given the need for further investigation of the CHC model with young children, the purpose of this study was to examine the relationship between the CHC cognitive abilities and achievement in preschool age children. Specifically, in this study the cognitive measures from the Woodcock-Johnson Tests of Cognitive Abilities – Third Edition (WJ III COG; Woodcock, McGrew & Mather, 2001) and the Woodcock-Johnson III Diagnostic Supplement to the Tests of Cognitive Abilities (WJ III DS; Woodcock, McGrew, Mather & Schrank, 2003) that play a role in achievement for young children as measured by the Woodcock-Johnson Tests of Achievement – Third Edition (WJ III ACH; Woodcock, McGrew & Mather, 2001 were explored. In addition, an attempt was made to better understand the predictive ability of different cognitive cluster scores from the WJ III COG and WJ III DS with WJ III ACH clusters and tests in preschool-age children.

CHAPTER THREE

Methodology

Research Questions

The following specific research questions were addressed:

1. What are the relationships between the WJ III COG General Intellectual Ability (GIA) score, the WJ III General Intellectual Ability - Early Development (GIA-EDev) score, and the WJ III ACH clusters: Basic Reading Skills, Basic Writing Skills, Math Reasoning, Pre-Academic Skills (Std), and Pre-Academic Skills and Knowledge (Ext)?
2. Which CHC abilities, as measured by the WJ III COG [specifically, Comprehension-Knowledge (Gc), Long-Term Retreival (Glr), Short-Term Memory (Gsm), Fluid Reasoning (Gf), Processing Speed (Gs), Auditory Processing (Ga), and Visual-Spatial Processing (Gv)], and additional clusters, as measured jointly by the WJ III COG and DS [specifically, Associative Memory (Glr), Auditory Memory Span (Gsm), and Visual-Spatial Thinking 3 (Gv3)] are the best predictors of Basic Reading Skills, Basic Writing Skills, Math Reasoning, Pre-academic Skills (Std), and Pre-academic Skills and Knowledge (Ext)?

Participants

The participants in this study included 179 preschool children, ranging in age from 3 years, 0 months to 6 years, 3 months, who were part of a special study conducted to examine concurrent validity of the WJ III (some of these participants were actually part of the larger standardization sample for the WJ III). Participants were selected from rural, urban, and suburban communities in the Southern United States, and attended public or private preschools, childcare facilities, and early learning and development centers, or were not involved in formal education or childcare settings. An attempt was made to obtain a sample of preschool children who varied in terms of socioeconomic status, ethnic background, and parental education levels. Characteristics of the participants are displayed in Tables 3.1 and 3.2.

Participants were 89 females and 90 males. Similar numbers of children were included across most age groups (e.g., 3:6 to 3:11, 4:0 to 4:5, 4:6 to 4:11, 5:0 to 5:5, and 5:6 to 5:11). However, the youngest group (3:0 to 3:5) and the oldest group (6:0 to 6:3) included fewer children than the other groups; it is unlikely that this had an impact on the results of this study. The majority of children were from White/Caucasian (65.4%) and African-American (33.0%) ethnic backgrounds. Three children (1.7%) were identified as from Asian/Pacific Islander backgrounds, while nine children (3.9%) were identified as being from a Hispanic background. Parental education backgrounds indicated that the majority of parents received a high school diploma (mothers, 21.2%; fathers, 27.4%), completed some college (mothers, 29.6%; fathers, 24.6%), or obtained a bachelor's degree or higher (mothers, 38.5%; fathers, 35.2%), suggesting a more educated sample than is typically found in most studies attempting to obtain a sample representative of general population. Parental education level was unreported for 7.3% of both mothers and fathers, which may be due to parents not wishing to share this information or not attending to this section of the permission form.

Procedure

The participants and data collected for this study were part of a larger validity study conducted as part of the WJ III standardization. Participants were administered all tests from the WJ III Tests of Cognitive Abilities, WJ III Diagnostic Supplement, and WJ III Tests of Achievement appropriate for preschool children, the Differential Ability Scale (DAS), and the

Table 3.1

Participant Characteristics (n = 179)

Characteristic	n	Percentage*
Gender		
Male	90	50.3%
Female	89	49.7%
Age		
3:0 to 3:5	12	6.7%
3:6 to 3:11	33	18.4%
4:0 to 4:5	32	17.9%
4:6 to 4:11	31	17.3%
5:0 to 5:5	33	18.4%
5:6 to 5:11	33	18.4%
6:0 to 6:3	5	2.8%
Race		
White/Caucasian	117	65.4%
African-American/Black	59	33.0%
Asian/Pacific Islander	3	1.7%
Other	0	0%
Hispanic		
Yes	9	3.9%
No	172	96.1%

* Percentages do not always add to 100 due to rounding.

Table 3.2

Parental Educational Levels of Participants (n = 179)

Parental Education	n	Percentage*
Maternal Education		
Less than HS diploma	6	3.4%
HS diploma/GED	38	21.2%
1-3 years of college	53	29.6%
Bachelors degree or higher	69	38.5%
Not Reported	13	7.3%
Paternal Education		
Less than HS diploma	10	5.6%
HS diploma/GED	49	27.4%
1-3 years of college	44	24.6%
Bachelors degree or higher	63	35.2%
Not Reported	13	7.3%

*Percentages do not always add to 100 due to rounding.

Wechsler Preschool and Primary Scale of Intelligence – Revised (WPPSI-R). However, only the WJ III tests were used in this analysis.

Telephone directories and lists obtained from the Department of Social Services were used to identify daycare centers, preschools, and child development centers for participation in this study. In an effort to obtain young children across multiple socioeconomic levels, settings, and ethnic backgrounds, childcare facilities were selected from rural, suburban, and urban communities. Directors of the programs were contacted by research team members to determine their interest in participating in the project. After programs indicated an interest in participating, permission letters were sent to parents through their children at the end of the school day with a brief description of the study. Parents who gave permission for their child(ren) to participate indicated by selecting "yes" on the permission form, and returned it to the program director. Permission slips requested parents to provide information regarding their child's age, sex, race, Hispanic origin (yes/no), place of birth, highest grade completed, and current occupations of each parent in the home. Permission forms were then collected by members of the research team, and purposive sampling procedures were used on the returned forms to select children who matched particular demographic characteristics.

Children participating in the study were assessed with all three measures following the standard administration procedures indicated in each test's manual. In order to avoid any bias resulting from test order, all tests were administered to participants in a counter-balanced manner over several sessions. Advanced graduate students in school psychology administered each of the tests to the children. Additionally, research assistants trained and involved in the standardization data collection administered some of the WJ III tests. Private rooms and other quiet areas were used for testing at the childcare facilities.

Instruments

Preschool tests of cognitive abilities selected from the Woodcock-Johnson Tests of Cognitive Abilities – Third Edition (WJ III COG), and the Woodcock-Johnson III Diagnostic Supplement to the Tests of Cognitive Abilities (WJ III DS), and a co-normed measure of achievement, The Woodcock-Johnson Tests of Achievement – Third Edition (WJ III ACH) were used in this study. All WJ III tests which, according to the test manuals, are appropriate for children as young as three years of age were included in the analyses. Descriptions of all the tests and clusters used in this study are found in Tables 3.3 – 3.6. "Content or substantive validity was ensured for the WJ III via the specification of test and cluster content according to CHC theory" (McGrew & Woodcock, 2001, p. 50). In addition, substantial developmental growth curve and internal structure evidence, as well as both convergent and divergent validity information is presented in the WJ III *Technical Manual* and provides support for the Broad and Narrow CHC factor structure of this comprehensive assessment battery.

Woodcock-Johnson III Tests of Cognitive Abilities. The WJ III COG is an individually administered battery of general cognitive functioning that contains twenty tests, each measuring a different aspect of cognitive ability based on the Cattell-Horn-Carroll (CHC) model of intellectual abilities. The WJ III COG provides two General Intellectual Ability scores (GIA-Std and GIA-Ext) that measure overall general intelligence derived from a weighted average of cognitive tests administered to the examinee. The GIA-Std and GIA-Ext scores can be interpreted as representing a child's overall cognitive functioning and incorporates one or two tests, respectively, from each of the CHC factors: Comprehension-Knowledge, Visual-Spatial Thinking, Auditory Processing, Fluid Reasoning, Processing Speed, Long-Term Retrieval, and Short-Term Memory (McGrew & Woodcock, 2001). Reliabilities for the individual tests from

Table 3.3

Specific Abilities Measured by Woodcock-Johnson Tests of Cognitive Abilities – Third Edition

Test	Specific Ability	CHC Cluster
Verbal Comprehension	Measures knowledge of vocabulary and the ability to reason using lexical (word) knowledge	Comprehension-Knowledge (Gc)
General Information	Measures depth of general verbal knowledge	Comprehension-Knowledge (Gc)
Visual-Auditory Learning	Measures the ability to learn, store, and retrieve a series of visual-auditory associations	Long-Term Retrieval (Glr)
Retrieval Fluency	Measures fluency of retrieval from stored knowledge within a given time period	Long-Term Retrieval (Glr)
Spatial Relations	Measures the ability to visualize spatial relationships by identifying pieces that form a complete target shape	Visual-Spatial Processing (Gv)
Picture Recognition	Measures visual memory of objects or pictures	Visual-Spatial Processing (Gv)
Sound Blending	Measures skill in synthesizing language sounds (phonemes)	Auditory Processing (Ga)
Auditory Attention	Measures the ability to overcome the effects of auditory distortion or masking in understanding oral language	Auditory Processing (Ga)
Concept Formation	Measures categorical reasoning based on principles of inductive logic and flexibility in thinking through a controlled-learning task	Fluid Reasoning (Gf)

Table 3.3 (continued)

Specific Abilities Measured by Woodcock-Johnson Tests of Cognitive Abilities – Third Edition

Test	Specific Ability	CHC Cluster
Analysis-Synthesis	Measures general sequential (deductive) reasoning through a controlled learning task	Fluid Reasoning (Gf)
Visual Matching	Measures the speed at which an individual can make visual symbol discriminations	Processing Speed (Gs)
Decision Speed	Measures the ability to make correct conceptual decisions quickly	Processing Speed (Gs)
Numbers Reversed	Measures the ability to hold a span of numbers in immediate awareness (memory) while performing a mental operation on it	Short-Term Memory (Gsm)
Memory for Words	Measures the ability to repeat lists of unrelated words in the correct sequence	Short-Term Memory (Gsm)

Table 3.4

Specific Abilities Measured by Woodcock-Johnson Tests of Achievement – Third Edition

Test	Specific Ability	Curricular Cluster
Letter-Word Identification	Measures letter and word identification skills	Basic Reading Skills Pre-Academic (Std & Ext)
Word Attack	Measures skill in applying phonic and structural analysis skills to the pronunciation of unfamiliar printed words and single letters	Basic Reading Skills
Applied Problems	Measures the ability to analyze and solve math problems of varying difficulty	Math Reasoning Pre-Academic (Std & Ext)
Quantitative Concepts	Measures knowledge of mathematical concepts, symbols, and vocabulary	Math Reasoning
Spelling	Measures the ability to write orally presented words correctly and prewriting skills such as drawing lines and tracing letters	Basic Writing Skills Pre-Academic (Std & Ext)
Picture Vocabulary	Measures oral language development and lexical (word) knowledge	Pre-Academic (Ext)
Academic Knowledge	Measures knowledge of the sciences, history, geography, government, economics, art, music, and literature	Pre-Academic (Ext)

Table 3.5

Specific Abilities Measured by Woodcock-Johnson III Diagnostic Supplement

Test	Specific Ability	CHC Cluster
Memory for Names	Measures the ability to learn associations between unfamiliar auditory and visual stimuli	Long-Term Retrieval (Glr)
Cross Out	Measures the ability to scan and compare visual information quickly	Processing Speed (Gs)
Visual Closure	Measures the ability to identify a drawing or picture that has been altered in some way	Visual-Spatial Processing (Gv)
Block Rotation	Measures the ability to match visual patterns and to maintain orientation when patterns of blocks are rotated in space	Visual-Spatial Processing (Gv)
Sound Patterns – Voice	Measures the ability to indicate whether pairs of complex speech sounds are the same or different	Auditory Processing (Ga)
Sound Patterns – Music	Measures the ability to indicate whether pairs of musical sounds are the same or different	Auditory Processing (Ga)
Number Series	Measures quantitative reasoning with numerical patterns	Fluid Reasoning (Gf)
Number Matrices	Measures quantitative reasoning by analyzing relationships among numbers	Fluid Reasoning (Gf)
Memory for Sentences	Measures the ability to remember and repeat single words, phrases, and sentences	Short-Term Memory (Gsm)

Table 3.6

Tests Included in the General Intellectual Ability – Early Development Scale

Test	Broad CHC Ability	Location
Verbal Comprehension	Comprehension-Knowledge (Gc)	WJ III Tests of Cognitive Abilities
Visual Matching	Processing Speed (Gs)	WJ III Tests of Cognitive Abilities
Incomplete Words	Auditory Processing (Ga)	WJ III Tests of Cognitive Abilities
Memory for Names	Long-Term Retrieval (Glr)	WJ III Diagnostic Supplement
Visual Closure	Visual-Spatial Processing (Gv)	WJ III Diagnostic Supplement
Memory for Sentences	Short-Term Memory (Gsm)	WJ III Diagnostic Supplement

the WJ III COG used in this study range from .69 to .95 for children between 3 and 6 years of age in the standardization sample. Reliabilities are between .96 and .97 for the GIA-Std score and are .98 for the GIA-Ext score for preschool-age children (between 3 and 6 years of age). Overall, the reliabilities of the CHC factor clusters for children between the ages of 3 and 6 are as follows: .92 to .93 for the Comprehension-Knowledge cluster, .76 to .90 for the Visual-Spatial Thinking cluster, .88 to .96 for the Auditory Processing cluster, .86 to .96 for the Fluid Reasoning cluster, .83 to .95 for the Processing Speed cluster, .87 to .88 for the Long-Term Retrieval cluster, and .88 to .91 for the Short-Term Memory cluster. Generally, these reliability values do not change very much across the lifespan; In fact, the majority of the factors appear to have their highest reliabilities during the preschool and early elementary age ranges, indicating that these clusters are consistent measures of the CHC broad abilities, even for preschool-age children.

Woodcock-Johnson III Diagnostic Supplement. The WJ III DS consists of eleven tests that can be used to supplement the tests and clusters included in the WJ III COG, and allows for further diagnostic utility. Using the WJ III DS in combination with the COG increases the number of clusters available for interpretation, and coverage of CHC narrow abilities. In addition, several tests in the WJ III DS are useful for assessment with preschool children as young as two years of age. When combined, these tests provide a General Intellectual Ability - Early Development (GIA-EDev) score, which measures six of the CHC broad cognitive abilities (Fluid Reasoning [Gf] is not included) that are thought to be most central for understanding young children's cognitive strengths and weaknesses (Ford, 2003; Schrank, Mather, McGrew & Woodcock, 2003), and are "particularly appropriate for evaluation of developmental delay in the cognitive domain [of preschool children]" (Ford, 2003, p. 44). The specific tests included in the

GIA-EDev score are presented in table 3.6. Reliabilities for the individual WJ III DS tests used in this study range from .69 to .95 for children between 3 and 6 years of age in the standardization sample. Reliabilities are between .93 and .95 for the GIA-EDev score for preschool-age children (between 3 and 6 years of age). Reliabilities of the special clusters for children between the ages of 3 and 6 are: .82 to .88 for the Visual Closure cluster, .88 to .93 for the Auditory Memory Span cluster, and .87 to .90 for the Associative Memory cluster. These reliability values indicate that the special clusters on the WJ III DS that are appropriate for preschool children are consistent measures of CHC narrow cognitive abilities, even during the preschool years.

Woodcock-Johnson III Tests of Achievement. The WJ III ACH is comprised of twenty-two tests that measure several curricular areas including: reading, oral language, mathematics, written language, and academic knowledge. Included in this battery are two additional measures of pre-academic functioning: the Pre-Academic-Standard (Pre-Std) cluster, which identifies skills in pre-reading and letter and word identification, writing production, and developing mathematics, and the Pre-Academic Knowledge and Skills-Extended (Pre-Ext), which measures language development and early knowledge of the sciences, social studies, and humanities, in addition to the early reading, writing, and mathematics skills measured by the Pre-Academic-Standard cluster (Schrank, Mather, McGrew & Woodcock, 2003). As stated by Ford (2003), "an understanding of the young child's pre-academic abilities can be helpful in understanding readiness for the academic demands of school" (p. 44). The specific tests included in each of the Pre-Academic-Standard and Pre-Academic Knowledge and Skills-Extended clusters is presented in Table 3.4.

Reliabilities for the individual WJ III ACH tests used in this study range from .70 to .99 for children between 3 and 6 years of age in the standardization sample. Reliabilities of the achievement clusters used in this study for children between the ages of 3 and 6 are: .92 to .98 for the Pre-Academic (Standard) cluster, .94 to .96 for the Pre-Academic Skills and Knowledge cluster, .94 to .98 for the Basic Reading Skills cluster, .77 to .92 for the Spelling test (as a measure of Basic Writing Skills), and .88 to .92 for the Applied Problems test (as a measure of Math Reasoning). Again, the high reliabilities demonstrated for all clusters (excluding the Spelling test) indicate that these are consistent measures of achievement for preschool-age children.

WJ III tests yield raw scores that can be converted into standard scores (based on a mean of 100 and a standard deviation of 15) and into criterion-referenced W scores, which allows for interpretation of "the difference between a child's measured ability and the ability of the median individual at his or her age" (Ford & Dahinten, 2005, p.23). In addition, because the WJ III COG, DS, and ACH were standardized on the same nationally representative sample, they are able to provide information essential to any comprehensive assessment of young children, and aid in a more accurate and valid understanding of the pre-academic skills related to cognitive development (Schrank, Mather, McGrew, & Woodcock, 2003).

Analyses

Initial Descriptive Analyses. Initial descriptive data analyses were conducted to determine how the performance of the present sample of preschool children is similar to that expected based on a mean of 100 and a standard deviation of 15. These initial analyses included a comparison of means, standard deviations, and ranges for the WJ III COG and ACH composite scores, and the WJ III COG, ACH, and DS test scores obtained by the current sample of preschool children with those expected for an average sample. These descriptive analyses were conducted using the SPSS statistical program (SPSS, 2003). The results of the descriptive data analyses are presented in detail in Chapter Four.

Research Question One. Pearson *r* correlations between the WJ III COG GIA scores, both standard and extended, the WJ III GIA Early Development (GIA-EDev) score, and the WJ III ACH clusters (Basic Reading Skills, Basic Writing Skills, Math Reasoning, Pre-Academic Skills – Standard, and Pre-Academic Skill and Knowledge – Extended) were calculated, in order to examine the strength of relationship between the overall ability scores and each achievement area.

Research Question Two. Individual stepwise regression equations were used to determine which WJ III COG cognitive clusters and WJ III COG and DS additional clusters [including Comprehension-Knowledge (Gc), Long-Term Retrieval (Glr), Short-Term Memory (Gsm), Auditory Processing (Ga), Processing Speed (Gs), Visual-Spatial Processing (Gv), Fluid Reasoning (Gf), Associative Memory (Glr), Auditory Memory Span (Gsm), and Visual-Spatial Thinking 3 (Gv3)] are the best predictors of reading, math writing, and general achievement as measured by the WJ III Tests of Achievement. The specific achievement clusters that were used as predictive variables included Basic Reading Skills, Basic Writing Skills, Math Reasoning, Pre-Academic Standard, and Pre-Academic Knowledge and Skills Extended.

Regression equations used for the prediction of both the Basic Writing Skills and Math Reasoning clusters of achievement were unable to be computed because of significant missing data. The Basic Writing Skills cluster is comprised of two tests: Spelling and Editing. Only the Spelling test had sufficient data to warrant analysis; therefore, the regression equation was computed for only the Spelling test and not the entire Basic Writing Skills cluster. According to the WJ III Technical Manual, the reliabilities for the Spelling test range from .77 to .92 for three- to six- year-old children, while the reliabilities for the complete cluster range from .90 to .94 for children aged four to six years (no reliability information is provided for children aged three years, suggesting that the entire Basic Writing Skills cluster is not appropriate for children this young; McGrew & Woodcock, 2001). The Math Reasoning cluster is comprised of the Applied Problems and Quantitative Concepts tests. Similarly to the Spelling test, only the Applied Problems test had sufficient data to run the analysis; therefore, the regression equation was computed based on the Applied Problems test and not the entire Math Reasoning cluster. Reliabilities for the Applied Problems test range from .88 to .94 for children aged three to six years, while the reliabilities for the complete Math Reasoning cluster range from .92 to .95 for same aged children (McGrew & Woodcock, 2001).

Although only the Applied Problems test was used as the sole measure of Math Reasoning in the regression equation, the reliability of this test is very high (.88 to .94) and nearly equal that of the entire cluster (.92 to .95). In addition, although the Spelling test was used as the sole measure of Basic Writing Skills, even though the reliability of this one test is not as high as the entire cluster, it is more appropriate for use with children as young as three years of age than the entire Basic Writing Skills cluster. This is due to the fact that the task demands for the Editing test (which, along with the Spelling test, makes up the Basic Writing Skills cluster) are too difficult for most preschool children between the ages of 3 and 5. In fact, the *WJ III Technical Manual* does not even provide reliability statistics for the Editing test for children under 6 years of age, demonstrating that this test is not an appropriate measure of writing skills for preschool-age children. However, caution should be taken when interpreting the results of the prediction of the Basic Writing Skills and Math Reasoning clusters, as the cluster scores on the

WJ III possess consistently higher reliabilities than any individual test, and "are the recommended scores for interpretation, particularly when important decisions are being made about an individual (McGrew & Woodcock, 2001, p. 37).

Standardized partial regression coefficients, which "indicate the proportion of standard deviation units that the criterion variable changes as a function of one standard deviation change in a predictor variable" (Floyd, Evans, & McGrew, 2003, p. 160), holding constant the other variables, were calculated from simultaneous multiple regression analyses (which were separate from those described above) with each achievement cluster as the criterion variable. For the primary regression analyses, the predictor variables were the seven CHC factor clusters [e.g., Comprehension-Knowledge (Gc), Auditory Processing (Ga)]. In addition, regression analyses were completed to investigate the relations between the special clusters [i.e., Auditory Memory Span (Gsm), Visual-Spatial Thinking (Gv3), and Associative Memory (Glr)]. In these regression analyses, the Auditory Memory Span cluster was substituted for the Short-Term Memory cluster, the Visual-Spatial Thinking cluster was substituted for the Visual-Spatial Processing cluster, and the Associative Memory cluster was substituted for the Long-Term Memory cluster. It is important that the explanatory variables in a model are as independent as possible in order to reduce multicollinearity in predictors (R. Floyd, personal communication, January 9, 2005), and due to the overlap between some of the tests that comprise both the special and factor clusters, these substitutions were necessary. The partial regression coefficients were then plotted on a graph, in order to examine the strength of the relation between that cluster and the following achievement clusters: Basic Reading Skills, Basic Writing Skills, Math Reasoning, Pre-Academic Skills (Std), and Pre-Academic Skills and Knowledge (Ext). This particular method of analysis was primarily conducted in addition to the individual stepwise regression equations, in order to be consistent with prominent researchers (namely, Evans, Floyd, McGrew & Leforgee, 2001; and Floyd, Evans, & McGrew, 2003) who have previously examined the role of cognitive abilities important for achievement in school-age and adolescent populations.

Missing Data. Data is missing on some variables for some of the participants in the study primarily due to the young ages of children participating in the study. Some of the youngest children (e.g., three year olds, younger four year olds) either did not complete some tasks due to noncompliance, or did not get items correct due to task difficulty or inability to understand task demands. There are two key problems that arise from missing data: a decrease in statistical power, and a bias in parameter estimates (Roth, 1994). A number of techniques, each with their own advantages and disadvantages, have been proposed to deal with these problems. The simplest method for coping with missing data is listwise deletion, which involves eliminating all participants who have any missing information, or pairwise deletion, which only eliminates data from those statistics that are using the information. These methods, however, either sacrifice a large proportion of data or make interpretation of results difficult (Roth, 1994; Tabachnick & Fidell). A slightly more sophisticated method, which preserves the data and is easy to use and interpret, is mean substitution, which involves substituting the mean value of a variable in place of missing data values for that variable. A disadvantage with this approach is that it tends to attenuate variance and covariance estimates (Roth, 1994; Tabachnick & Fidell, 2001). Missing data in this study was addressed with the expectation maximization (EM) algorithm, which "forms a missing data correlation (or covariance) matrix by assuming the shape of a distribution (such as normal) for the partially missing data and basing inferences about missing values on the likelihood under that distribution" (Tabachnick & Fidell, 2001, p. 63). According to Roth (1994), Monte Carlo tests of this method "suggest it produces less biased estimates than listwise deletion, more accurate estimates than pairwise deletion, and less biased estimates than mean substitution (p. 545). The Prelis 2,54 program was used to impute values for the missing data with the expectation maximization algorithm, in order to capitalize on the largest number of participants possible.

CHAPTER FOUR

Results

The purpose of this chapter is to present the results of the investigation of how the Woodcock-Johnson III Tests of Cognitive Abilities (WJ III COG) and the Woodcock-Johnson III Diagnostic Supplement to the Tests of Cognitive Abilities (WJ III DS) relate to the Woodcock-Johnson III Tests of Achievement (WJ III ACH) for preschool age children. Initial descriptive analyses will be presented first, followed by data with regard to each of the research questions presented in Chapter Three. Discussion and implications of the findings will be presented in Chapter Five.

Initial Descriptive Analyses

An attempt was made to compare composite, cluster, and test scores for the WJ III COG, DS, and ACH for participants in the current sample to those in the WJ III standardization sample (means and standard deviation values for the COG, DS, and ACH are found in Tables 4.1, and 4.2). However, comparison of children's mean scores on the WJ III clusters and tests to those from the WJ III standardization sample using standard scores (based on a mean of 100 and standard deviation of 15) was not possible, as the WJ III Technical Manual only presents reliability statistics for *W* scores, and not standard scores. In addition, comparisons of *W* scores from different standardization samples is not reasonable due to their examination being limited to the sample from which they were developed. Nevertheless, it was possible to compare the scores of participants in the current sample to what would be anticipated based on a mean of 100 and a standard deviation of 15. In general, means and standard deviations for the WJ III COG and DS composites, clusters, and tests were within the overall range expected, though participants in this study generally scored slightly below the mean and standard deviations

Table 4.1

Means and Standard Deviations for WJ III COG and DS Composite and Cluster Scores (n = 179)

Cluster/Test	M	SD
General Intellectual Ability - Standard	95.06	13.61
General Intellectual Ability - Extended	93.66	15.27
General Intellectual Ability – Early Development	85.91	21.35
Verbal Comprehension	94.79	14.16
Visual Matching	96.99	15.63
Incomplete Words	99.28	11.93
Memory for Names	97.72	17.02
Visual Closure	99.92	16.43
Memory for Sentences	99.80	13.57
Comprehension-Knowledge (Gc)	95.25	13.18
Verbal Comprehension	94.79	14.16
General Information	98.05	12.28
Fluid Reasoning (Gf)	97.76	12.43
Concept Formation	97.72	13.66
Analysis-Synthesis	99.66	11.01
Processing Speed (Gs)	95.80	15.39
Visual Matching	96.99	15.63
Decision Speed	96.88	13.73
Short-Term Memory (Gsm)	101.70	14.76
Numbers Reversed	109.75	15.71
Memory for Words	97.67	15.68
Long-Term Retrieval (Glr)	97.10	14.60
Visual-Auditory Learning	97.18	15.65
Retrieval Fluency	100.76	13.54
Auditory Processing (Ga)	100.28	14.94
Sound Blending	98.89	13.27
Auditory Attention	102.66	13.00
Visual-Spatial Thinking (Gv)	97.04	12.96
Spatial Relations	98.42	14.16
Picture Recognition	97.06	14.39
Visual Closure (Gv3)	99.37	14.40
Auditory Memory Span	98.14	15.15
Associative Memory	95.45	15.14

Table 4.2

Means and Standard Deviations for WJ III ACH Clusters based on Standard Scores (n = 179)

Cluster/Test	M	SD
Pre-Academic - Standard	102.83	15.10
Letter-Word Identification	111.70	16.87
Applied Problems	91.28	17.85
Spelling	104.48	14.85
Pre-Academic Skills and Knowledge - Extended	100.56	16.02
Letter-Word Identification	111.70	16.87
Applied Problems	91.28	17.85
Spelling	104.48	14.85
Picture Vocabulary	96.22	14.94
Academic Knowledge	95.25	15.71
Basic Reading Skills	104.75	16.42
Letter-Word Identification	111.70	16.87
Word Attack	98.31	16.82
Basic Writing Skills*	104.49	14.84
Math Reasoning**	91.26	17.85

* Basic Writing Skills cluster consisted of the Spelling test only due to missing data.
**Math Reasoning cluster consisted of the Applied Problems test only due to missing data.

revealed less variability. However, participants' scores on the General Intellectual Ability – Early Development composite were significantly lower than expected, although standard deviations were higher. For the WJ III achievement clusters, means and standard deviations were also within the range expected, though scores on the Basic Reading Skills and Basic Writing Skills were somewhat higher than expected, and scores on the Math Reasoning cluster were considerably lower than expected. An examination of the reliabilities of these three clusters does not provide an overall explanation for this unexpected result, as the Basic Reading Skills and Applied Problems test both demonstrate strong reliabilities for children between 3 and 5 years of age, although the reliabilities for the Spelling test are somewhat low.

Research Question One: Relationship Between Composite Scores and Achievement Clusters

In this question, the relationships between the WJ III COG General Intellectual Ability (GIA) scores, both standard and extended, the WJ III General Intellectual Ability – Early Development (GIA-EDev) score, and the WJ III ACH clusters: Basic Reading Skills, Basic Writing Skills, Math Reasoning, Pre-Academic Skills (Standard) and Pre-Academic Skills and Knowledge (Extended), were investigated. One goal of this research question was to provide further validity evidence for the use of the WJ III GIA-EDev score with preschool age and older cognitively delayed children, rather than the traditional GIA standard or extended scores. Pearson *r* correlations between all these scores were calculated and are presented in Table 4.3. Note, however, that the differences between correlations were not tested for significance, and are instead discussed in comparative terms.

As expected, a strong correlation of .95 ($p < .01$) was demonstrated between the GIA standard and GIA extended scores, indicating that they are both measuring overall intellectual

Table 4.3

Intercorrelations of the WJ III General Intellectual Ability (GIA) scores with WJ III Tests of Achievement Clusters (n = 179)

Composite/Cluster	1.	2.	3.	4.	5.	6.	7.	8.
1. GIA (Standard)	--	.95	.83	.61	.42	.26	.58	.61
2. GIA (Extended)		--	.80	.60	.43	.30	.58	.62
3. GIA-EDev			--	.67	.45	.25	.62	.66
4. Basic Reading Skills				--	.50	.15	.72	.64
5. Basic Writing Skills*					--	.20	.77	.67
6. Math Reasoning**						--	.62	.70
7. Pre-Academic (Std)							--	.95
8. Pre-Academic Skills and Knowledge (Ext)								--

* Basic Writing Skills cluster consisted of the Spelling test only due to missing data.
**Math Reasoning cluster consisted of the Applied Problems test only due to missing data.

functioning, or *g*. The General Intellectual Ability – Early Development score also had strong correlations with both the GIA standard score (.83, $p < .01$) and the GIA extended score (.80, $p < .01$), suggesting that they are all measuring the construct of general cognitive ability; however, the somewhat lower correlation between the GIA-EDev score with the GIA standard and GIA extended scores than was seen between the GIA standard and extended scores suggests that the GIA-EDev score does indeed capture a unique aspect of intellectual ability with preschool children.

The Pre-Academic Skills (Standard) cluster is a broad measure of pre-academic skills development including pre-reading and letter and word identification skills, writing production, and developing skills in analyzing and solving problems involving numbers. It is designed to be a more appropriate measure of overall early achievement development for young children. Pre-Academic Skills (Standard) had significant correlations of .58, .58, and .62 ($p < .01$) with the GIA standard score, GIA extended score, and GIA-EDev score, respectively, indicating a moderate relationship between this cluster and the overall measures of general cognitive functioning. Of these three relationships, the strongest correlation was between the Pre-Academic Skills cluster and the GIA-EDev score, suggesting that the overall measure of intellectual functioning appropriate for preschool children is more closely related to the early reading, writing and mathematics skills measured by the Pre-Academic (Standard) cluster than the other two overall intellectual functioning scores.

The Pre-Academic Knowledge and Skills (Extended) cluster measures language development and early knowledge of the sciences, social studies, and humanities, in addition to the early reading, writing, and mathematics skills measured by the Pre-Academic (Standard) cluster. Pre-Academic Knowledge and Skills (Extended) showed slightly higher correlations of

.61, .62, and .66 (all ps < .01) with the GIA standard, GIA extended, and GIA-EDev scores than the Pre-Academic (Standard) cluster. Again, the strongest relationship was between the Pre-Academic Skills and Knowledge (Extended) cluster and the GIA Early Development score, providing further support for the use of the General Intellectual Ability – Early Development score with preschool children and lower functioning older children.

The Basic Reading skills cluster is a measure of a measure of sight vocabulary, phonics, and structural analysis skills, and it consists of two achievement tests: Letter-Word Identification and Word Attack. These tests are measures of Reading Decoding (RD), a narrow CHC ability subsumed under the broad ability of reading/writing (Grw). Historically, letter and word identification and reading tasks have shown moderate associations with overall *g*. Basic Reading Skills also had significant moderate correlations with the GIA standard, GIA extended, and GIA-EDev scores (.61, .60, and .67, respectively, all ps < .01), with the strongest relationship demonstrated between Basic Reading Skills and the General Intellectual Ability - Early Development score for this sample of children three to six years of age.

Due to a significant amount of missing data, an examination of the Basic Writing Skills cluster with the overall GIA scores could not be examined. However, the Spelling test, which is one of the two tests in the Basic Writing Skills cluster, did have sufficient data for analysis. Similarly, the relationship of the Math Reasoning cluster with overall GIA was not able to be examined. Therefore the Applied Problems test, one of the two tests in cluster which had sufficient data, was used in the calculations. Although all the WJ III tests were developed with high enough reliabilities to be considered stand-alone tests, caution should be always be taken when interpreting results from a single test and not at the cluster level. Internal consistency and construct validity can be diminished due to the lack of varied items used to measure a single construct (in this case basic writing skills or math reasoning).

The Spelling test provides information "on a wide range of skills beginning with drawing lines and tracing letters, progressing to producing upper and lowercase letters, and writing words correctly" (Ford, 2003). This test measures the narrow ability of Spelling (SG) in the CHC model, under the broad ability of Written Language (Grw). The Spelling test showed somewhat lower, although still moderate, correlations of .42, .43, and .45 ($p < .01$ for all) with the overall GIA Standard, GIA Extended, and GIA-EDev scores. Similar to results found for the Pre-Academic (Standard and Extended) and Basic Reading Skills clusters, the strongest relationship was between the Spelling test and the GIA-EDev score designed especially as the overall measure of intellectual functioning most appropriate for use with preschool-age children.

The Applied Problems test measures the ability to analyze and solve orally presented problems involving numbers and counting. This test measures the broad CHC ability of Mathematics (Gq) and the narrow abilities of Quantitative Reasoning (RQ), Mathematics Achievement (A3), and Mathematics Knowledge (KM), subsumed under this broad ability. Applied Problems had the lowest correlations with the GIA standard, GIA extended, and GIA-EDev scores (.26, .30, and .25, respectively; all $ps < .01$), indicating small, yet significant relationships.

Research Question Two: Prediction of Achievement from WJ III COG and DS Ability Clusters and Additional Clusters

Stepwise Regression Equations. In this question, the WJ III COG cognitive ability clusters, Comprehension-Knowledge (Gc), Long-Term Retreival (Glr), Short-Term Memory (Gsm), Fluid Reasoning (Gf), Processing Speed (Gs), Auditory Processing (Ga), and Visual-

Spatial Processing (Gv), and WJ III COG and DS additional clusters, Associative Memory (Glr), Auditory Memory Span (Gsm), and Visual-Spatial Thinking 3 (Gv3) were analyzed through individual multiple stepwise regression equations to find the best predictors of Basic Reading Skills, Basic Writing Skills, Math Reasoning, Pre-academic Skills (Std), and Pre-academic Skills and Knowledge (Ext) achievement clusters from the WJ III ACH.

The prediction of each achievement cluster was analyzed two ways: 1) with chronological age (in months) entered into the regression equation as the first block, followed by the stepwise method of regression with all ability and additional clusters as the second block, and 2) with only the ability and additional clusters entered into the regression equation using the stepwise method (chronological age in months was not factored into the regression equation). These two methods yielded identical results for the Pre-academic (Std), Pre-academic Skills and Knowledge (Ext), and Math Reasoning clusters, and therefore, results will be presented from the first method of analysis (with age entered into the regression equation first) only. However, the results for the Basic Reading Skills and Basic Writing Skills clusters differed depending on whether or not chronological age was entered as a predictor into the regression equation. For these clusters, results will be presented for both methods of analysis. Relative Pratt indexes, which attribute a certain proportion of the overall R^2 to each explanatory or independent variable (Pratt, 1987; Thomas, Hughes, & Zumbo, 1998), were also calculated in order to ascertain the relative importance of each of the variables within the model for each achievement cluster. As an operating principle, the Pratt Index for a particular variable should be greater than 1 / 2p for that variable to be considered important, where p is the number of predictor variables in the regression equation (Thomas, 1992). For the purpose of this study, a Pratt Index less than .071 (1 / 14) would be considered to be practically 'unimportant'. Tables 4.4, 4.5, 4.6, 4.7, and 4.8

display the standardized regression coefficients (β), the change in R^2, the F values for the change in R^2 after entry of the independent variables, and the relative Pratt index for that variable, for the first method of analysis (when age is entered first into the regression equation). In addition, Tables 4.9 to 4.10 display these same values for the prediction of Basic Reading Skills, Basic Writing Skills, and Math Reasoning, when age was not entered into the regression equation, as this method produced different results for these three clusters. For the Pre-Academic Skills (Standard) cluster, the stepwise regression analysis revealed that the model most appropriate for preschool children, over-and-above age, includes Processing Speed (Gs), Comprehension-Knowledge (Gc), Associative Memory (Glr) and Fluid Reasoning (Gf), $F(5, 173) = 29.130$, $p < .0001$, $R^2 = .457$. Using Cohen's (1992) conventions of small ($R^2 = .0196$), medium ($R^2 = .1304$) and large ($R^2 = .2592$) effect sizes, the model can be viewed as having a large effect on Pre-Academic Skills. Pratt Index calculations revealed that Processing Speed (Gs) was the most important variable in explaining Pre-Academic Skills (Standard), followed by Associative Memory (Glr), Comprehension-Knowledge (Gc), Fluid Reasoning (Gf), and finally, chronological age (in months).

The stepwise regression equation for the Pre-Academic Skills and Knowledge (Extended) cluster revealed that the most appropriate and significant model for explaining this achievement cluster, over-and-above age, included the ability and additional clusters: Comprehension-Knowledge (Gc), Processing Speed (Gs), Associative Memory (Gsm), and Fluid Reasoning (Gf), $F(5,173) = 42.233$, $p < .0001$, $R^2 = .550$. This is a large effect size according to Cohen's (1992) conventions. Pratt indexes were again calculated, and showed that for preschool children the most important cognitive ability for explaining Pre-Academic Skills and Knowledge (Extended) was Gc, followed by Gs, Associative Memory, Gf, and then chronological age.

Table 4.4

Stepwise Regression of WJ III Ability and Additional Clusters on Pre-Academic Skills (Standard

Predictor	Pratt Index	β	R^2	Change in R^2	F for Change
Variables Entered					
1. Age	.036	.090	.033*		
2. Processing Speed (Gs)	.352	.317	.285	.253	62.24**
3. Comprehension-Knowledge (Gc)	.208	.191	.398	.113	32.78**
4. Associative Memory (Glr)	.209	.209	.432	.034	10.38**
5. Fluid Reasoning (Gf)	.194	.196	.457	.025	8.00**

*p < .05; **p < .01

NOTE: The Pratt Index and β are based on the final model with 5 independent variables. F represents the significance of change in R^2 as a result of each independent variable being entered into the equation.

Table 4.5

Stepwise Regression of WJ III Ability and Additional Clusters on Pre-Academic Skills and Knowledge (Extended)

Predictor	Pratt Index	β	R^2	Change in R^2	F for Change
Variables Entered					
1. Age	.003	.017	.013		
2. Comprehension-Knowledge (Gc)	.362	.332	.359	.346	94.87**
3. Processing Speed (Gs)	.273	.287	.485	.126	42.69**
4. Associative Memory (Glr)	.249	.257	.536	.051	19.08**
5. Fluid Reasoning (Gf)	.124	.147	.550	.014	5.40*

*p < .05; **p < .01

NOTE: The Pratt Index and β are based on the final model with 5 independent variables. F represents the significance of change in R^2 as a result of each independent variable being entered into the equation.

Table 4.6

Stepwise Regression of WJ III Ability and Additional Clusters on Applied Problems Test

Predictor	Pratt Index	β	R^2	Change in R^2	F for Change
Variables Entered					
1. Age	.207	-.263	.046**		
2. Comprehension-Knowledge (Gc)	.277	.214	.199	.153	33.50**
3. Visual-Spatial Thinking (Gv)	.259	.200	.252	.053	12.40**
4. Long-Term Retrieval (Glr)	.258	.180	.273	.022	5.16*

*p < .05; **p < .01

NOTE: The Pratt Index and β are based on the final model with 4 independent variables. F represents the significance of change in R^2 as a result of each independent variable being entered into the equation.

Table 4.7

Stepwise Regression of WJ III Ability and Additional Clusters on Basic Reading Skills

Predictor	Pratt Index	β	R^2	Change in R^2	F for Change
Variables Entered					
1. Age	.275	.319	.180**		
2. Comprehension-Knowledge (Gc)	.274	.253	.404	.225	66.34**
3. Associative Memory (Glr)	.145	.184	.446	.042	13.33**
4. Fluid Reasoning (Gf)	.224	.217	.480	.033	11.14**
5. Short-Term Memory (Gsm)	.084	.122	.492	.013	4.28*

*p < .05; **p < .01

NOTE: The Pratt Index and β are based on the final model with 5 independent variables. F represents the significance of change in R^2 as a result of each independent variable being entered into the equation.

Table 4.8

Stepwise Regression of WJ III Ability and Additional Clusters on Spelling Test

Predictor	Pratt Index	β	R^2	Change in R^2	F for Change
Variables Entered					
1. Age	.074	.141	.028*		
2. Processing Speed (Gs)	.784	.474	.304	.276	69.79**
3. Auditory Memory Span (Gsm)	.143	.140	.321	.017	4.35*

*p < .05; **p < .01

NOTE: The Pratt Index and β are based on the final model with 3 independent variables. F represents the significance of change in R^2 as a result of each independent variable being entered into the equation.

Table 4.9

Stepwise Regression of WJ III Ability and Additional Clusters on Basic Reading Skills (Age Not Entered)

Predictor	Pratt Index	β	R^2	Change in R^2	F for Change
Variables Entered					
1. Comprehension-Knowledge (Gc)	.357	.266	.284**		
2. Fluid Reasoning (Gf)	.366	.286	.347	.063	16.89**
3. Associative Memory (Glr)	.158	.162	.380	.033	9.39**
4. Short-Term Memory (Gsm)	.117	.138	.397	.016	4.66*

*p < .05; **p < .01

NOTE: The Pratt Index and β are based on the final model with 4 independent variables. F represents the significance of change in R^2 as a result of each independent variable being entered into the equation.

Table 4.10

Stepwise Regression of WJ III Ability and Additional Clusters on Spelling Test (Age Not Entered)

Predictor	Pratt Index	β	R^2	Change in R^2	F for Change
Variables Entered					
1. Processing Speed (Gs)	.849	.491	.281**		
2. Fluid Reasoning (Gf)	.151	.164	.307	.025	6.39*

*p < .05; **p < .01

NOTE: The Pratt Index and β are based on the final model with 2 independent variables. F represents the significance of change in R^2 as a result of each independent variable being entered into the equation.

For the prediction of the Applied Problems test (as a measure of Math Reasoning), the stepwise regression equation identified the following variables as significant predictors, over and above age: Comprehension-Knowledge (Gc), Visual-Spatial Thinking (Gv), and Long-Term Retrieval (Glr), $F(4, 174) = 16.348$, $p < .0001$, $R^2 = .273$. According to Cohen's (1992) conventions, this model can be viewed as having a large effect on math reasoning (as measured by the Applied Problems test). Pratt Index calculations revealed that Comprehension-Knowledge (Gc) was the most important variable in explaining math reasoning in preschool children, followed by Visual-Spatial Thinking (Gv), Long-Term Retrieval (Glr), and lastly, chronological age.

For the prediction of Basic Reading Skills, different results were found when chronological age was entered into the regression equation first, than when age was not entered into the equation at all (the two methods of analysis discussed earlier). When age was entered first, the stepwise regression equation revealed that the most appropriate and significant model for explaining the Basic Reading Skills achievement cluster, over-and-above age, included the clusters: Comprehension-Knowledge (Gc), Associative Memory (Glr), Fluid Reasoning (Gf), and Short-Term Memory (Gsm), $F(5,173) = 33.547$, $p < .0001$, $R^2 = .492$. According to Cohen's (1992) conventions, this model can be viewed as having a large effect on early reading achievement in preschool children. Pratt index calculations revealed that the most important ability cluster for predicting Basic Reading Skills was Comprehension-Knowledge (Gc), followed by age, Fluid Reasoning (Gf), Associative Memory (Glr), and Short-Term Memory (Gsm).

When age was not entered into the regression equation, the model most appropriate for explaining the Basic Reading Skills cluster included Comprehension-Knowledge (Gc), Fluid

Reasoning (Gf), Associative Memory (Glr) and Short-Term Memory (Gsm), $F(4, 174) = 28.582$, $p < .0001$, $R^2 = .397$. Similarly to results shown for when age was entered into the regression equation first, this model can be viewed as having a large effect on Basic Reading Skills. Pratt index calculations revealed that Fluid Reasoning (Gf) was the most important variable for predicting reading achievement in preschool children, followed by Comprehension-Knowledge (Gc), Associative Memory (Glr), and then Short-Term Memory (Gsm).

Results also differed for the prediction of Basic Writing Skills (using the Spelling test) depending on whether or not chronological age was entered into the regression equation. When age was entered first, the stepwise regression equation indicated that Processing Speed (Gs) and Auditory Memory Span (Gsm) were significant predictors, over-and-above age, $F(3,175) = 27.591$, $p < .0001$, $R^2 = .321$. According to Cohen's (1992) conventions, this model can be viewed as having a large effect on early writing skills in preschool children. Pratt index calculations revealed that the most important ability cluster for predicting Basic Writing Skills (as measured by the Spelling test) is Processing Speed (Gs), followed by Auditory Memory Span (Gsm), and then age.

When age was not entered into the regression equation, the model most appropriate for explaining the Spelling test included Processing Speed (Gs) and Fluid Reasoning (Gf), $F(2, 176) = 38.924$, $p < .0001$, $R^2 = .307$. Again, this model can be viewed as having a large effect on Basic Writing Skills (as measured by the Spelling test). Pratt index calculations revealed that Processing Speed (Gs) was the most important variable for predicting early writing achievement in preschool children, followed by Fluid Reasoning (Gf).

Standardized Partial Regression Coefficient Graphs. Figures 4.1 through 4.10 present the results of the regression coefficient analyses. Each figure displays five columns representing the

Figure 4.1

Standardized Partial Regression Coefficients for Prediction of Achievement Clusters Using Comprehension-Knowledge (Gc) Cluster

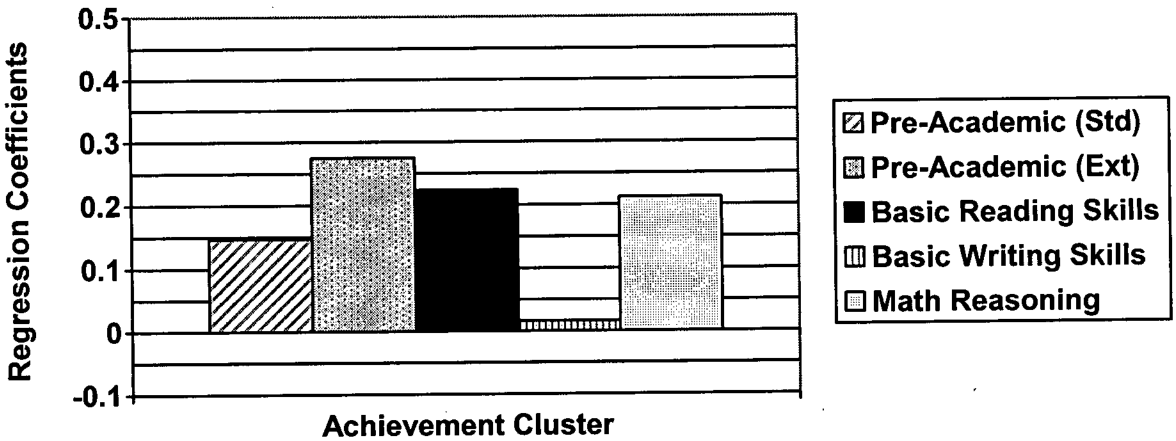


Figure 4.2

Standardized Partial Regression Coefficients for Prediction of Achievement Clusters Using Auditory Processing (Ga) Cluster

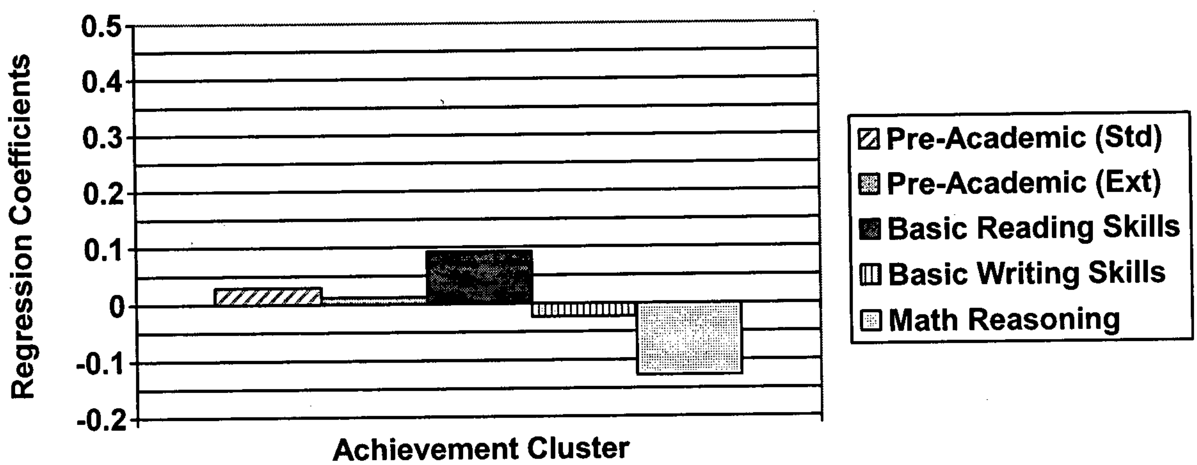


Figure 4.3

Standardized Partial Regression Coefficients for Prediction of Achievement Clusters Using Fluid Reasoning (Gf) Cluster

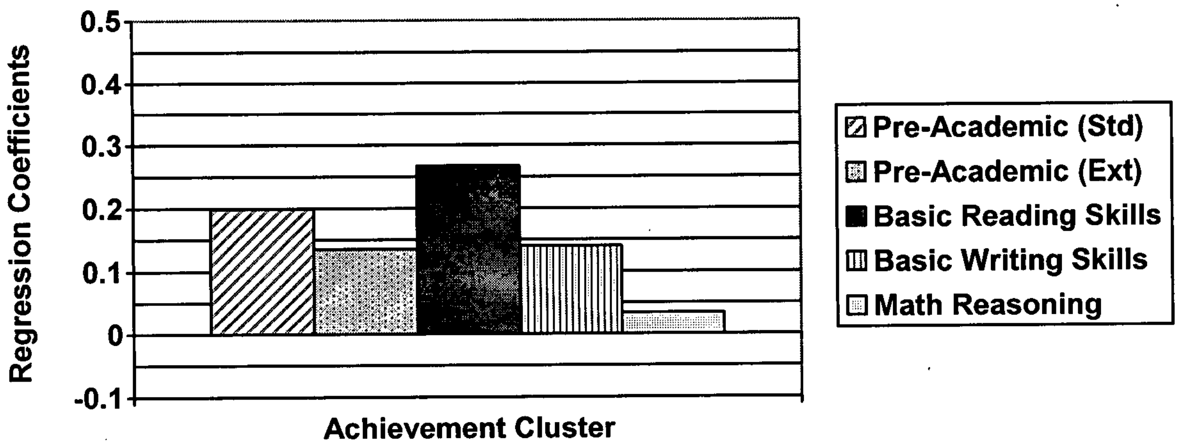


Figure 4.4

Standardized Partial Regression Coefficients for Prediction of Achievement Clusters Using Long-Term Retrieval (Glr) Cluster

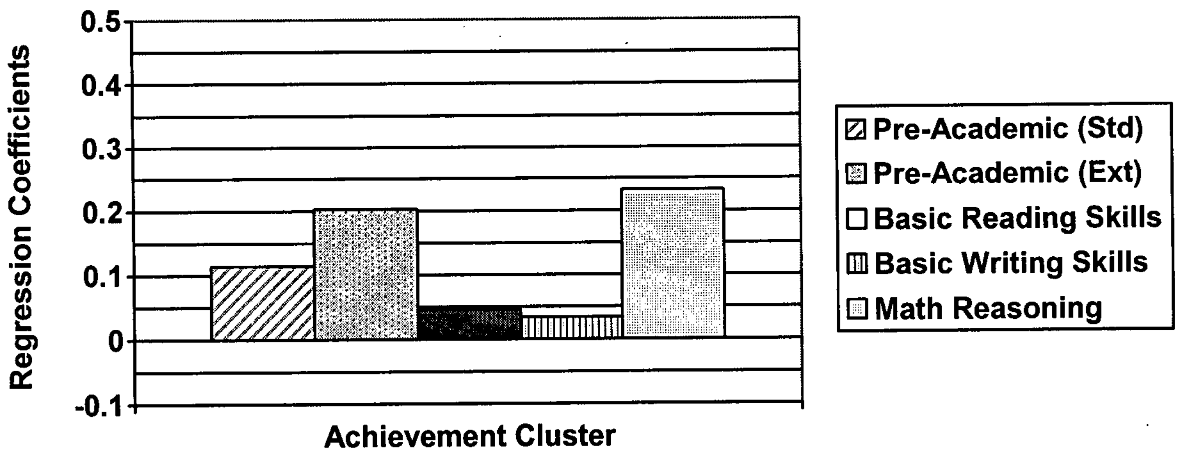


Figure 4.5

Standardized Partial Regression Coefficients for Prediction of Achievement Clusters Using Processing Speed (Gs) Cluster

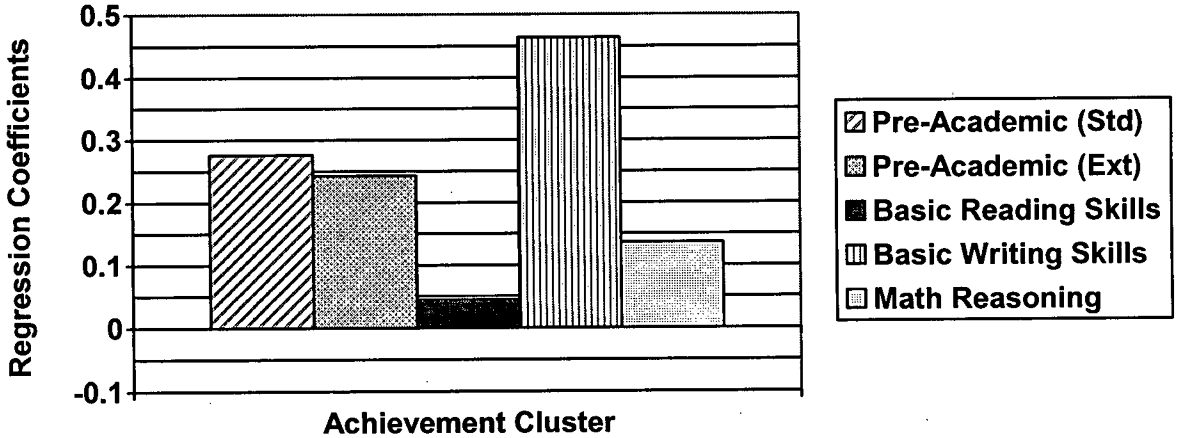


Figure 4.6

Standardized Partial Regression Coefficients for Prediction of Achievement Clusters Using Short-Term Memory (Gsm) Cluster

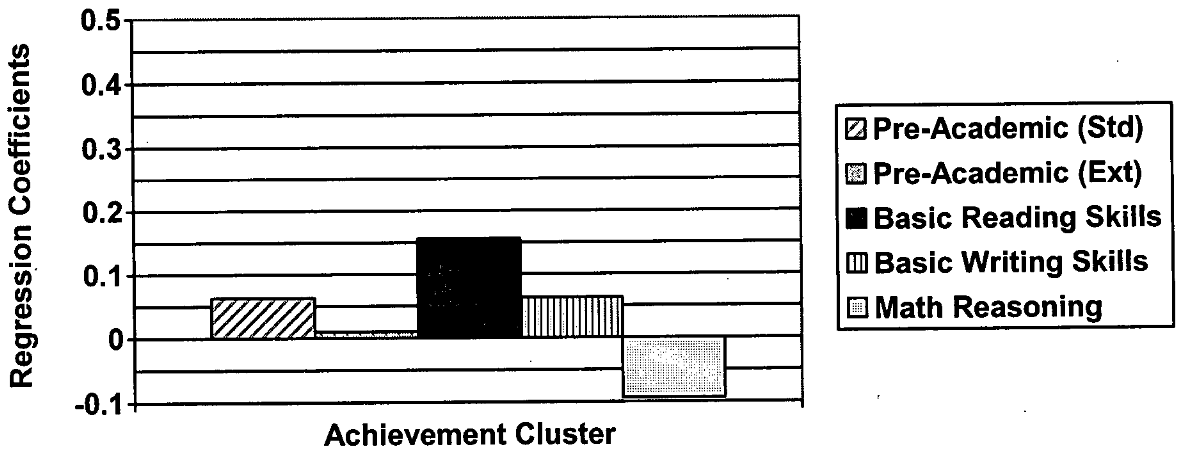


Figure 4.7

Standardized Partial Regression Coefficients for Prediction of Achievement Clusters Using Visual-Spatial Processing (Gv) Cluster

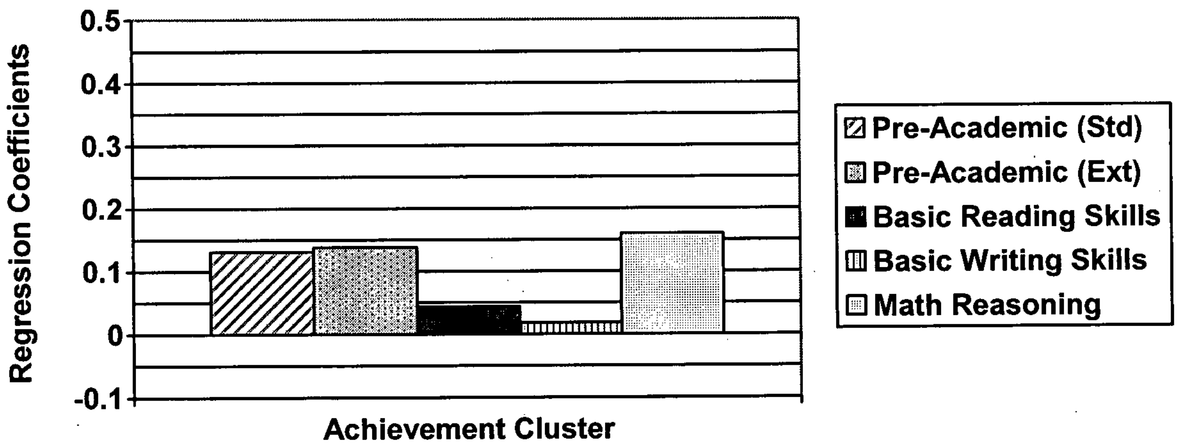


Figure 4.8

Standardized Partial Regression Coefficients for Prediction of Achievement Clusters Using Visual-Spatial Thinking-3 (Gv3) Cluster

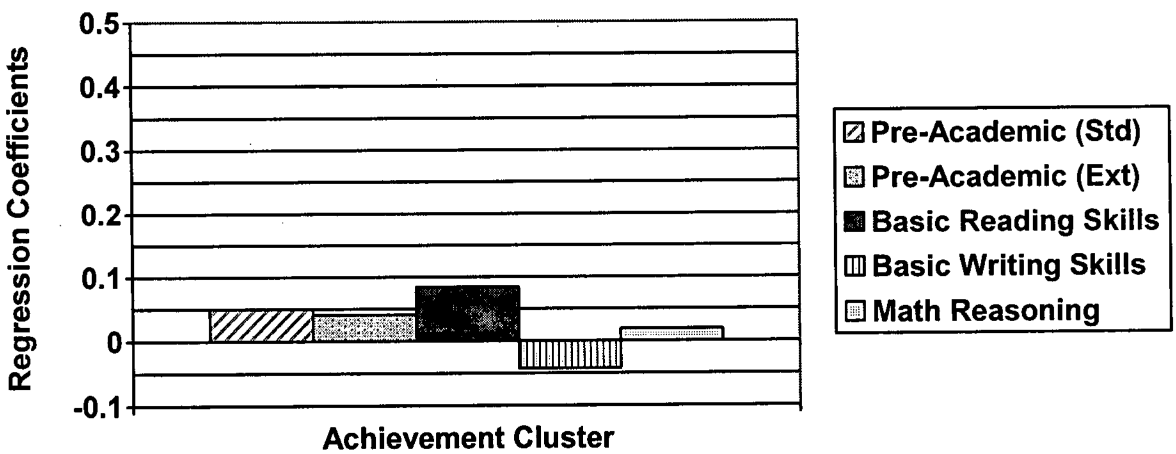


Figure 4.9

Standardized Partial Regression Coefficients for Prediction of Achievement Clusters Using Associative Memory (Glr) Cluster

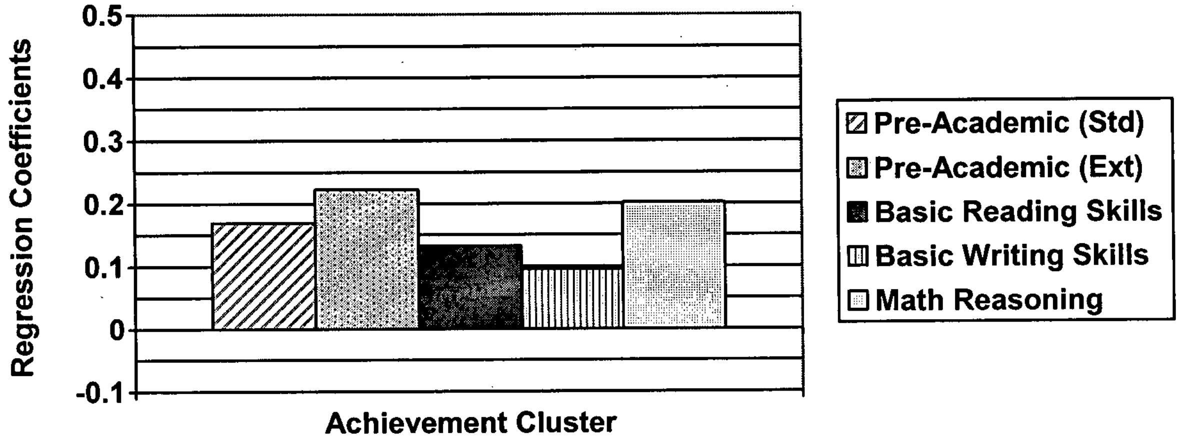
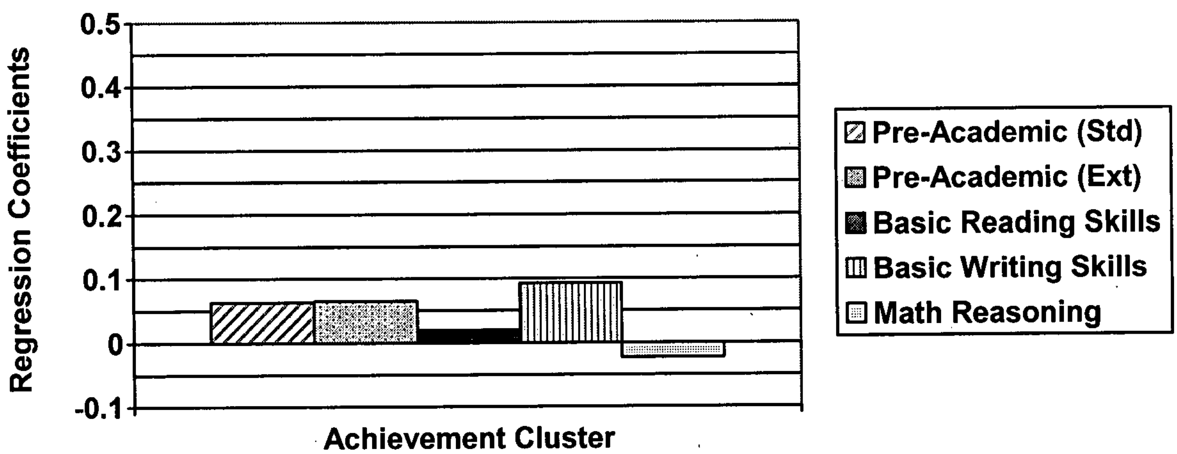


Figure 4.10

Standardized Partial Regression Coefficients for Prediction of Achievement Clusters Using Auditory Memory Span (Gsm) Cluster



standardized partial regression coefficient values for each CHC factor or additional cluster (e.g., Auditory Processing, Associative Memory) that was used as an explanatory variable for each of the achievement clusters: Basic Reading Skills, Basic Writing Skills, Math Reasoning, Pre-Academic (Standard), and Pre-Academic Knowledge and Skills (Extended). Previously established rules-of-thumb (Evans, Floyd, McGrew, & Leforgee, 2001; Floyd, Evans, & McGrew, 2003; McGrew, & Knopik, 1993) define statistical and practical significance to be associated with standardized partial regression coefficients of .10 or above, with coefficients between .10 and .29 classified as moderate relations, and those .30 or above as strong relations in similar previous analyses.

Standardized partial regression coefficients revealed differential relations between the WJ III cognitive clusters and the achievement clusters [Pre-Academic Skills (Std), Pre-Academic Skills and Knowledge (Ext), Basic Reading Skills, Basic Writing Skills (as measured by the Spelling test), and Math Reasoning (as measured by the Applied Problems test)] for preschool-age children. As can be seen from the above figures, Comprehension-Knowledge (Gc), Fluid Reasoning (Gf), Processing Speed (Gs), and Associative Memory (Glr), demonstrated the strongest and most consistent relations with the achievement clusters. Gc and Associative Memory were moderately related to all academic clusters during the preschool years except for Basic Writing Skills, while Gf demonstrated moderate relations with all the achievement clusters excluding Math Reasoning, and Gs demonstrated strong relations with Basic Writing Skills, and moderate relations with Pre-Academic Skills (both Standard and Extended), and Math Reasoning.

Three CHC factor clusters, Long-Term Retrieval (Glr), Short-Term Memory (Gsm), and Visual-Spatial Processing (Gv), demonstrated weaker and less consistent relations with the five achievement clusters. Glr and Gv were moderately related to Pre-Academic Skills (both Standard and Extended) and Math Reasoning during the preschool years, whereas, Gsm only demonstrated moderate relations with the Basic Reading Skills cluster. In contrast, Auditory Processing (Ga), Visual-Spatial Thinking-3 (Gv3), and Auditory Memory Span (Gsm) did not demonstrate significant relations with any of the achievement clusters during the preschool years.

CHAPTER FIVE

Discussion and Implications

The purpose of this chapter is to expand the discussion of the results of the investigation of the relationships between WJ III General Intellectual Ability scores and the achievement clusters, and of the cognitive abilities related to early academic achievement for preschool-age children. This study provided concurrent validity information for the CHC cognitive abilities most important for early academic achievement. The results of the study also provided additional information regarding the nature of cognitive and academic abilities in young children, and the utility of the WJ III for this population.

An expansion of the findings in Chapter Four is discussed by research question in this chapter. Implications of these conclusions as they relate to clinical and research issues will be explored, and important contributions to the literature will be outlined. Limitations of this study and directions for future research will also be discussed.

Initial Descriptive Analyses

Comparing the performance of the present sample of preschool children on the WJ III to that expected based on standard scores with a mean of 100 and a standard deviation of 15 revealed most observed means and standard deviations for the COG clusters and tests that were lower than would be expected. This is especially surprising, given that parental education levels for the sample of preschool children in this study were higher than typically seen in nationally representative standardization samples. Particularly worthy of note are this samples' much lower than expected observed scores for the GIA – Early Development scale; mean scores for this index almost equaled one standard deviation below the mean. It is unknown why this particular sample demonstrated such low scores on the GIA – Early Development scale. An examination of the frequency and distribution of scores revealed no indication of severe outliers or other explanations. In contrast to the lower than expected scores for the COG clusters and tests, observed scores for the ACH clusters and tests revealed means and standard deviations somewhat higher than would be expected (based on M = 100 and SD = 15), a finding which is more consistent with higher parental education levels of this sample.

Research Question One: Relationship Between Composite Scores and Achievement Clusters

In this question, the relationships between the WJ III COG General Intellectual Ability (GIA) scores, both standard and extended, the WJ III General Intellectual Ability – Early Development (GIA-EDev) score, and the WJ III ACH clusters: Basic Reading Skills, Basic Writing Skills, Math Reasoning, Pre-Academic Skills (Standard) and Pre-Academic Skills and Knowledge (Extended), were investigated. The GIA Standard, Extended, and Early Development scores were all highly correlated with each other. This is to be expected given that they are all designed to measure overall general intellectual functioning, or *g*. In addition, the GIA Standard and Extended scores demonstrated a stronger relationship with each other (correlation of .95) than either did with the GIA – Early Development score, which is consistent with previous research (McCullough, 2001) and suggests that the GIA – Early Development scale captures something unique with preschool children. Overall, the GIA – Early Development scale demonstrated higher correlations than both the GIA (Standard) and GIA (Extended) with all achievement clusters except for Math Reasoning (although the correlation for the GIA-EDev was nearly equivalent to the correlation for the GIA-Std, with values of .25 and .26, respectively), providing strong support for the appropriateness of using the GIA-EDev with preschool-age children, as this score is more strongly related to early academic abilities for young children than is the GIA Standard or Extended (which has traditionally been used with school-age children and adolescents).

Research Question Two: Prediction of Achievement from WJ III COG and DS Ability Clusters and Additional Clusters

In this question, the WJ III COG cognitive ability clusters, Comprehension-Knowledge (Gc), Long-Term Retreival (Glr), Short-Term Memory (Gsm), Fluid Reasoning (Gf), Processing Speed (Gs), Auditory Processing (Ga), and Visual-Spatial Processing (Gv), and WJ III COG and DS additional clusters, Associative Memory (Glr), Auditory Memory Span (Gsm), and Visual-Spatial Thinking 3 (Gv3) were analyzed through individual multiple stepwise regression equations to find the most important cognitive abilities for Basic Reading Skills, Basic Writing Skills, Math Reasoning, Pre-academic Skills (Std), and Pre-academic Skills and Knowledge (Ext) achievement clusters from the WJ III ACH. Additionally, standardized partial regression coefficients were calculated from the multiple regression analyses, and were then plotted on a graph, in order to examine the strength of the relation between each cognitive ability and additional cluster and the achievement clusters.

Stepwise Regression Equations. In the examination of Pre-Academic Skills (Std), it was found that Processing Speed (Gs), Associative Memory (Glr), Comprehension-Knowledge (Gc) and Fluid Reasoning (Gf) were the most important variables (in that order) contributing to this achievement cluster, over-and-above age. These same variables were identified for Pre-Academic Skills (Ext), although Comprehension-Knowledge (Gc) was found to be most important, followed by Processing Speed (Gs), Associative Memory (Glr), and Fluid Reasoning (Gf). These were expected findings, and are consistent with previous literature regarding the cognitive variables important for explaining different areas of achievement in school-age children and adolescents (Evans, Floyd, McGrew, & Leforgee, 2001; Floyd, Evans, & McGrew, 2003; McGrew, Keith, Vanderwood, & Flanagan, 1997). Because the Pre-Academic Skills (Std) and Pre-Academic Skills and Knowledge (Ext) clusters are intended to measure general academic and knowledge skills development and are made up of tests requiring early reading, writing, numerical and language abilities, one would expect to find several cognitive abilities as essential contributors to this achievement cluster, with those contributors having shown relations to reading, writing, and mathematics abilities. For example, Processing Speed (Gs) and Comprehension-Knowledge (Gc) have been identified by many researchers (e.g., Flanagan, Ortiz, Alfonzo, and Mascolo, 2002; McGrew, Keith, Vanderwood, and Flanagan, 1997; McGrew & Knopik, 1993), as being the most consistent and significant predictors of reading, writing, and math achievement across the school years and into adulthood, with speed being especially relevant in the early years.

In the prediction of Basic Reading Skills, Comprehension-Knowledge (Gc), Fluid Reasoning (Gf), Associative Memory (Glr), and Short-Term Memory (Gsm) abilities were identified as the most important variables (in that order) over-and-above age. Similar results were found when age was not entered into the regression equation, although the order of importance for these four variables differed, with Fluid Reasoning (Gf) being the most important contributor to Basic Reading Skills in preschool children, followed by Comprehension-Knowledge (Gc), Associative Memory (Glr), and Short-Term Memory (Gsm). These results are consistent with previous research identifying Comprehension-Knowledge and memory abilities as important factors for basic reading skills in school-age children, even after controlling for overall intellectual ability, or *g* (Catts, Gillispie, Leonard, Kail, & Miller, 2002; Flanagan, Ortiz, Alfonzo, & Mascolo, 2002; McGrew, Keith, Vanderwood, & Flanagan, 1997).

Fluid Reasoning has also been found to be an important factor, but for reading comprehension in the later years of childhood, rather than basic reading skills (McGrew, Flanagan, Keith, & Vanderwood, 1997), and is therefore a somewhat unexpected finding. It may be that Fluid Reasoning is more important for predicting early reading abilities in preschool children than it is for predicting reading skills in older populations. The main reason for conducting this study was to investigate how the cognitive abilities important for early academic achievement in young children may be different than those identified as contributing to achievement in older children, adolescents and adults. Due to the rapid growth and development observed during the preschool years, it is quite possible that those cognitive factors thought of as central to academic abilities for this age group are different than those for older populations. It may also be possible that the measures identified as fluid reasoning (Gf) may actually operate, look differently, or measure something different in preschool age children (Tusing, Maricle, & Ford, 2003; Tusing and Ford, 2004), which may impact the interpretation of the findings. More research is needed on effective ways to measure fluid reasoning in preschool age children (Tusing, Maricle, & Ford, 2003), as different measures of fluid reasoning for preschool age children may impact results and prove more consistent with previous studies with school age populations.

For Basic Writing Skills (as measured by the Spelling test), only Processing Speed (Gs) and Auditory Memory Span (Gsm) were identified as important factors, over-and-above age (when it was entered into the equation first), and Processing Speed (Gs), and Fluid Reasoning (Gf) were identified as important contributors when age was not entered into the equation. Although previous research by McGrew and Knopik (1993) found Gs and Gf to be important for writing achievement, and Flanagan, Ortiz, Alfonzo, and Mascolo's (2002) review found that Gs and memory abilities were also related to writing achievement, it is surprising that Comprehension-Knowledge (Gc) was not identified as an important factor for predicting writing skills in this study, since it has demonstrated the most consistent relationship with writing achievement in previous literature (Flanagan et al., 2002; McGrew & Knopik, 1993). This unexpected finding may be due to differences in populations studied (young children in this study versus school-age children and adolescents in other studies), or to differences in skills measured between this study and other studies (for example, this study used the Spelling test as the sole measure of Basic Writing Skills, whereas other studies have examined the entire Basic Writing Skills cluster and also written expression skills). The danger of relying on a single test as the sole criterion variable will be discussed in the next section. An alternative explanation is that the task demands of the Spelling test at the preschool age range may reflect more processing speed skills than higher order crystallized abilities. Further research exploring the nature of cognitive abilities as they relate to early writing skills with preschool-age children is clearly warranted.

The fact that different results were found for the prediction of Basic Reading Skills and Basic Writing Skills depending on whether or not age was entered into the regression equation, suggests that the cognitive abilities that play an important role for these two academic areas may change throughout the preschool years (i.e., as young children get older and move through the preschool years). Because this is a period of rapid development, the skills expected from a 6 year old child are very different from those skills anticipated from child who is 3 years of age. This observation is consistent with previous findings in the literature that the cognitive abilities and factors predicting academic achievement in many areas (e.g., writing, reading, and mathematics) change as children move through the school years and into adulthood.

Three variables were identified as important for Math Reasoning (as measured by the Applied Problems test), over-and-above age: Comprehension-Knowledge (Gc), Visual-Spatial Processing (Gv), and Long-Term Retrieval (Glr). Flanagan, Ortiz, Alfonzo, and Mascolo (2002), and Floyd, Evans, and McGrew (2003) have found support for the significance of all three of these factors to mathematics achievement during childhood and adolescence. However, these same researchers have also identified Fluid Reasoning (Gf) and Short-Term Memory (Gsm) as demonstrating moderate relations to math reasoning throughout childhood and adolescence. Similar to that discussed for Basic Writing Skills, these differences may be due to populations sampled, or to differences in task demands and skills measured between this study and other studies (the prediction of Math Reasoning in this study also relied on a sole test, Applied Problems).

Overall, in the examination of all five achievement clusters (i.e., Pre-Academic Skills (Std), Pre-Academic Skills and Knowledge (Ext), Basic Writing Skills, Basic Reading Skills, and Math Reasoning) several findings were both surprising and unexpected. First, the CHC factor of Auditory Processing (Ga) was not found to be a significant factor for any of the achievement clusters when other variables were taken into account, even though previous studies (e.g., McGrew & Flanagan, 1998; McGrew, Flanagan, Keith, & Vanderwood, 1997) have identified Auditory Processing as an important cognitive ability for reading, writing, and mathematics achievement across the school years. One explanation for this result could be that during the preschool years, other cognitive factors, such as Comprehension-Knowledge (Gc) or Processing Speed (Gs) are more important contributors to early academic abilities and thereby overshadow the auditory processing skills required by early reading, writing, and numerical tasks (i.e., other cognitive clusters most likely account for more variance in the prediction of achievement).

Alternatively, it may be that Auditory Processing (Ga) does not play a role in predicting overall academic achievement or reading, writing, and mathematics until children are somewhat older, and have begun formal schooling. Clearly, further research is needed with preschool children in order to determine whether the reason for this unexpected result is because Auditory Processing does not help predict academic achievement for preschool-age children in general, or whether this result is a function of the current study's specific sample of children.

A second surprising result was that Fluid Reasoning (Gf) was identified as an important cognitive ability in early academic achievement for three of the five achievement clusters studied when age was entered into the regression equation first, and for four of five clusters when age was not entered into regression equation. Traditionally, Fluid Reasoning has not been considered to be a significant cognitive factor for academic abilities in preschool age children. In fact, on the WJ III, Fluid Reasoning is the only CHC cognitive ability *not* included in calculating the General Intellectual Ability – Early Development index, which is designed to be the most appropriate measure of overall cognitive ability for preschool-age children and individuals who have severe developmental delays (Schrank, Mather, McGrew, & Woodcock, 2003). The findings from this study suggest that Fluid Reasoning may be more central to young children's cognitive and academic development than once believed. It may be possible that fluid reasoning is important but that it has not been well examined in widely used measures of preschool cognitive abilities, or is an artifact of the fact that there are few tests with measures of fluid reasoning in young children. Future research on the cognitive factors that relate to early achievement in preschool-age children is clearly warranted to explore this issue further.

Standardized Partial Regression Coefficient Graphs. A long history of research literature has established a strong connection between verbal abilities and academic achievement (e.g., Catts, Gillispie, Leonard, Kail, & Miller, 2002; Flanagan & McGrew, 1998; Floyd, Evans, & McGrew, 2003; Williams, McCallum, & Reed, 1996). Thus, it was not surprising that the Comprehension-Knowledge (Gc) cluster demonstrated consistent moderate relationships with all of the achievement clusters, except Basic Writing Skills. Tusing (1998) found that preschool children tend to rely heavily on verbal or Gc abilities, and therefore, these abilities should be related to early academic achievements in this population. This result is also consistent with Evans, Floyd, McGrew, and Leforgee's (2001) findings for the relationship between Gc abilities and reading achievement, and with Floyd, Evans, and McGrew's (2003) study of the relationship between Gc abilities and math achievement during the school-age and adolescent years.

Processing Speed (Gs) and Fluid Reasoning (Gf) abilities were also found to be fairly strongly related to most of the achievement clusters examined. A wide array of prior research indicates that Gs is important for the early acquisition of many cognitive and academic skills (Evans et al., 2001; Kail, 1991), and that problem-solving and reasoning abilities (Gf) are necessary for comprehension and math skill development (Floyd, Evans, & McGrew, 2003). An unexpected finding was that Gs abilities demonstrated only a weak relationship to Basic Reading Skills, and that Gf abilities were not significantly related to Math Reasoning for preschool children, since consistent moderate relationships have been demonstrated with their school-age and adolescent counterparts (Evans, Floyd, McGrew, & Leforgee, 2001; Floyd, Evans, & McGrew, 2003). It was also surprising that Auditory Processing (Ga) abilities demonstrated only weak relations with all the academic achievement clusters, since a well-publicized finding in the learning disability research is the key role that auditory processing abilities play in early reading skill development (especially phonological processing abilities, e.g., Catts et al., 2002), and very early math development (Floyd, Evans, & McGrew, 2003). One would expect that Auditory

Processing would demonstrate fairly strong relations to, at the very least, reading and math achievement during the preschool years, if consistent significant relationships have previously been established between auditory processing skills and achievement for children in the early elementary school years (i.e., grades 1 to 3).

Visual-Spatial Processing (Gv) abilities were found to be moderately related to Math Reasoning and the Pre-Academic Skills (both Standard and Extended) clusters, but have only a weak relationship to Basic Reading Skills, and Basic Writing Skills, which is consistent with Evans, Floyd, McGrew, and Leforgee's (2001) findings that visual-spatial processing abilities are not related to reading achievement across the school years, but inconsistent with Floyd, Evans, and McGrew's (2003) study, which demonstrated that these abilities are also not significantly related to math achievement for school-age children. It is possible that visual-spatial abilities are associated with the development of very early numerical skills before children enter formal schooling.

Glr abilities, both those measured by the Long-Term Retrieval CHC factor cluster, and those measured by the Associative Memory additional cluster, were found to be moderately related to all achievement areas except Basic Writing Skills, which is consistent with prior literature focusing on early elementary school-age children. The moderate relations between the Associative Memory cluster and early reading and math achievement suggest that the ability to store and retrieve associations may be important when preschool children are learning early pre-reading skills and numerical skills, such as letter and number identification. In contrast to Long-Term Retrieval skills, Short-Term Memory (Gsm) abilities were found to be moderately related with only Basic Reading Skills, consistent with research by Evans, Floyd, McGrew, and Leforgee (2001), suggesting that the ability to attend to and immediately recall information presented is not as important for early academic achievement in preschool children, than is the ability to retrieve information that has previously been learned.

Finally, the additional clusters: Visual-Spatial Thinking (Gv3), which measures an additional narrow ability called closure speed, and Auditory Memory Span (Gsm), a narrow ability of the broad Short-Term Memory ability, were not found to be significantly related to any of the achievement clusters, suggesting that these abilities are not important for understanding early academic achievement for preschool children. Because these clusters contain information only available from using the Diagnostic Supplement for the WJ III, which is a very recently developed instrument, no previous research has investigated these special measures of Gv and Gsm (namely, Closure Speed and Auditory Memory Span) with either preschool or school-age children, or with adolescents.

Contributions to the Field

The contributions that the present study makes to practice in education and psychology are great. First, the current study provides strong support for the claim that the GIA – Early Development score is the most appropriate measure of overall intellectual functioning for preschool-age children or individuals who function at a preschool level (Schrank, Mather, McGrew & Woodcock, 2003). In addition, the present investigation extends previous research on the cognitive factors most important to reading, writing, and mathematics achievement across the lifespan, by providing a downward extension to the school-age and adolescent age ranges typically studied. As results of the current study demonstrated, some of the cognitive abilities identified as important to early academic achievement in several curricular areas for young children (e.g., Auditory Memory Span for writing achievement) were different than those previously identified for school-age children, adolescents and adults (see, for example, Evans, Floyd, McGrew, & Leforgee, 2001, Floyd, Evans, & McGrew, 2003, and McGrew & Knopik, 1993 for details).

This study also provides a greater understanding of the differential nature of cognitive abilities for young children, particularly using a CHC theoretical perspective. As stated by Tusing and Ford (2004), "given that norm-referenced assessment with young children is frequently criticized, advances in the level of sophistication and predictive value attainable when young children's cognitive abilities are assessed within a CHC framework are meaningful" (p. 112). Finally, the current study adds to the accumulating knowledge on how the WJ III can be more effectively utilized for preschool-age children, and leads to a better understanding of the areas to be addressed in early intervention/prevention services for young children.

Limitations of the Study

The present study was limited with regard to issues surrounding missing data, unknown abilities which may be better predictors of achievement in preschool children, and the degree to which the findings of this study an be generalized to other populations. These limitations are outlined and discussed below.

Missing Data

Missing data existed in this study for certain WJ III tests. Some of the youngest children (e.g., three year olds, younger four year olds) either did not complete some tasks due to noncompliance, or did not get items correct due to task difficulty or inability to understand task demands. Missing data in this study was addressed using the expectation maximization (EM) algorithm, which imputed missing values through a process estimating missing data and then parameters. Due to significant amounts of missing data, the regression equations used for the prediction of both the WJ III ACH Math Reasoning cluster and the Basic Writing Skills cluster were unable to be computed. Therefore, both these clusters were based solely on one test from each cluster for which missing data was not an issue: the Applied Problems test as a measure of Math Reasoning, and the Spelling test as a measure of Basic Writing Skills. Although the reliabilities for the Spelling and Applied Problems tests were almost as high as the reliabilities for their entire clusters for children aged three to six years, caution should always be taken when interpreting results of a regression equation based on a single test. Different results may have been found for the prediction of Math Reasoning and Basic Writing Skills in preschool children if sufficient data had been available to include all tests that comprise these clusters.

Unknown Abilities

The present study investigated specific abilities that have been proposed as part of CHC theory and are measured by the WJ III Tests of Cognitive Abilities, Tests of Achievement, and Diagnostic Supplement. Although both the WJ III battery and CHC theory have been well-validated and supported in the research literature, other cognitive and academic abilities not explored in this study may exist. It is possible that the WJ III does not capture all potential cognitive abilities and academic skills that preschool children possess. There may very likely be other unidentified cognitive factors which would have been identified as better predictors of early academic achievement in young children. For example, information-processing theories (such as those proposed by Campione, Brown, and Borkowki) and multi-factor theories of intelligence (such as those posited by Gardner and Thorndike) (Sattler, 2001), suggest other cognitive abilities not measured by the WJ III, which could also be important predictors of early academic achievement for preschool-age children.

Generalization

Given that the current study investigated cognitive abilities and academic achievement in preschool children from the United States, aged 3 years, 0 months to 6 years, 3 months, who generally performed within the average range, the generalizability of these findings is limited to other similar groups. Although the WJ III was designed for use with children as young as 2 years, 0 months, inadequate floors on some of the tests did not allow for the inclusion of 2 year olds in this study, and therefore, results cannot be generalized to children younger than those that comprise the present sample. It is possible that toddlers below 3 years of age do not yet have the same structure and differentiation of cognitive abilities as older preschool-age children (those between 3- and 6-years-old). Indeed, several other commonly used standardized assessment batteries for preschool children (e.g., Differential Ability Scales, Elliot, 1990; Wechsler Preschool and Primary Scale of Intelligence – Third Edition, Wechsler, 2004) posit that for children as young as 2 years of age, cognitive structure is not differentiated beyond verbal and non-verbal abilities. It is most likely that there are additional cognitive abilities other than verbal and non-verbal performance which are important to early achievement for 2-year-old children; however, it cannot be assumed that the cognitive abilities identified as important to achievement in the present study of preschool children (3 years of age and older) will necessarily be exactly the same for children younger than 3.

In addition, it has been well demonstrated in previous literature (e.g., Evans, Floyd, McGrew, & Leforgee, 2001; Floyd, Evans, & McGrew, 2003; McGrew & Flanagan, 1998; McGrew, Flanagan, Keith, & Vanderwood, 1997; McGrew & Knopik, 1993) that the cognitive abilities important for preschool achievement change as children develop and move through the formal schooling process. Therefore, the cognitive abilities identified as important to early academic achievement for preschool-age children in the current study cannot necessarily be generalized for children older than 7 years of age or younger than 3 years of age, despite the strong psychometric properties inherent to the WJ III assessment tool utilized for this study.

Implications for Future Research

Future research in this area should include the continued investigation of cognitive and academic abilities for preschool children. Although some of the results revealed during the examination of the cognitive factors important for early academic achievement in preschool children were consistent with previous literature studying school-age children, adolescents, and adults, several surprising and unexpected results were also discovered, particularly the importance of Fluid Reasoning, and the apparent insignificance of Auditory Processing abilities. This implies a need for further investigation of the structure underlying the WJ III COG and ACH tests as they relate to young children, in order to gain an even better understanding of the utility of the WJ III battery for this population. Specifically, structural equation modeling of the WJ III including the Tests of Achievement should be conducted to determine how the WJ III ACH tests load onto the WJ III COG factors in a preschool sample.

Additionally, differential results were found between the present study and the only other study that has investigated the prediction of achievement from cognitive abilities for preschool-age children (i.e., McCullough, 2001). As this was the first study to include scores from the WJ III Diagnostic Supplement in addition to the Tests of Cognitive Abilities and Tests of Achievement, this information is of great value to both researchers and clinicians, and differential results are to be expected. However, because this is only one study, further research replicating this investigation is warranted to broaden our understanding of using the WJ III with preschool-age children. Subsequent replications of this study will either provide support for or refute the results of this study, and will aid in broadening the literature regarding the nature of cognitive and academic abilities for preschool children. As the link between cognitive ability and later school achievement is better understood through further investigation and exploration, educational practices and interventions that address important cognitive skills as they relate to specific learning needs of young children, can be more appropriately enhanced and developed.

REFERENCES

Anastasi, A. (1986). Intelligence as a quality of behavior. In R. J. Sternberg & D. K. Detterman (Eds.), *What is intelligence? Contemporary viewpoints on its nature and definition* (pp. 19-22). Norwood, NJ: Ablex Publishing Corporation.

Bagnato, S. J., & Neisworth, J. T. (1994). A national study of the social and treatment "invalidity" of intelligence testing for early intervention. *School Psychology Quarterly, 9*, 81-102.

Bracken, B. A. (1994). Advocating for effective preschool assessment practices: A comment on Bagnato and Neisworth. *School Psychology Quarterly, 9*, 103-108.

Bracken, B. A., & Walker, K. C. (1997). The utility of intelligence tests for preschool children. In D. P. Flanagan, J. L. Genshaft, & P. L. Harrison (Eds.). Contemporary intellectual assessment: Theories, tests, and issues (pp. 484-502). New York: Guilford Press.

Carroll, J. B. (1993). *Human cognitive abilities: A survey of factor analytic studies*. New York: Cambridge University Press.

Catts, H. W., Gillispie, M., Leonard, L. B., Kail, R. V., & Miller, C. A. (2002). The role of speed of processing, rapid naming, and phonological awareness in reading achievement. *Journal of Learning Disabilities, 35,* 509-524.

Cohen, J. (1992). A power primer. *Psychological Bulletin, 112,* 155-159.

Das (1986). On definition of intelligence. In R. J. Sternberg & D. K. Detterman (Eds.), *What is intelligence? Contemporary viewpoints on its nature and definition* (pp. 55-56). Norwood, NJ: Ablex Publishing Corporation.

Evans, J. J., Floyd, R. G., McGrew, K. S., & Leforgee, M. H. (2001). The relations between measures of Cattell-Horn-Carroll (CHC) cognitive abilities and reading achievement during childhood and adolescence. *School Psychology Review, 31*, 246-262.

Flanagan, D. P., & Alfonzo, V. C. (1995). A critical review of the technical characteristics of new and recently revised intelligence tests for preschool children. *Journal of Psychoeducational Assessment, 13*, 66-90.

Flanagan, D. P., Ortiz, S. O., Alfonzo, V. C., & Mascolo, J. (2002). *The achievement test desk reference (ATDR): Comprehensive assessment and learning disabilities.* Boston: Allyn & Bacon.

Floyd, R. G., Evans, J. J., & McGrew, K. S. (2003). Relations between measures of Cattell-Horn-Carroll (CHC) cognitive abilities and mathematics achievement across the school-age years. *Psychology in the schools, 40*, 155-171.

Floyd, R. G., Shaver, R. B., & McGrew, K. S. (2003). Interpretation of the Woodcock-Johnson III Tests of Cognitive Abilities: Acting on evidence. In F. A. Schrank & D. P. Flanagan (Eds.), *WJ III clinical use and interpretation.* New York: Academic Press.

Ford, L. (2003). Assessment of young children. In F.A. Schrank, N. Mather, K. McGrew, & R. W. Woodcock (Eds.), *Manual for Woodcock-Johnson III Diagnostic Supplement to the Tests of Cognitive Abilities* (pp. 37-46). Itasca, IL: Riverside Publishing.

Ford, L., & Dahninten, V. S. (2005). The use of intelligence tests in the assessment of preschoolers. In D.P. Flanagan, & P. L. Harrison (Eds). *Contemporary intellectual assessment: Theories, research, and issues* (2nd ed.). New York: Guilford.

Kozey, M., Merkel, C., Morgan, J., Swart, S., Ford, L., & Tusing, M. (2005, April). *Contemporary perspectives and critical review of cognitive measures for young children.*

Paper presented at the National Association of School Psychologists Annual Convention, Atlanta, GA.

Greenspan, S. L., & Meisels, S. J. (1996). Toward a new vision for the developmental assessment of infants and young children. In S. J. Meisels, & E. Fenichel (Eds.), *New visions for the developmental assessment of infants and young children* (pp. 11-26). Washington, DC: Zero to Three.

Gyurke, J. S. (1994). A reply to Bagnato and Neisworth: Intelligent versus intelligence testing of preschoolers. *School Psychology Quarterly, 9*, 109-112.

Horn, J. L., & Noll, J. (1997). Human cognitive abilities: Gf-Gc theory. In D. P. Flanagan, J. L. Genshaft, & P. L. Harrison (Eds.), *Contemporary intellectual assessment* (pp. 53-91). New York: Guilford Press.

Kail, R. (1991). Development of processing speed in childhood and adolescence. In H.W. Reese (Ed.), *Advances in child development and behavior* (pp. 151-185). San Diego, CA: Academic Press.

Kelley, M. F., & Surbeck, E. (2000). History of preschool assessment. In B.A. Bracken (Ed.), *The Psychoeducational assessment of preschool children* (3rd ed., pp. 1-18). Boston: Allyn & Bacon.

League, S. (2000). *Joint factor analysis of the Woodcock-Johnson III and the Wechsler Preschool and Primary Scale of Intelligence-Revised.* Unpublished doctoral dissertation. University of South Carolina.

Mather, N. & Woodcock, R. W. (2001). Examiner's Manual. *Woodcock-Johnson III Tests of Achievement.* Itasca, IL: Riverside Publishing.

McLean, M., Wolery, M., & Bailey, D. B., Jr. (2004). *Assessing infants and preschoolers with special needs* (3rd ed.). Upper Saddle River, NJ: Pearson Education, Inc.

McCullough, J. M. (2001). *Relationship between cognitive abilities and achievement in preschool children.* Unpublished masters thesis. University of South Carolina.

McGrew, K. S. (2005). The Cattell-Horn-Carroll theory of cognitive abilities. In D.P. Flanagan, & P. L. Harrison (Eds). *Contemporary intellectual assessment: Theories, research, and issues* (2nd ed.). New York, NY: Guilford.

McGrew, K. S., & Flanagan, D. P. (1998). *The intelligence test desk reference: Gf-Gc cross-battery assessment.* Needham Heights, MA: Allyn and Bacon.

McGrew, K. S., Flanagan, D. P., Keith, T. Z., & Vanderwood, M. (1997). Beyond g: The impact of Gf-Gc specific cognitive abilities research on the future use and interpretation of intelligence tests in the schools. *School Psychology Review, 26*, 189-211.

McGrew, K. S., & Knopik (1993). The relationship between the WJ-R Gf-Gc cognitive clusters and writing achievement across the life-span. *School Psychology Review, 22*, 687-695.

McGrew, K. S., & Woodcock, R. W. (2001). Technical Manual. *Woodcock-Johnson III.* Itasca, IL: Riverside Publishing.

Meisels, S. J., Atkins-Burnett, S. (2000). The elements of early childhood assessment. In J. P. Shonkoff and S. J. Meisels (Eds.), *Handbook of early childhood intervention* (2nd ed, pp. 231-257). Cambridge, UK: Cambridge University Press.

Nagle, R. J. (2000). Issues in preschool assessment. In B.A. Bracken (Ed.), *The Psychoeducational assessment of preschool children* (3rd ed., pp. 19-32). Boston: Allyn & Bacon.

Neisworth, J. T., & Bagnato, S. J. (2004). The mismeasure of young children: The authentic assessment alternative. *Infants and Young Children, 17,* 198-212.

Paget, K. D., & Nagle, R. J. (1986). A conceptual model of preschool assessment. *School Psychology Review, 15*(2), 154-165.

Phelps, L., McGrew, K. S., Knopik, S. N., & Ford, L. (in press). The general (g), broad and narrow CHC stratum characteristics of the WJ III and WISC-III tests: A confirmatory cross-battery investigation. *Journal of School Psychology.*

Pratt, J. W. (1987). Dividing the indivisible: Using simple symmetry to partition variance explained. In T. Pukkila and S. Puntanen (Eds.), *Proceedings of the Second International Conference in Statistics* (pp. 245-260). Tampere, Finland: University of Tampere.

Proctor, B. E., Floyd, R. G., & Shaver, R. B. (2005). Cattell-Horn-Carroll broad cognitive ability profiles of low math achievers. *Psychology in the Schools, 42,* 1-12.

Roth, P. L. (1994). Missing data: A conceptual review for applied psychologists. *Personnel Psychology, 47,* 537-560.

Sattler, J. M. (2001). *Assessment of children: Cognitive applications (4th ed.).* San Diego, CA: Jarome M. Sattler, Publisher, Inc.

Schrank, F. A. (2005). Woodcock-Johnson III Tests of Cognitive Abilities. In D.P. Flanagan, & P. L. Harrison (Eds). *Contemporary intellectual assessment: Theories, research, and issues* (2nd ed.). New York, NY: Guilford.

Schrank, F. A., Mather, N., McGrew, K., & Woodcock, R. W. (2003). Manual. *Woodcock-Johnson III Diagnostic Supplement to the Tests of Cognitive Abilities*. Itasca, IL: Riverside Publishing.

Tabachnick, B. G., & Fidell, L. S. (2001). *Using multivariate statistics* (4^{th} ed.). Boston, MA: Allyn and Bacon.

Teague, T. (1999). Confirmatory analysis of Woodcock-Johnson Third Edition and the Differential Ability Scale with preschool age children. Unpublished doctoral dissertation. University of South Carolina, Columbia.

Thomas, D. R. (1992). Interpreting discriminant functions: A data analytic approach. *Multivariate Behavioral Research, 27,* 335-362.

Thomas, D. R., Hughes, E., & Zumbo, B. D. (1998). On variable importance in linear regression. *Social Indicators Research: An International and Interdisciplinary Journal for Quality-of-Life Measurement,*

Tideman, E., & Gustafsson, J. (2004). Age-related differentiation of cognitive abilities in ages 3-7. *Personality and Individual Differences, 36,* 1965-1974.

Tusing, M. E., & Ford, L. (2004). Examining preschool cognitive abilities using a CHC framework. *International Journal of Testing, 4,* 91-115.

Tusing, M. E., Maricle, D. E., & Ford, L. (2003). Assessment with the Woodcock-Johnson III and young children. In F. A. Schrank & D. P. Flanagan (Eds.), *WJ III clinical use and interpretation*. New York: Academic Press.

Williams, P., McCallum, R., & Reed, M. (1996). Predictive validity of the Cattell-Horn Gf-Gc constructs to achievement. *Assessment, 3,* 43-51.

Woodcock, R. W., McGrew, K. S., & Mather, N. (2001). *Woodcock-Johnson III.* Itasca, IL: Riverside Publishing.

Woodcock, R. W., McGrew, K. S., & Mather, N. (2001). *Woodcock-Johnson III Tests of Achievement.* Itasca, IL: Riverside Publishing.

Woodcock, R. W., McGrew, K. S., & Mather, N. (2001). *Woodcock-Johnson III Tests of Cognitive Abilities.* Itasca, IL: Riverside Publishing.

Woodcock, R. W., McGrew, K. S., Mather, N., & Schrank, F. J. (2003). *Woodcock-Johnson III Diagnostic Supplement to the Tests of Cognitive Abilities.* Itasca, IL: Riverside Publishing.

APPENDIX

Pratt Indexes for Regression Analysis (Question Two) – Age entered into equation first

$d_i = \beta_i \times r_i / R^2$

Preschool Academic Skills (Standard):

d (Age) = (.090) (.181) / .457 = **.036**
d (Gs) = (.317) (.508) / .457 = **.352**
d (Gc) = (.191) (.497) / .457 = **.208**
d (Assoc Mem) = (.209) (.458) / .457 = **.209**
d (Gf) = (.196) (.454) / .457 = **.194**

Preschool Academic Skills (Extended):

d (Age) = (.017) (.116) / .550 = **.003**
d (Gc) = (.332) (.599) / .550 = **.362**
d (Gs) = (.287) (.523) / .550 = **.273**
d (Assoc Mem) = (.257) (.533) / .550 = **.249**
d (Gf) = (.147) (.466) / .550 = **.124**

Basic Reading Skills

d (Age) = (.319) (.424) / .492 = **.275**
d (Gc) = (.253) (.533) / .492 = **.274**
d (Assoc Mem) = (.184) (.387) / .492 = **.145**
d (Gf) = (.217) (.508) / .492 = **.224**
d (Gsm) = (.122) (.337) / .492 = **.084**

Basic Writing Skills (Spelling):

d (Age) = (.141) (.168) / .321 = **.074**
d (Gs) = (.474) (.531) / .321 = **.784**
d (Aud Mem Span) = (.140) (.327) / .321 = **.143**

Math Reasoning (Applied Problems):

d (Age) = (-.263) (-.215) / .273 = **.207**
d (Gc) = (.214) (.353) / .273 = **.277**
d (Gv) = (.200) (.354) / .273 = **.259**
d (Glr) = (.180) (.392) / .273 = **.258**

Pratt Indexes for Regression Analysis (Question Two) – Age not entered into equation

$d_i = \beta_i \times r_i / R^2$

Preschool Academic Skills (Standard):

d (Gs) = (.316) (.508) / .449 = **.357**
d (Gc) = (.195) (.497) / .449 = **.216**
d (Assoc Mem) = (.204) (.458) / .449 = **.208**
d (Gf) = (.216) (.454) / .449 = **.218**

Preschool Academic Skills (Extended):

d (Gc) = (.323) (.599) / .549 = **.352**
d (Gs) = (.286) (.523) / .549 = **.272**
d (Assoc Mem) = (.256) (.533) / .549 = **.248**
d (Gf) = (.151) (.466) / .549 = **.128**

Basic Reading Skills

d (Gc) = (.266) (.533) / .397 = **.357**
d (Gf) = (.286) (.508) / .397 = **.366**
d (Assoc Mem) = (.162) (.387) / .397 = **.158**
d (Gsm) = (.138) (.337) / .397 = **.117**

Basic Writing Skills (Spelling):

d (Gs) = (.491) (.531) / .307 = **.849**
d (Gf) = (.164) (.283) / .307 = **.151**

Math Reasoning (Applied Problems):

d (Glr) = (.234) (.392) / .208 = **.441**
d (Gv) = (.165) (.354) / .208 = **.281**
d (Gc) = (.164) (.353) / .208 = **.278**