

PRESCHOOLERS' AWARENESS OF THEIR MATHEMATICAL ABILITIES

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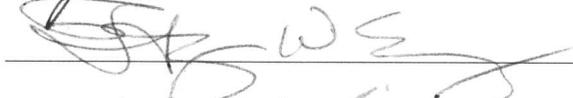
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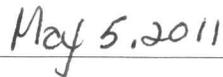
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Preschoolers' Awareness of Their Mathematical Abilities

A dissertation submitted in partial fulfillment of the requirements for the degree of  
Doctor of Philosophy at George Mason University

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## TABLE OF CONTENTS

	Page
Abstract.....	v
Introduction.....	1
Method.....	19
Results.....	26
Discussion .....	32
Appendices.....	39
List of References.....	48

## ABSTRACT

### PRESCHOOLERS' AWARENESS OF THEIR MATHEMATICAL ABILITIES

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During the first several years of life, preschool children develop an awareness of self, as well as basic mathematical abilities. It has been shown that children who are more aware of their own abilities are also those who are more successful on measures of cognition. It is easy to see that the same would be true of the relation between self-awareness and mathematical abilities. The present study is aimed at discovering how these two constructs are related. Ninety-nine preschool children were administered tests of perceived cognitive competence and mathematical abilities (WJIII-Applied Problems, seriation, oddity). The following research questions are asked: Do children who score higher on measures of mathematics also give high ratings of their own general cognitive competence? Second, do children who score higher on measures of mathematics also give higher ratings of their performance on those measures? The analyses indicated that, the children's perceived general cognitive competence ratings were significantly related to their performance on the WJIII-Applied Problems test. No significant relations were

found between the children's oddity and seriation scores and their perceived general cognitive competence ratings. The children's oddity test scores were significantly related to their ratings of their performance on the oddity measure. No significant relations were found between the children's performance on the WJIII-Applied Problems and seriation tests and their ratings of their abilities on these measures. These findings suggest preschool children have begun to develop an awareness of their cognitive abilities, but that this development is not complete even by four years of age.

## 1. INTRODUCTION

Development occurs more rapidly during the first several years of life than during any other period in the lifespan. Two of the many constructs that develop during this period are self-awareness and basic mathematical abilities. Both of these are developed as a result of interactions with other objects in the world, including, but not limited to, social interactions.

Mastery of self-awareness and basic mathematical abilities allows for more efficient cognitive processing. They allow one to choose the appropriate behaviors to engage in when interacting with other objects and to engage in a more effective problem-solving strategy when failure occurs. This is exhibited by the fact that children who have a more accurate view of their abilities are also the ones who score higher on cognitive measures (Measelle, Ablow, Cowan, & Cowan, 1998).

### **Development of Self-Awareness**

Over the past several decades a considerable amount of attention has been paid to self-awareness, what it is and how it develops. Although Epstein described the self as “a slippery concept whose adequate definition is irritatingly elusive” (1973, p. 404), scientists still aim to construct a widely agreed upon definition and method of how to measure it.

Historically different schools of thought have developed their own theories for what the self is and how an awareness of it develops. Psychoanalytic theorists suggested that a sense of self separate from other objects emerges gradually as a result of the gradual differentiation of self and others, through which one learns to control their instinctual desires (Freud, 1965 as cited in Brooks-Gunn & Lewis, 1984). Behaviorists posited that the self is comprised of two components the “I” and the “me”. They argue that the “I” consists of four types of awareness: (1) *personal autonomy*- an awareness that one is in control of oneself, (2) *individuality*- an awareness that one is distinct from other object, (3) *continuity*- an awareness that the self continues to exist through time, (4) *reflection*- an awareness of personal meaning. The “me”, which is the categorical self, is made up of one’s parts, including the body and possessions (Butterworth, 1992). Sociologists concluded that an awareness of self develops as a result of interactions with other individuals, through which one develops a sense of self that is distinct from others, but in relation to them (Mead, 1934). Epistemologists believed that a sense of self develops through changes in cognitive structures, which results in children being able to consider the social world and understand that they are related to this world, but a distinct entity within it (Piaget, 1963).

More recently other theorists have changed and expanded on the historic definition of self-awareness. Geangu (2008) defined self-awareness as an understanding that one is aware that one’s own bodily and mental states belong to oneself. Rochat (2003) stated that self-awareness is a dynamic process that develops in six stages over the first several years of life: (0) confusion as a result of no self-awareness; (1) self-world

differentiation; (2) situation, in which one is capable of exploring the relation of their own body to a reflection in a mirror; (3) identification of an image of the self as *me*; (4) permanence, an understanding that the self is not limited to the temporal situation; (5) meta self-awareness, which allows one to be aware of oneself from both a first and third person perspective. Others have defined the self as a knowledge of one's own body and competencies, which is developed through experiences with self-exploration, as well as experience with how their own actions effect the world around them (Rochat, 2001).

For the purposes of this paper, self-awareness will be defined as an understanding that one has ownership over one's own bodily and mental states (Geangu, 2008). It is believed that this awareness is developed through interactions and active exploration of oneself, as well as other objects and individuals.

Although an awareness of self begins to develop during the first several years of life, this construct continues to develop over the course of the lifespan. While children are in preschool, they are developing an awareness of their image, thoughts, knowledge, and self-concept.

In order to investigate the development of self-recognition in children, previous researchers have measured children's preference for attending to videotapes of themselves and their peers. By the time children are three months of age they show preference for watching the videotapes of their peers over videotapes of themselves (Bahrck, Moss, & Fadil, 1996). These findings suggest that even by a few months of age children are capable of discriminating between images of themselves and images of others.

Researchers (e.g. Amsterdam, 1972; Bullock & Lutkenhaus, 1990; Lewis & Brooks-Gunn, 1979) who have further investigated the development of visual recognition observed toddlers' behaviors in front of a mirror in order to determine at what age children are capable of identifying their own images as themselves. These observations showed that by two years of age, children are capable of identifying their reflection in a mirror as themselves. Further, by this age children are capable of using their name or a personal pronoun when referring to themselves or when identifying an image of themselves.

Critics have argued that recognition of the self in the mirror does not indicate that the individual has an awareness of self, but rather an awareness of the reflective property of mirrors. Mitchell (1993) argued that children are able to recognize themselves in the mirror because they have a kinesthetic sense of self and awareness that mirrors reflect images. Children are aware that their bodies are continuous and that mirrors reflect images accurately. Therefore, if the mirror is reflecting the movement of their hand, and their hand is attached to their body, then the mirror image must be an image of their body. However, observations of children who have no previous experience with mirrors have shown that an ability to recognize oneself in a mirror is not dependent on previous experience with mirrors (Priel & de Schonen, 1986). Thus, it has been widely accepted that children's ability to recognize themselves in mirrors is an indicator that they have developed an awareness of self.

The findings of the above studies indicate that by the time children enter preschool, they have developed a representation of their own image, which they are

capable of holding in their minds to discriminate between images of themselves and images of others.

The earliest manifestation of children using their own names as well as personal pronouns also occurs around two years of age. It has been argued that children's early use of their own names may be a result of rote memorization and not a valid indicator of a developed self-metarepresentation (Lewis & Ramsay, 2004). However, it has been widely accepted that children's use of personal pronouns including *me* and *mine* is a valid indicator of a developed self-metarepresentation (Harter, 1983; Hobson, 1990; Lewis & Ramsay, 2004). Between two and three years of age, children begin to use their names and personal pronouns in everyday speech to refer to themselves as active agents, as well as the owners of objects and internal states (Bullock & Lutkenhaus, 1990). Though children begin to develop an understanding of the usage of this language as toddlers, this ability continues to develop into the preschool age.

At about the same time children are beginning to develop the ability to use their own names and personal pronouns, they are also beginning to develop the ability to use terms to classify characteristics about themselves. Around two years of age children begin to be able to classify their own gender, age, and physical characteristics (Stipek, Gralinski, & Kopp, 1990). This ability also continues to develop into the preschool age, with preschool children being able to describe themselves using concrete, observable characteristics, including the tasks which one is capable of performing (Keller, Ford, & Meacham, 1978).

During the preschool years children are also beginning to develop an understanding of thought processes. Preschool aged children understand that thinking is an activity that occurs internally and that the mind and brain are involved in the thought process (Wellman, 1990). They are also aware that one can have thoughts about objects that are not physically present when one is thinking about them and that there is a difference between thoughts and reality, including the difference between thinking about an action and performing that action (Flavell, Green, & Flavell, 1995). They also understand that thinking is something that only animates are capable of doing (Lillard, Zeljo, Curenton, & Kaugers, 2000).

Though preschool children have begun to develop an understanding of thought, this understanding is far from complete even by 5 years of age. Many preschoolers often fail to recognize when they themselves have been thinking and often have difficulty identifying what they had been thinking about (Flavell et al., 1995). These children also fail to recognize instances when other individuals are thinking. When they do recognize that another person is thinking, they are not often capable of inferring what the person is thinking about, even when there is clear evidence (Flavell et al., 1995).

Children begin to develop an understanding that they are objects of knowledge, and they begin to understand how knowledge is formed during preschool. Preschoolers understand that there is a difference between knowing and guessing; however, they often base their classification of whether an answer was known or guessed on the accuracy of the answer (Montgomery, 1992). By four years of age children are capable of

understanding that they may have knowledge of some information even if they are unable to access that information at the present time (Cultice, Somerville, & Wellman, 1983).

When asked to identify how they came to acquire a specific piece of knowledge, three-year-old children are frequently unable to identify how they came to know that information, but five-year-old children typically do not have any problems identifying the source of their knowledge (Gopnik & Graf, 1988). Identifying when they acquired knowledge is also typically a difficult task for preschool children. Even immediately after preschool children have acquired new information, they will typically claim that they have had knowledge of this information for an extended period of time. This holds true even for five-year-old children, indicating that an ability to identify when knowledge is acquired does not develop until sometime in elementary school. It should also be noted that preschool children are much better at identifying when knowledge was acquired when they are learning new behaviors (e.g. how to fold origami) than when they are learning new facts (e.g. the meaning of the Japanese counting words) (Esbensen, Taylor, & Stoess, 1997).

Preschool children are also capable of identifying the process through which they applied their knowledge to a problem. Demetriou and Kazi (2006) found that children as young as three years of age were capable of identifying the process they used to complete a task immediately following a task measuring their mathematical abilities. They also found that the children who were successful on the task were more accurate when identifying the process they used than the children who were not successful on the task.

This finding suggests that there is a relationship between children's cognitive performance and their awareness of their cognitive abilities.

Finally, preschool children have also begun to develop a self-concept that allows them to use evaluative language to make judgments about themselves. Young children's development of self-concepts occurs in the context of interpersonal relationships (Brown, Mangelsdorf, Agathen, & Ho, 2008). It is believed that through these interactions, children become aware of how others view them and as a result are capable of forming their own concepts of themselves (Colwell & Lindsey, 2003). Especially important are the interactions that the children have with their parents. Parents play a significant role in determining how their children feel about themselves, as they are typically the ones who help children to internalize and express their emotions through modeling emotion reactivity and socialization behaviors (Brown et al., 2008). Parents' use of emotional references is related to the structure of their children's self-concepts, as a result of an increased likelihood that the children will internalize the emotions and incorporate them into their self-concepts (Welch-Ross, Fasig, & Farrar, 1999).

In order to be able to develop a self-concept children must be able to access memories of their previous behaviors so that they can base their assessment of themselves on their previous performance. By three years of age children are capable of retrieving general memories, but they are not capable of retrieving specific memories until four or five years of age (Marsh, Ellis, & Craven, 2002).

The development of language is also critical for the formation of a self-concept. Language development allows children to use personal pronouns, self-descriptions,

evaluative language, and construct memories (Marsh et al., 2002). Stipek, Gralinski and Kopp (1990) found that the ability to use self-descriptive and evaluative language develops around two-years of age, indicating that by the time children are enrolled in preschool they have the language skills necessary to verbalize their self-concepts.

There is no general agreement as to whether children's self-concepts are developed early in life and are enduring or if they develop early in life but change in middle childhood. Many believe that experiences during the first stage of life are crucial to the development of a self-concept. It is believed that these early experiences serve as a basis for children's self-concept, and that once this self-concept is established it is enduring (Marsh et al., 2002). However, others have found evidence that suggests that the self-concepts, that children develop during the first few years of life, are consistently high, and that as children have more life experiences their self-concepts become more realistic (Marsh et al., 2002). It is believed that young children are not capable of forming accurate self-concepts because they are not able to distinguish between their actual competence and their ideal competence (Harter & Pike, 1984). Cognitive development, as well as life experiences, allows children to have a better understanding of their strengths and weaknesses so that as they age their self-concepts are more representative of their actual abilities.

It has been shown that children between the ages of eight and 18 years are capable of differentiating their abilities on five domains: scholastic competence, athletic competence, peer acceptance, physical appearance, and conduct and behavior (Harter & Pike, 1984). However, factor analyses have revealed that children younger than eight

years of age are not capable of differentiating between their abilities on this many domains. Harter and Pike (1984) found that preschool children's perceptions of themselves might fall into two domains, cognitive competence and social competence.

### **Development of Basic Mathematical Abilities**

All children will develop at least basic mathematical abilities and the environment in which they live will determine the abilities that they develop. All children have a natural tendency to learn regardless of whether their environment provides opportunities for direct instruction (Ginsburg, Cannon, Eisenband, & Pappas, 2006).

Some theorists have even suggested that children have a biological basis for basic mathematical concepts (e.g. Gelman, 2000; Geary 1996). Gelman (2000) suggested that individuals are born with mental structures that promote the development of mathematical abilities. Geary (1996) proposed that mathematical abilities can be separated into two basic categories: those that are biologically primary and those that are biologically secondary. Abilities that are biologically primary are those that were developed in our ancestors to solve recurring problems and will develop naturally in all typically developing children at the same time and in the same way. It is assumed that biologically primary abilities set the foundation for the development of biologically secondary abilities, which are specific to a given culture and need repetition in order to develop (Geary, 1995). The abilities that are assumed to be biologically primary are: (1) numerosity- the ability to determine small quantities without counting; (2) ordinality- a basic understanding of the *more than, less than* relationship; (3) counting- an

understanding that there are serial-ordered words for counting, measuring, and simple arithmetic; (4) simple arithmetic- the ability to detect increases and decreases in small set quantities (Geary, 1995).

It is widely accepted that even environments absent of formal mathematical instruction offer children numerous opportunities to learn mathematical skills (Ginsburg et al., 2006). Although some environments offer richer experiences than others, all environments offer children shapes to discern, objects to count and locations to identify (Ginsburg et al., 2006). All children are exposed to environments that have mathematical phenomena (Ginsburg & Seo, 1999) and support for the development of some mathematical skills (Gelman, Massey, & McManus, 1991). Children are also offered opportunities to learn mathematical skills during social situations. Almost every cultural group has developed a method for counting that is passed on to the children in the group (Zaslavsky, 1973). In most cultures it is typical for parents to offer their children informal mathematical instruction (Ginsburg et al., 2006). Parents may also facilitate their children's learning through stories, games, pretend play, and television shows and movies (Ginsburg et al., 2006).

As of 2009, in the United States, 47% of three-year-old children and 74% of four-year-old children were enrolled in some form of preschool program (Barnett, Espstein, Friedman, Sansanelli & Hustedt, 2009). Even though there are so many children in the United States who are enrolled in preschool programs, currently there are not national standards that define the skills that children are expected to demonstrate competency in by the end of preschool.

Though national standards for preschool education do not exist, there are mathematical concepts that children are typically exposed to during preschool. Preschool programs typically provide children with instruction in the following areas: number concepts, time and space, geometry, early algebra concepts, simple addition and subtraction, measurement, and data analysis (Madison Early Learning Initiative, 2009).

An understanding of the concept of numbers is typically exhibited through behaviors such as an understanding of number words, counting, and mastery of the counting principles. Before children develop the ability to count they must first develop an awareness of counting words. At two years of age, children begin to spontaneously say number words (Durkin, Shire, Riem, Crowther, & Rutter, 1986), and by three years of age, they are aware of the sequence of numbers from one to ten (Siegler & Robinson, 1982). However, they are typically only able to enumerate small sets of objects, and they tend to be inaccurate (Fusion, 1991). Though their enumeration does contain inaccuracies, children do typically follow counting principles. They are aware that only one word should be assigned to each object, counting words should always occur in the same order, anything can be counted, the last number indicates the total number of objects in the set, and objects can be counted in any order as long as each object is only counted once (Ginsburg et al., 2006). By four years of age children are typically much more accurate when counting from one to ten, though some struggle with numbers greater than ten as a result of the number words not mapping onto the base-ten number system (e.g. eleven) (Geary, 2006). Once children have developed an understanding of

the number words greater than ten, they often enjoy counting large quantities (Irwin & Burgham, 1992).

Skills associated with understanding time and space include being able to use simple maps and direction words, and being able to put events in sequence. While children are in preschool they develop the ability to use simple maps and landmarks in order to identify the location of objects (Newcombe & Huttenlocher, 1992; Newcombe & Learmonth, 1999). However, even by four years of age, children have difficulty using maps that are drawn from a vantage point other than their own (Gisburg et al., 2006), and they can have difficulty recognizing the symbolic function of representational symbols (Liben & Downs, 2001). During this time, children are also learning how to use directional words (e.g. up, down, top, bottom, inside, outside) in their own speech as well as follow directions that include directional words (Madison Early Learning Initiative, 2009). Preschool children are also learning how to sequence everyday activities using words such as: *before, after, then, next, first, last* (Madison Early Learning Initiative, 2009).

The geometric concepts that are typically developed in preschool are being able recognize shapes and use them in drawings, as well as geometric reasoning skills. Preschoolers' tendency to base their identification and reasoning of shapes on the appearance of the object often results in them misidentifying objects as a result of them being non-prototypical (van Hiele, 1986). Circles are typically the easiest shape for children to learn, because their form varies the least; squares, rectangles, and triangles are also typically learned early (Clements, Swaminathan, Hannibal, & Sarama, 1999). In

preschool children are also learning to recognize shapes in their environment (e.g. the tiles on the floor are squares) and use shapes in their paintings and drawings (Madison Early Learning Initiative, 2009).

The early algebra concepts that are typically focused on during preschool include recognizing and completing simple patterns. By four years of age, children are capable of completing simple patterns (e.g. ABCABC), however they tend to show a bias for patterns involving items that were used in previous pattern instruction (Ginsburg et al., 2006). Preschool children often misidentify objects in a series as a pattern, even when the series does not follow any rules, and they often have difficulty identifying nonsymmetrical patterns (Rawson, 1993).

Preschoolers show an interest in addition and subtraction concepts and they understand that addition results in an increase in the number set and subtraction results in a decrease in the number set. By three years of age children are capable of successfully completing simple addition and subtraction problems, especially when they are allowed to use nonverbal responses to the problem set (Jordan, Huttenlocher, & Levine, 1994).

It is expected that preschool children will begin to develop an understanding of basic measurement concepts, such as an understanding of basic measurement terms (e.g. bigger, smaller), as well as the ability to use measurement tools. By two years of age, children begin to understand the concept of *more* and *a lot*, and they are capable of recognizing that one set of objects has more items than another set of objects (Walkerline, 1988). Between three and four years of age children begin to apply measurement terms to their everyday lives. For example, they talk about growing older

and bigger, they ask for more of an item, and they compare the size of their toys to the toys of their peers (Ginsburg et al., 2006). At this age, children also begin to learn how measurement tools, such as rulers and scales, work and how they can be used when comparing objects (Madison Early Learning Initiative, 2009).

Finally, during preschool, children are developing an understanding of how data can be sorted and analyzed. According to the 2002 report of the National Association for the Education of Young Children (NAEYC), by the time children are in preschool, most will be capable of using measurement tools and observational skills to observe objects and scientific phenomena. They are able to reason and hypothesize about the phenomena they are observing, as well use materials to collect and represent their findings (e.g. graphs) (NAEYC, 2002).

At the same time, children are developing basic mathematical abilities they are also mastering abstract principles, such as oddity and seriation. Mastery of the oddity and seriation principles have been shown to be especially important during the transition between preschool and kindergarten, as mastery of these principles has been shown to be related to children's academic performance (Ciancio, Rojas, McMahon, & Pasnak, 2001). Children's performance on tests of oddity and seriation are related to their performance on measures of basic mathematical skills (Greene, Pasnak, & Romero, 2009) and instruction on these measures has been shown to also improve performance on measures of basic mathematical skills (Pasnak, Kidd, Gadzichowski, Gallington, & Saracina, 2008; Kidd, Pasnak, Gadzichowski, Ferral-Like, & Gallington, 2008). It is believed that both the oddity and seriation principles serve as a foundation for the cognitive development

occurring during preschool (Ciancio et al., 2001), as the majority of kindergarten instruction is based on the assumption that children have mastered an understanding of basic abstract principles (Pasnak, Maccubbin, & Ferral-Like, 2007).

The oddity principle involves identifying the item in a series that differs from the others on only one dimension. Mastery of this principle is related to being able to sort and classify objects, such as coins. It is believed that the oddity principle is that first abstract principle that children develop and as such, it marks a transition between pre-operational to concrete operational thinking in children (Pasnak et al., 2007). In order to master the oddity principle children must be able to use relational reasoning, basing their answers on the relationship between the objects and not the concrete properties of the objects (Pasnak et al., 2007).

The seriation principle involves relating objects to other objects in a series and being able to line them according to their sizes in either an increasing or decreasing pattern. It also involves being able to insert an object into its proper position in the series. Mastery of this principle is related to being able to compare the size of objects and is thought to develop in four stages: (1) the inability to seriate; (2) the ability to seriate only through trial and error; (3) the ability to seriate through use of the extremum method- building a series by choosing the largest object in the series, then the next largest and so forth until the series is complete; (4) the ability to correctly seriate a series, and then insert an object into the middle of the series (Southard & Pasnak, 1997). Being able to insert an object into a series requires that children be able to simultaneously consider the relationship between the object being inserted and all of the items before and after it

in the series (Southard & Pasnak, 1997).

### **The Present Study**

It is easy to see how having an awareness of self could be related to cognitive performance. Self-monitoring, self-regulation, self-evaluation, and self-representation allow one to develop accurate mental activity maps and make more efficient problem-solving decisions, which make cognitive processes more effective (Demetriou & Kazi, 2006). Having an awareness of one's cognitive processes allows one to organize their thought processes and remain focused on goals in order for them to successfully complete a task (Demetriou & Kazi, 2006).

To date, there is has been very little research looking at the relationship between preschool children's perception of their abilities and their actual abilities. The majority of the research investigating this relationship has focused on children 8 years and older. The research that explored this relationship in preschool children has yielded mixed results. Marsh and colleagues (Marsh et al., 2002) found a significant relationship between preschoolers' performance on measures of mathematics and their mathematics self-concepts. However, Montgomery (1992) found that preschool children often overestimate their abilities as a result of conflating knowing with guessing. Other researchers have suggested that while children are capable of forming differentiated self-concepts, they are incapable of understanding the administration of measures aimed at assessing these self-concepts (Measelle, Ablow, Cowan, & Cowan, 1998).

The present study is aimed at exploring the relationship between children's performance on measures of mathematics and the accuracy of their evaluations of their

performance. It is assumed that there will be a relationship between children's cognitive performance and their ratings of their abilities, as it has been shown that intelligence has a self-awareness component to it (Demetriou & Kazi, 2006). Hence, it is hypothesized that children who score higher on measures of mathematics will also have higher ratings of their own perceived general cognitive competence, as well as higher ratings of their performance on these measures.

## 2. METHOD

### **Participants**

The participants for this study were 99 preschool children in the Washington DC metropolitan area. Forty-seven of the children attended the same Head Start center, while the other children all attended the same private preschool center. Fifty-one of the children were female. All children were between two and six years of age (mean= 4.77, SD= .78).

### **Procedures**

The children were recruited through their preschool centers through letters sent home to their parents describing the study and requesting informed consent. Informed consent was obtained for all of the children attending the Head Start center. Informed consent was obtained for 72 percent of the children attending the private preschool center. There were no direct benefits offered to the participants.

All of the children were administered four measures of basic mathematical abilities and one measure of perceived general cognitive competence over the course of one academic year. Immediately following the administration of each of the math measures, the children were asked to rate their performance on the measure.

The measures were administered using a Latin square design. Latin square designs ensure that each measure is administered after each other measure the same

number of times in order to control for performance on one measure effecting performance on another measure. Children were only tested on one measure per day, in order to control against fatigue.

## **Measures**

**Measures of mathematics: WJIII-Applied Problems.** Mathematical abilities were measured using the Woodcock-Johnson III: Applied Problems (McGrew & Woodcock, 2001) (WJIII-Applied Problems). This subtest is a 39-item test that assesses mathematical skills, such as being able to show the appropriate number of fingers, counting, and adding. It is administered orally and visual stimuli are provided (e.g., children are shown a picture with two apples and two birds and are asked how many apples are in the picture), which makes it especially appealing for research with preschool children. Testing was terminated once the child incorrectly answered six consecutive problems. Cronbach's alpha for four-year-old children on this measure is .79, with a standard error of 4.6 (McGrew & Woodcock, 2001). Raw scores for the WJIII-Applied Problems were used, thus each child had a score with a possible range of 0 to 39.

**Measures of mathematics: Seriation and Oddity.** Since WJIII-Applied Problems was normed on English-speaking children, and is administered in English, we also included a measure of mathematical abilities that does not require language for responses and is culture-free. Pasnak et al. (2009) developed measures that assess young children's seriation and oddity abilities without the use of language. The seriation and oddity tests would be ideal in this circumstance, because the constructs that they measure have been shown to serve as a foundation for the development of mathematical skills

typically taught in kindergarten (Pasnak et al. 2009).

The seriation test consists of ten items and two practice items that require the children arrange everyday objects by their size. The first two items require that the children seriate three objects (i.e., put objects in order based on their size), the second two items require that the children seriate four objects. The next two items require that the children seriate three objects, and once they complete this initial step, they are given a fourth object to insert into the series. Items seven and eight require the children to seriate four objects and insert the fifth. Finally, items nine and ten require the children seriate five objects and insert the sixth. This test is also administered one-on-one and requires approximately 15 minutes to complete. Again, all children are administered all items regardless of their performance. Raw scores for the seriation test were used, thus each child had a score with a possible range of 0 to 10.

The oddity test consists of 20 items and two practice items. All items use everyday objects (e.g., erasers, popsicle sticks, beads), and have three objects that are identical and one that varies from the others on one dimension; color, size, orientation or form. The five color problems have objects that are identical with the exception that one is a different color than the other three (e.g., three blue popsicle sticks and one yellow popsicle stick). The five size problems have objects that are identical with the exception that one of the objects is a different size than the others (e.g., three small beads and one large bead). The five orientation problems consist of objects that are all identical with the exception that one of the objects is oriented differently from the other three objects (e.g., three dinosaurs facing right, and one dinosaur facing left). Finally, the five form

problems have objects that are identical in every aspect, with the exception that one varies either in shape, an internal detail, or a missing piece (e.g. three circular yo-yo's and one square yo-yo). This test is administered one-on-one and takes approximately 15 minutes. There is not a ceiling for this measure so all items are administered to all children, regardless of their performance. Raw scores for the oddity test were used, thus each student had a score with a possible range of 0 to 20.

**Perceived Abilities: General Cognitive Competence.** Perceived general cognitive competence was measured using The Pictorial Scale of Perceived Competence and Social Acceptance for Young Children (Harter & Pike, 1984). This scale measures preschoolers' perceptions of their own abilities on four domains: cognitive abilities, physical abilities, social acceptance, and maternal acceptance.

The relevant subscale for this research was perceived cognitive abilities. To measure children's perceived cognitive competence, the children were shown six pictures that represented different skills they are expected to have mastered during preschool. These skills are: the ability to put together puzzles, getting stars on papers, knowing the names of colors, the ability to count, knowledge of the alphabet, and knowing the first letter of one's name (Harter & Pike, 1984). For each item, two images are shown to the child. One image depicts a child who is successfully completing the task of interest (e.g., a child who has assembled a puzzle with the exception of a few pieces). The second image depicts a child who is not successful on the same task (e.g., a child who has only assembled a few pieces of a puzzle). The administrator shows the child the images, points to the image of the successful child and says, "this child is pretty good at this

task”, then the administrator points to the image of the child who is not successful and says, “this child is not very good at this task.” The child is then asked to point to which child they are more like. Under each of the pictures there are two circles, one large and one small. Once the child pick the image that is most like them, they are asked to point to the large circle if the image is a lot like them, or the small circle if the image is a little like them. The child’s responses are recorded on a four-point scale: 4 indicates being a lot like the successful child, 3 indicates being a little like the successful child, 2 indicates being a little like the unsuccessful child, and 1 indicates being a lot like the unsuccessful child (Harter & Pike, 1984).

Use of this perceived cognitive competence scale is desirable because preschoolers have very limited reading abilities, and the pictures have been shown to maintain the attention of the children during the administration of the measure (Harter & Pike, 1984). The measure is administered one-on-one and takes approximately 15 minutes to complete. Cronbach’s alpha for preschool children on this measure is .6 (Harter & Pike, 1984). For the present study, an average score was calculated for each child, based on their responses to the six cognitive items; thus each child had a score that ranged from 0 to 4.

**Perceived Abilities: Specific Cognitive Competence.** The approach used for the perceived general cognitive competence was adapted to produce additional measures of metacognition apart from the children’s perceived general cognitive competence ratings. These new metacognitive measures were developed, one for each measure of mathematical competence (WJIII-Applied Problems, seriation, and oddity). Immediately

following the administration of the WJIII-Applied Problems, the children were shown an image of a child who was counting well and an image of a child who was counting poorly. The children then asked to point to which child they were more like when they were taking the test. They were then asked to point to one of the circles under the image to indicate whether they were a lot like the child in the image or a little like the child in the image. Similar assessments were conducted immediately following the seriation and oddity tests. The children were asked to choose whether their behavior on the task was more like the child who was pretty good or not so good, and whether they were a lot or a little like that child. These assessments of performance on the mathematics measures were scored on the same four-point scale as the perceived general cognitive assessment ratings.

### **Analyses**

In order to account for the 1.5 percent missing data, multiple imputation was conducted using NORM software (Schafer, 1999). Five datasets were imputed, and identical analyses were conducted on each. The betas, standard errors, Wald, and  $t$  statistics were then averaged across the five analyses. The reported results of the analyses are based on the aggregates. Statistical significance was determined by evaluation of the averaged beta and Wald statistics.

To answer the first research question, whether children who have higher scores on measures of mathematics rated their own general cognitive competence higher, hierarchical linear regression analyses were conducted. Scores on each of the math measures were used to predict ratings of perceived general cognitive competence, while

controlling for the effects of the age, gender, and the preschool center attended.

The second research question is whether children who have higher scores on measures of mathematics rate their performance on those measures higher. The children's ratings of their performance on the WJIII-Applied Problems, seriation, and oddity tests were essentially dichotomous, with the majority of children choosing 4, "very good". For this reason, the data were dichotomized (those children who chose 4 vs. the children who chose 1, 2 or 3). In order to account for the dichotomous nature of the data hierarchical logistic regressions were conducted. Scores on each of the math measures were used to predict the children's ratings of their performance on the measures, while controlling for the effects of age, gender and center.

### 3. RESULTS

As shown in Table 1, the children's average score on the WJIII-Applied Problems was 11.23 (SD = 5.27), which corresponds to the performance of a four and a half year old child based on the normed average (McGrew & Woockcock, 2001). On both the seriation and oddity test the average scores were slightly above 50 percent. Furthermore, children's ratings of their perceived cognitive competence were high, as the average score was 3.48 (SD = .53) out of 4.

Correlations between each of the variables can be seen in Table 2. The age of the children was significantly related to their scores on the WJIII-Applied Problems test,  $r(95) = .43, p < .01$ , and their scores on the oddity test,  $r(94) = .67, p < .01$ , as well as their ratings of their perceived cognitive competence  $r(94) = .31, p < .01$ . The preschool that the children attended was significantly related to their performance on the WJIII-Applied Problems test,  $r(96) = -.57, p < .01$ , and their seriation test scores,  $r(95) = .37, p < .01$ . The children's perceived general cognitive competence ratings were related to their performance on the WJIII-Applied Problems test,  $r(95) = .35, p < .01$ , and their scores on the oddity test  $r(94) = .34, p < .01$ . Finally the children's performance on the WJIII-Applied Problems test was related to their performance on the seriation test,  $r(95) = .37, p < .01$ , and their performance on the oddity test  $r(95) = .59, p < .01$ .

## **Research Question 1: Is Children's Performance on Measures of Mathematics Predictive of Their Perceived General Cognitive Competence?**

Individual hierarchical linear regressions were conducted to explore whether children's performance on measures of mathematics (WJIII-Applied Problems, seriation, and oddity) were able to significantly predict their perceived general cognitive competence.

The first hierarchical linear regression assessed the relationship between the children's performance on the WJIII-Applied Problems test and the children's perceived general cognitive competence ratings (Table 3). The first step of the model, which included only the main effects, indicated that there was a significant main effect for the children's scores on the WJIII-Applied Problems test ( $\beta = .36, p < .05$ ). The children who scored higher on the WJIII-Applied Problem test also had higher ratings of their perceived general cognitive competence. There were no other significant main effects in the first step of the model. The  $R^2$  value indicated that the first step of the model accounted for 16 percent of the total variance in the model. The second step of the model, which included both the main effects and the WJIII-Applied Problems test by age, WJIII-Applied Problems test by gender, and WJIII-Applied Problems test by center interactions, indicated there were not any significant main effects. The only significant interaction was the WJIII-Applied Problems test by gender interaction ( $\beta = -.82, p < .01$ ). The main effect for the children's scores on the WJIII-Applied Problems was not significant in this step. As seen in Figure 1, males who scored higher on the WJIII-Applied Problems test also had higher ratings of their perceived general cognitive

competence, while females ratings of their perceived general cognitive competence did not vary based on their WJIII-Applied Problems test scores. The  $R^2$  value indicated that the second step accounted for an additional 8 percent of the total variance in the model.

The second hierarchical linear regression analyzed the relationship between children's performance on the seriation test and their perceived general cognitive competence ratings (Table 4). The first step of the model, which included only the main effects, indicated that there was a significant main effect for age ( $\beta = .32, p < .01$ ), with the older children having higher ratings of their perceived general cognitive competence. There were no other significant main effects in the first step of the model. The  $R^2$  value indicated that the first step of the model accounts for 12 percent of the total variance in the model. The second step of the model included the main effects as well as the seriation by age, seriation by gender, and seriation by center interactions. This step also indicated that there was a significant main effect for age ( $\beta = .34, p < .01$ ). There were no other significant main effects or interactions in the second step. The  $R^2$  value indicated that the second step of the model accounted for an additional 3 percent of the total variance in the model.

The third hierarchical linear regression assessed the relationship between the children's performance on the oddity test and their perceived general cognitive competence ratings (Table 5). The first step of the model, which only included the main effects, indicated that there were not any significant main effects. There was a linear trend indicating that the children who scored higher on the oddity test were also more likely to have higher perceived general cognitive competence ratings, however this

relationship was not strong enough to reject the null hypothesis ( $\beta = .21, p > .05$ ).  $R^2$  for the first step indicated that the main effects account for 13 percent of the total variance in the model. The second step of the model included the main effects as well as the oddity by age, oddity by gender and oddity by center interactions. This analysis did not reveal any significant main effects or interactions.  $R^2$  for the second step indicated that including the interactions in the model only explains an additional 1 percent of the total variance in the model.

The lack of main effects for age in the models that included the WJIII-Applied Problems test scores and the oddity test scores may be a result of these measures being highly correlated with the children's ages. Due to the high correlation between these scores and age, any effect that may have been found for one variable may have been removed when the other variable was included in the model.

## **Research Question 2: Is Children's Performance on Measures of Mathematics Predictive of Their Assessment of Their Performance on the Measure?**

Due to the dichotomous nature of the children's ratings of their performance on the measures of mathematics (WJIII-Applied Problems, seriation, and oddity), the relationships between their performance on each of the measures of mathematics and their assessment of their performance on those measures were analyzed using hierarchical logistic regressions.

The first hierarchical logistic regression analyzed the relationship between the children's performance on the WJIII-Applied Problems test and their ratings of their performance on the WJIII-Applied Problems test (Table 6). Sixty-three percent of the

children rated their performance on the WJIII-Applied Problems test as a 4. The first step of the model, which included the main effects, did not indicate that there were any significant main effects. Nagelkerke  $R^2$  for the first step was .16. The second step of the model included the main effects as well as the WJIII-Applied Problems test by age, WJIII-Applied Problems test by gender, and WJIII-Applied Problems test by center interactions. The second step of the model also did not reveal any significant main effects, nor did it reveal any significant interactions. There was a suggestion of a relationship between the children's performance on the WJIII-Applied Problems test and their ratings of their performance on the WJIII-Applied Problems test, with the children who scored higher on the WJIII-Applied Problems test being more likely to rate their performance on the WJIII-Applied Problems test as a 4, although this relationship was not strong enough to reject the null hypothesis ( $\chi^2 = 1.73, p > .05$ ). Nagelkerke  $R^2$  for the second step was .20, which indicates that adding the interactions to the model increases the goodness of fit of the model.

The second hierarchical logistic regression assessed the relationship between the children's performance on the seriation test and their ratings of their performance on the seriation test (Table 7). Sixty-five percent of the children rated their performance on the seriation test as a 4. The first step of the model included only the main effects. This analysis did not reveal any significant main effects. Nagelkerke  $R^2$  for the first step was .06. The second step included the main effects as well as the seriation by age, seriation by gender, and seriation by center interactions. The second step did not indicate that there were any significant main effects or interactions. The children who scored higher

on the seriation test were somewhat more likely to rate their performance on the seriation test as a 4 ( $\chi^2 = 1.09, p > .05$ ), though this relationship was not strong enough to reject the null hypothesis. Nagelkerke  $R^2$  for the second step was .15, indicating that including the interactions improved the goodness of fit of the model.

The third hierarchical logistic regression analyzed the relationship between the children's performance on the oddity test and their ratings of their performance on the oddity test (Table 8). Sixty-eight percent of the children rated their performance on the oddity test as a 4. The first step of the model analyzed the main effects. This analysis indicated that there was a significant main effect for the children's scores on the oddity test ( $\chi^2 = 5.24, p < .05$ ), with the children who scored higher on the oddity test being more likely to rate their performance on the oddity test as a 4. Nagelkerke  $R^2$  for the first step of the model was .27. The second step of the model included the main effects as well as the oddity by age, oddity by gender, and oddity by center interactions. There were not any significant main effects or interactions in this step of the model. There was a tendency for males to be more likely to rate their performance on the oddity test as a 4 ( $\chi^2 = 3.52, p > .05$ ) however this relationship was not strong enough to reject the null hypothesis. Nagelkerke  $R^2$  for the second step of the model was .29.

#### 4. DISCUSSION

Three findings emerged from the present study: (1) preschool children's performance on the WJIII-Applied Problems was related to their perceived general cognitive competence, and this relation varied based on the gender of the child; (2) preschool children's perceived cognitive competence was related to their age; (3) preschool children's performance on the oddity test was related to their assessment of their performance on this measure.

**Preschool children's performance on the WJIII-Applied Problems was related to their perceived general cognitive competence and this relation varied based on the gender of the child**

Results indicated that preschool children who scored higher on the WJIII-Applied Problems were also more likely to have higher perceived general cognitive competence ratings, but that this relation is stronger for males than for females. These results are consistent with the findings of Marsh and colleagues (Marsh et al., 2002), who also found a relation between children's performance on mathematical measures and their cognitive self-concepts. This suggests that preschool children are capable of accurately forming a cognitive self-concept.

Novel to the present study is the finding that the relation between the children's perceived general cognitive competence ratings and their WJIII-Applied Problems scores

was stronger for males than it was for females. Previous researchers (Eccles, Wigfield, Harold, & Blumenfeld, 1993; Marsh et al., 2002), who have investigated whether males and females differ in their cognitive self-concept ratings, have found that males tend to have higher mathematical self-concepts, but females have higher reading self-concepts. However, to date there is no literature considering whether there is a relation between preschool children's gender and the accuracy of their self-concept. There are a few possible explanations for the finding. One possible explanation is that males may be receiving more accurate feedback at home and in the classroom than females are, allowing them to form a more accurate self-concept. It may also be that as Roberts (1991) suggested, males and females respond differently to evaluative feedback. Another possibility is that at this stage in life, male children develop the ability to form an accurate self-concept before females.

Though there was a relation between preschool children's performance on the WJIII-Applied problems and the perceived general cognitive competence ratings, the relation between their seriation and oddity test scores and their perceived general cognitive competence ratings were nonsignificant. The lack of relation between preschool children's seriation test scores and their perceived general cognitive competence may be a result of the seriation test being too difficult for the children. It has been suggested that the ability to seriate objects is not mastered until after children have mastered the oddity principle (Pasnak, Campbell, Perry, & McCormick, 1989), so it may be that the majority of the children in this study had not yet mastered this task, and as Montgomery (1992) suggested, they confused knowing the answer with guessing. As

mentioned previously, the lack of relation between children's oddity scores and their perceived general cognitive competence ratings may be a result of the multicollinearity that exists between children's performance on the oddity test and their ages.

### **Preschool children's perceived cognitive competence was related to their age**

The regression analysis examining the relation between preschool children's performance on the seriation test and their perceived general cognitive competence ratings indicated that there was a significant relation between the children's ages and their perceived general cognitive competence ratings, with the older children having higher ratings. As mentioned above, this relation may not have been significant for the analyses involving the children's WJIII-Applied Problems and oddity test scores as a result of these measures being highly correlated with the children's ages. Though the relation between age and perceived general cognitive competence ratings was not significant in the analyses that included the children's WJIII-Applied Problems and oddity test scores, linear trends were present.

It was surprising that older children had higher ratings of their perceived general cognitive competence, as previous researchers have found that younger children are more likely to have higher self-concept ratings than older children (Mash 1989; Harter, 1999). It is assumed that young children will have high self-concepts, which are then lowered as a result of life experiences, that allow them to form more accurate concepts of self (Marsh et al., 2002).

A possible explanation for the older children having higher ratings of their perceived general cognitive competence than the younger children may be that the

younger children are not capable of understanding the administration of the measure used in the present study. It has been suggested that preschool children are capable of forming an accurate self-concept, but that current measures are not capable of accurately measuring their self-concepts (Measelle et al., 1998). This suggests that the younger children in the present study may not have been developmentally ready for the measure of perceived general cognitive competence.

**Preschool children's performance on the oddity test was related to their assessment of their performance on this measure**

Results indicated that there was a relation between children's performance on the oddity test and their ratings of their performance on the oddity test. Children who scored higher on the oddity test were more likely to rate their performance on this measure as a four. These findings suggest that preschool children are capable of accurately assessing their performance on measures of mathematics immediately following the administration of the measure.

It is likely that there was a relation between children's performance on the oddity test and their ratings of their performance on this measure, but not between their performance on the WJIII-Applied Problems and seriation tests and their ratings of their performance on these measures, because oddity only tests one skill. The oddity test requires only one step and measures only children's ability to choose the object that differs from the others in an array. Given that the WJIII-Applied Problems tests multiple skills (e.g. counting, addition, subtraction), and the seriation test requires two steps (lining up the objects by size, inserting an object into the series), these measures may

result in the children's performance being more ambiguous. Preschool children may be unclear about how to rate their abilities when they are successful on one step or item type, but not on others on the same measure. For example, children who are able to successfully seriate objects, but cannot successfully insert objects may rate their abilities highly, because they see themselves as being successful on a significant portion of the task. However, because the item is marked incorrect, if any portion is wrong, the children's ratings of their performance will not be related to their performance on the measure. It should also be mentioned that the lack of an association between children's performance on the WJIII-Applied Problems and their ratings of their performance on this measure may be a result of the way this test is structured. The WJIII-Applied Problems test is structured so that the items get successively harder, and administration is halted after the children get a certain number incorrect (McGrew & Woodcock, 2001). It is possible that when the children are assessing their abilities they only consider the last few problems that were administered, in which case, when assessing their performance on the WJIII-Applied Problems the children may only be considering their performance on the hardest problems that were administered to them, and which they likely got wrong. This suggests that preschool children have begun to develop the ability to accurately evaluate their performance on a task, but that this ability is limited to less complex tasks.

As mentioned previously, another possible explanation for why there are not significant relations between children's performance on the WJIII-Applied Problems and seriation tests and their ratings of their abilities on these measures is that children may be conflating knowing with guessing. Unlike the oddity principle, which is expected to be

one of the first mathematical abilities to develop (Pasnak et al., 1995), the WJIII-Applied Problems test includes items that children are not expected to have mastered until sometime in elementary school (McGrew & Woodcock, 2001), and children typically do not master the seriation principle until after they have mastered the oddity principle (Pasnak et al., 1989). As such, it is possible that children are more likely to be guessing on the WJIII-Applied Problems and seriation tests than they are on the oddity test. If children are not able to distinguish knowing from guessing, they may be likely to rate their abilities higher than they actually are.

### **Limitations**

It is also important to note the limitations of the present study. First, as mentioned previously, it has been argued that preschool children are not capable of understanding the administration of measures of self-concept (Measelle et al., 1998). Though, the presence of significant relationships between the children's perceived cognitive competence and their performance on the mathematical measures suggest that the children were capable of understanding the administration of the measures. Second, the fact that the majority of the children rated their abilities as *very good*, may signify that there is a restriction of range. It may be necessary to offer the children a larger range of options for rating their performance. Finally, the children's high ratings of their perceived cognitive competence may also be a result of social desirability bias. Even if children believe that they are *not very good* at competing a task, they may rate their abilities as *good* or *very good* because they believe this is the response they are supposed

to give. From a young age children are told that they are supposed to be good, so it makes sense that they would want to convey themselves as good to the researcher.

### **Conclusion**

The current study was focused on the degree to which preschool children's performance on measures of mathematics was related to their perceived cognitive competence. The results of this study suggest that preschool children are capable of forming accurate self-concepts, but that this ability is still developing. It is likely that preschool children have begun to form self-concepts and that these become more accurate with life experiences. This is supported by the findings that children's perceived general cognitive competence ratings were related to their WJIII-Applied Problems scores, but not their oddity or seriation tests scores. Further, there was a significant relation between children's oddity test scores and their ratings of their performance on this measures, but there were not significant associations between children's WJIII-Applied Problems and seriation test scores and their ratings of their performance on these measures.

From this study, it is clear that preschool children are capable of forming accurate perceived cognitive competence ratings, but that this ability is not fully developed by four years of age.

## APPENDIX: TABLES AND FIGURES

Table 1

Descriptive Statistics for Measures of Mathematics and Perceived  
General Cognitive Competence

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Variable	Mean	SD
WJIII-Applied Problems Test	11.23	5.27
Seriation Test	5.86	5.41
Oddity Test	11.51	6.10
Perceived General Cognitive Competence	3.48	0.53

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Table 2

Correlation Coefficients for Measures of Mathematics and Perceived General Cognitive Competence

Variable	1	2	3	4	5	6	7
1. Applied Problems	-	0.37**	.59**	.35**	.43**	0.06	-0.57**
2. Seriation Test		-	-0.19	0.08	-0.06	-0.09	-0.37**
3. Oddity Test			-	.34**	.64**	0.05	-0.19
4. Perceived General Cognitive Competence				-	.31**	-0.03	-0.07
5. Age					-	-0.05	0.06
6. Gender						-	0.07
7. Center							-

*Note.* \* $p < .05$ , \*\*  $p < .01$

Table 3

Hierarchical Linear Regression Analysis Predicting Children's Perceived General Cognitive Competence From Their WJIII-Applied Problems Test Scores

Predictor	B	SE	$\beta$
Step 1			
Age	0.11	0.08	0.15
Gender	-0.06	0.10	-0.06
Center	0.14	0.14	0.13
Applied Problems	0.04	0.02	0.36*
Step 2			
Age	0.11	0.01	0.16
Gender	-0.07	0.10	-0.06
Center	0.16	0.14	0.15
Applied Problems	0.07	0.05	0.67
Applied Problems*Age	0.00	0.01	-0.02
Applied Problems*Gender	-0.05	0.02	-0.82**
Applied Problems*Center	0.03	0.02	0.49

Step 1  $R^2 = .16$

Step 2  $R^2 = .24$

Note. \*  $p < .05$ , \*\* $p < .01$

Table 4

Hierarchical Linear Regression Analysis Predicting Children's Perceived General Cognitive Competence From Their Seriation Scores

Predictor	B	SE	$\beta$
Step 1			
Age	0.22	0.07	0.32**
Gender	-0.01	0.11	-0.01
Center	-0.05	0.11	-0.05
Seriation	0.01	0.01	0.10
Step 2			
Age	0.24	0.07	.34**
Gender	0.01	0.11	0.01
Center	-0.08	0.12	-0.08
Seriation	0.08	0.05	0.86
Seriation* Age	-0.01	0.02	-0.08
Seriation* Gender	-0.03	0.02	-0.47
Seriation* Center	-0.03	0.03	-0.39

Step 1  $R^2 = .12$

Step 2  $R^2 = .15$

Note. \*  $p < .05$ , \*\*  $p < .01$

Table 5

Hierarchical Linear Regression Analysis Predicting Children's Perceived General Cognitive Competence From Their Oddity Scores

Predictor	B	SE	$\beta$
Step 1			
Age	0.13	0.09	0.19
Gender	-0.03	0.11	-0.03
Center	-0.04	0.11	-0.34
Oddity	0.02	0.01	0.21
Step 2			
Age	0.14	0.09	0.20
Gender	-0.04	0.11	-0.04
Center	-0.05	0.12	-0.05
Oddity	0.01	0.04	0.11
Oddity* Age	0.00	0.01	-0.04
Oddity* Gender	-0.01	0.02	-0.08
Oddity* Center	0.01	0.02	0.19

Step 1  $R^2 = .13$

Step 2  $R^2 = .14$

Note. \*  $p < .05$ , \*\*  $p < .01$

Table 6

Hierarchical Logistic Regression Analysis Predicting Children's Assessment of Their Performance on The WJIII-Applied Problems Test From Their WJIII-Applied Problems Test Scores

Predictor	B	SE	Wald
Step 1			
Age	0.52	0.38	1.96
Gender	-0.45	0.46	0.77
Center	-0.21	0.62	0.13
Applied Problems	0.09	0.07	1.73
Step 2			
Age	0.47	0.39	1.60
Gender	-0.70	0.51	1.47
Center	-0.19	0.62	0.78
Applied Problems	0.48	0.26	2.68
Applied Problems *Age	0.01	0.07	0.71
Applied Problems * Gender	-0.19	0.11	2.82
Applied Problems * Center	-0.05	0.12	0.22

Step 1 Nagelkerke  $R^2 = .16$

Step 2 Nagelkerke  $R^2 = .20$

Note. \*  $p < .05$ , \*\*  $p < .01$

Table 7

Hierarchical Logistic Regression Analysis Predicting Children's Assessment of Their Performance on the Seriation Test From Their Seriation Test Scores

Predictor	B	SE	Wald
Step 1			
Age	0.48	0.29	2.73
Gender	-0.05	0.43	0.02
Center	0.00	0.47	0.01
Seriation	0.06	0.05	1.79
Step 2			
Age	0.50	0.33	2.38
Gender	0.07	0.46	0.05
Center	-0.26	0.51	0.31
Seriation	0.22	0.21	1.09
Seriation *Age	-0.11	0.08	2.05
Seriation * Gender	0.14	0.10	0.12
Seriation * Center	-0.64	0.13	2.26

Step 1 Nagelkerke  $R^2 = .06$

Step 2 Nagelkerke  $R^2 = .15$

Note. \*  $p < .05$ , \*\*  $p < .01$

Table 8

Hierarchical Logistic Regression Analysis Predicting Children's Assessment of Their Performance on the Oddity Test From Their Oddity Test Scores

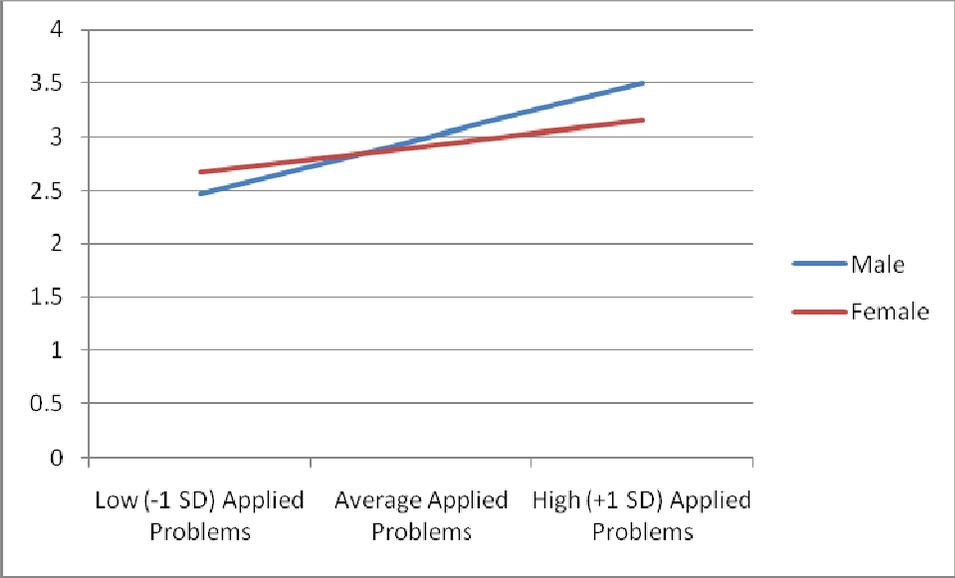
Predictor	B	SE	Wald
Step 1			
Age	0.41	0.43	0.95
Gender	-0.82	0.50	2.67
Center	0.51	0.51	1.00
Oddity	0.13	0.06	5.24*
Step 2			
Age	0.52	0.44	1.43
Gender	-1.02	0.52	3.52
Center	0.78	0.62	1.64
Oddity	-0.02	0.20	0.02
Oddity * *Age	-0.02	0.07	0.08
Oddity * Gender	-0.04	0.09	0.19
Oddity * Center	0.16	0.11	2.14

Step 1 Nagelkerke  $R^2 = .27$

Step 2 Nagelkerke  $R^2 = .29$

Note. \*  $p < .05$ , \*\*  $p < .01$

Figure 1



Gender Differences In the Relationship Between Children's The WJIII-Applied Problems test Scores and Their Perceived General Cognitive Competence Ratings

## REFERENCES

## REFERENCES

- Amsterdam, B. (1972). Mirror self-image reactions before age two. *Developmental Psychobiology*, 5, 297-305. doi:10.1002/dev.420050403
- Bahrnick, L.E., Moss, L., & Fadil, C. (1996). Development of visual self-recognition in infancy. *Ecological Psychology*, 8(3), 189-208. doi:10.1207/s15326969eco08031
- Barnett, W.S., Espstein, D.J., Friedman, A.H., Sansanelli, R., & Hustedt, J.T. (2009). The state of preschool 2009. Retrieved from <http://nieer.org/yearbook/>
- Brooks-Gunn, J., & Lewis, M. (1984). The development of early visual self-recognition. *Developmental Review*, 4, 215-239. doi:10.1016/S0273-2297(84)80006-4
- Brown, G.L., Mangelsdorg, S.C., Agathen, J.M., Ho, M.H. (2008). Young children's psychological selves: Convergence with maternal reports of child personality. *Social Development*, 17(1), 161-182.
- Bullock, M., & Lutkenhaus, P. (1990). Who am I? Self understanding in toddlers. *Merrill-Palmer Quarterly*, 36(2), 217-238.
- Butterworth, G. (1992). Origins of self-perception in infancy. *Psychological Inquiry*, 3, 103-111. doi:10.1207/s15327965pli0302\_1
- Ciancio, D., Rojas, A.C., McMahon, K., Pasnak, R. (2001). Teaching oddity and insertion to Head Start children. An economical cognitive intervention. *Journal of Applied Developmental Psychology*, 22(6), 603-621. doi:10.1016/s0193-3973(01)00096-x
- Clements, D.H., Swaminathan, S., Hannibal, M.A., & Sarama, J. (1999). Young children's concepts of shape. *Journal for Research in Mathematics Education*, 30(2), 192-212. doi:10.2307/749610
- Colwell, M.J., & Lindsey, E.W. (2003). Teacher-child interactions and preschool children's perceptions of self and peers. *Early Child Development and Care*, 173, 249-258. doi:10.1080/0300443030303096

- Cultice, J.C., Somerville, S.C., & Wellman, H.M. (1983). Preschoolers' memory monitoring: Feeling-of-knowing judgments. *Child Development*, 54(6), 1480-1486. doi:10.2307/1129810
- Demetriou, A., & Kazi, S. (2006). Self-awareness in g (with processing efficiency and reasoning). *Science Direct*, 34, 297-317. doi:10.1016/j.intell.2005.10.002
- Durkin, K., Shire, B., Riem, R., Crowther, R.D., & Rutter, D.R. (1986). The social and linguistic context of early number word use. *British Journal of Developmental Psychology*, 4, 269-288.
- Eccles, J., Wigfield, A., Harold, R.D., & Blumenfeld, P. (1993). Age and gender differences in children's self-and task perceptions during elementary school. *Child Development*, 64(3), 830-847. doi:10.2307/1131221
- Epstein, S. (1973). The self-concept revisited: Or a theory of a theory. *American Psychologist*, 28(5), 404-416. doi:10.1037/h0034679
- Esbensen, B.M., Taylor, M., & Stoess, C. (1997). Children's behavioral understanding of knowledge acquisition. *Cognitive Development*, 12(1), 53-84. doi:10.1016/s0885-2014(97)90030-7
- Flavell, J.H., Green, F.L., & Flavell, E.R. (1995). The development of children's knowledge about attentional focus. *Developmental Psychology*, 31, 70-712. doi:10.1037/0012-1649.31.4.706
- Fusion, K.C. (1991). Children's early counting: Saying the number word sequence, counting, objects, and understanding cardinality. In K. Durkin & B. Shire (Eds.), *Language in mathematical education: Research and practice* (pp. 27-39). Milton Keynes: Open University Press.
- Geangu, E. (2008). Notes on self awareness development in early infancy. *Cognition, Brain, Behavior*, 12(1), 103-113.
- Geary, D.C. (1995). *The child's understanding of number*. Cambridge, MA: Harvard University Press.
- Geary, D.C. (1996). Biology, culture, and cross-national differences in mathematical ability. In R.J. Sternberh & T. Ben-Zeev (Eds.), *The nature of mathematical thinking* (pp.145-171). Mahwah, NJ: Lawrence Erlbaum Associates.

- Geary, D.C. (2006). Development of mathematical understanding. In Kuhn, D., Siegler, R.S., Damon, W., & Lerner, R.M. (Eds.), *Cognition, perception, and language* (6<sup>th</sup> ed.) (pp.777- 810). Hoboken, NJ: John Wiley & Sons Inc.
- Gelman, R. (2000). The epigenesis of mathematical thinking. *Journal of Applied Developmental Psychology*, 21(1), 27-37.
- Gelman, R. (2000). Domain specificity and variability in cognitive development. *Child Development*, 71(4), 854-856. doi:10.1111/1467-8624.00193
- Gelman, R., Massey, C.M., & McManus, M. (1991). Characterizing supporting environments for cognitive development: Lessons from children in a museum. In L.B. Resnick, J.K. Levine, & S.D. Teasley (Eds.), *Perspectives on socially shared cognition* (pp.226-256). Washington D.C.: American Psychological Association.
- Ginsburg, H. P., Cannon, J., Eisenband, J., & Pappas, S. (2006). Mathematical thinking and learning. In K. McCartney & D. Phillips (Eds.), *Blackwell handbook on early childhood development* (pp. 208–230). Malden, MA: Basil Blackwell.
- Ginsburg, H.P., Seo, K.H. (1999). The mathematics in children's thinking. *Mathematical Thinking and Learning*, 1(2), 113-129. doi: 10.1207/s15327833mtl0102\_2
- Gopnik, A., & Graf, P. (1988). Knowing how you know: Young children's ability to identify and remember the sources of their beliefs. *Child Development*, 59(5), 1366-1371. doi:10.2307/1130499
- Greene, M.R., Pasnak, R., & Romero, S.L. (2009). A time lag analysis of temporal relations between motivation, academic achievement, and two cognitive abilities. *Early Education and Development*, 20(5), 799-825. doi:10.1080/10409280802581177
- Harter, S. (1983). To smile or not to smile: Issues in the examination of cross-cultural differences and similarities. *Monographs of the Society for Research in Child Development*, 48(5), 80-87.
- Harter, S. (1999). Symbolic interactionism revisited: Potential liabilities for the self constructed in the crucible of interpersonal relationships. *Merrill-Palmer Quarterly: Journal of Developmental Psychology*, 45(4), 677-703.
- Harter, S., & Pike, R. (1984). The pictorial scale of perceived competence and social acceptance for young children. *Child Development* 55(6), 1969-1982. doi:10.2307/1129772

- Hobson, P.R. (1990). On acquiring knowledge about people and the capacity to pretend: Response to Leslie (1987). *Psychological Review*, 97(1), 114-121. doi:10.1037/0033-295x.97.1.114
- Irwin, K., & Burgham, D. (1992). Big numbers and small children. *The New Zealand Mathematics Magazine*, 29(1), 9-19.
- Jordan, N.C., Levine, S.C., & Huttenlocher, J. (1995). Calculation abilities in young children with different patterns of cognitive functioning. *Journal of Learning Disabilities*, 28(1), 53-64. doi:10.1177/002221949502800109
- Keller, A., Ford, L. H., & Meacham, J.A. (1978). Dimensions of self-concept in preschool children. *Developmental Psychology*, 14, 483-489. doi:10.1037/0012-1649.14.5.483
- Kidd, J.K., Pasnak, R., Gadzichowski, M., Ferral-Like, M., & Gallington, D. (2008). Enhancing early numeracy by promoting the abstract thought involved in the oddity principle, seriation and conservation. *Journal of Advances Academics*, 19(2), 164-200.
- Lewis, M., & Brooks-Gunn, J. (1979). Social cognition and the acquisition of self. New York: Plenum Press.
- Lewis, M., & Ramsay, D. (2004). Development of self-recognition, personal pronoun use, and pretend play during the 2<sup>nd</sup> year. *Child Development*, 75(6), 1821-1831. doi:10.1111/j.1467-8624.2004.00819.x
- Liben, L.S., & Downs, R.M. (2001). Geography for young children: Maps as tools for learning environments. In S.L. Golbeck (Eds.), *Psychological perspectives on early childhood education: Reframing dilemmas in research and practice, The Rutgers invitational symposium on education series* (pp.220-252). Mahwah, NJ: Lawrence Erlbaum Associates Publishers.
- Lillard, A.S., Zeljo, A., Curenton, S., & Kaugers, A. (2000). Children's understanding of the animacy constraint on pretense. *Merrill-Palmer Quarterly*, 46, 21-44.
- Madison Early Learning Initiative, & Madison Metropolitan School District (2003). Early learning standards. Retrieved from <http://oldweb.madison.k12.wi.us>.
- Marsh, H.W., Ellis, L.A., & Craven, R.G. (2002). How do preschool children feel about themselves? Unraveling measurement and multidimensional self-concept structure. *Developmental Psychology*, 38(3), 376-393. doi:10.1037/0012-1649.38.3.376

- Marsh, H.W. (1989). Age and sex effects in multiple dimensions of self-concept: Preadolescence to early adulthood. *Journal of Educational Psychology*, 81(3), 417-430. doi:10.1037/0022-0663.81.3.417
- McGrew, K. S., & Woodcock, R. W. (2001). *Woodcock–Johnson III technical manual*. Itasca, IL: Riverside Publishing.
- Mead, G.H. (1934). *Mind, self, and society from the standpoint of a social behaviorist*. Chicago: University Press.
- Measelle, J.R., Ablow, J.C., Cowan, P.A., & Cowan, C.P. (1998). Assessing young children's views of their academic, social, and emotional lives: An evaluation of the self-perception scales of the Berkeley Puppet Interview. *Child Development*, 69(6), 1556-1576. doi:10.2307/1132132
- Mitchell, R. (1993). Mental models of mirror self-recognition: Two theories. *New Ideas in Psychology*, 11, 295-325. doi:10.1016/0732-118X(93)90002-U
- Montgomery, D.E. (1992). Young children's theory of knowing: The development of a fold epistemology. *Developmental Review*, 12(4), 410-430. doi:10.1016/0273-2297(92)90016-U
- NAEYC (2002). Early childhood mathematics: Promoting good beginnings. Retrieved from <http://www.naeyc.org/files/naeyc/file/positions/psmath.pdf>
- Newcombe, N., & Huttenlocher, J. (1992). Children's early ability to solve perspective taking problems. *Developmental Psychology*, 28, 654-664. doi:10.1037/0012-1649.28.4.635
- Newcome, N., & Learmonth, A. (1999). Change and continuity in early spatial development: Claiming the "radical middle". *Infant Behavior & Development*, 22(4), 457-474. doi:10.1016/S0163-6383(00)00019-9
- Pasnak, R., Campbell, J., Perry, P., & McCormick, P. (1989). Piacceleration instruction for children who are mentally retarded. *Education & Training in Mental Retardation*, 24(4), 352-362.
- Pasnak, R., Kidd, J.K., Gadzichowski, M.K., Gallington, D.A. & Saracina, R.P. (2008). Can emphasizing cognitive development improve academic achievement? *Educational Research*, 50(3), 261-276. doi:10.1080/00131880802309408
- Pasnak, R., Kidd, J.K., Gadzichowski, M.K., Gallington, D.A., Saracina, R.P., & Addison, K.T. (2009). Promoting early abstraction to promote early literacy and numeracy.

*Journal of Applied Developmental Psychology*, 30(3), 239-240.  
doi:10.1016/j.appdev.2008.12.006

- Pasnak, R., Maccubbin, E., & Ferral-Like, M. (2007) Using developmental principles to assist at-risk preschoolers in developing numeracy and phonemic awareness. *Perceptual and Motor Skills*, 105, 163-176. doi:10.2466/PMS.105.5.163-176
- Pasnak, R., Whitten, J. C., Perry, P., Waiss, S., Madden, S. E., & Watson-White, S. A. (1995). Achievement gains after instruction on classification and seriation. *Education and Training in Mental Retardation and Developmental Disabilities*, 30, 109-117.
- Piaget, J. (1963). *The origins of intelligence in children*. New York: W.W. Norton & Co.
- Priel, B., & de Schonen, S. (1986). Self-recognition: A study of a population without mirrors. *Journals of Experimental Child Psychology*, 41(2), 237-250.  
doi:10.1016/0022-0965(86)90038-X
- Rawson, B. (1993). Searching for pattern. *Education*, 22(1), 3-13.
- Rochat, P. (2001). Origins of self-concept. In G. Bremner, & A. Fogel (Eds.), *Blackwell handbook of infant development, Handbooks of developmental psychology* (pp.191-212). Malden: Blackwell Publishing.
- Rochat, P. (2003). Five levels of self-awareness as they unfold early in life. *Consciousness and Cognition: An International Journal*, 12(4), 717-731.  
doi:10.1016/S1053-8100(03)00081-3
- Roberts, T. (1991). Gender and the influence of evaluation on self-assessments in achievement settings. *Psychological Bulletin*, 109(2), 297-308. doi:10.1037/0033-2909.109.2.297
- Schafer, J.L. (1999). NORM: Multiple imputation of incomplete multivariate data under a normal model, version 2. Software for Windows. Retrieved from <http://www.stat.psu.edu/~jls/misoftwa.html>
- Siegler, R.S., & Robinson, M. (1982). The development of numerical understandings. In H.W. Reese & L.P. Lipsett (Eds.), *Advances in child development and behavior: Vol. 16* (pp. 242-312). New York: Academic Press
- Southard, M., & Pasnak, R. (1997). Effects of maturation on preoperational seriation. *Child Study Journal*, 27(4), 255-268.

- Stipek, D.J., Gralinski, J.H., & Kopp, C.B. (1990). Self-concept development in toddler years. *Developmental Psychology*, 26(6), 972-977. doi:10.1037/0012-1649.26.6.972
- van Hiele, P.M. (1986) *Structure and Insight: A Theory of Mathematics Education*. Orlando, Florida: Academic Press.
- Walkerdine, V. (1988). *The mastery of reason: Cognitive development and the production of rationality*. Kentucky: Taylor & Frances/Routledge.
- Welch-Ross, M.K., Fasig, L.G., Farrar, M.J. (1999). Predictors of preschoolers' self-knowledge: Reference to emotion and mental states in mother-child conversation about past events. *Child Development*, 14(3), 401-422. doi:10.1016/S0885-2014(99)00012-X
- Wellman, H.M. (1990). *The child's theory of mind*. Cambridge, MA: MIT Press.
- Zaslavsky, C. (1973). *Africa counts: Number and pattern in African culture*. Boston: Prindle, Weber & Schmidt.

## CURRICULUM VITAE

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