GENDER, VIDEO GAME PLAYING, AND KINDERGARTEN CHILDREN'S MENTAL ROTATION ABILITIES

A Dissertation Presented to the
Faculty of the College of Education
University of Houston

In Partial Fulfillment
Of the Requirements for the Degree

Doctor of Education

by

Preeti P. Jain

May, 2012

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Abstract

Strength in spatial abilities, specifically mental rotation abilities, has been consistently associated with increased mathematical achievement (Casey, Nuttall, & Pezaris, 1997). This particular skill, mental rotation, has also been consistently stronger in males than females (Linn & Peterson, 1985). This ability may develop at a very young age and early childhood play experiences may influence mental rotation abilities (Serbin & Connor, 1979; Voyer, Nolan, & Voyer, 2000). Video game playing is becoming increasingly pervasive in young children's lives. While video game playing appears to improve mental rotation skills in adults (Cherney, 2008), there is little information on young children's informal video game playing habits and no information on the relationship between this type of play and mental rotation abilities among kindergarten children. To address this issue, this study evaluated kindergarten children's mental rotation abilities and their video game playing habits. Whether these abilities and habits differed for boys and girls was also explored.

The study used archival data collected as part of an experimental study conducted by Andrews (2009) to examine the development of spatial skills and reasoning in kindergarten students. The participants were 96 kindergarten students (51 girls and 45 boys) randomly selected from two public elementary schools in a large urban school district in southeast Texas.

Parents of the participants completed a questionnaire designed to measure children's home play activities (Andrews, 2009). The questionnaire included items related to their children's home video game playing habits. The participants' mental rotation abilities were measured using the Mental Rotation Task, a developmentally appropriate measure designed by Casey and colleagues (2008).

These two scales, the questionnaire responses and the scores on the Mental Rotation Task, were the measures used as the dependent variables for this study. Chi-square tests for independence, multivariate analysis of variance (MANOVA), and univariate analyses were used to analyze within-group and between-group variances on these dependent variables and assess the strength of association between the variables.

The results of the study indicated that boys are significantly more likely than girls to play video games and spend significantly more time doing so. There was no significant effect for gender on the mental rotation task scores. Among kindergarten children, the amount of time spent playing video games per week did not significantly affect mental rotation abilities. The study also provided data on an area not yet explored in early childhood research: the interaction effects of gender, amount of kindergarten children's home video game playing, and its association with mental rotation skills. The result of the analysis indicated that for this age group there was no significant interaction effect for gender and video game playing on mental rotation task performance.

This study provides empirical data and adds to the limited body of information on young children's mental rotation abilities and involvement with video game playing.

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Chapter I

Introduction

The importance of young children's mathematical learning has, since the turn of the century, received a great deal of attention. This may be due in part to recent research that has identified early math achievement as predictive for future school success. Early childhood mathematics ability was identified as a better predictor of later success in school than early reading ability (Duncan et al., 2007; Ginsburg, Lee, & Boyd, 2008). It may also be due in part to recent reports of our nation's poor performance relative to other nations in the area of mathematics (Zhao, 2009). These findings have underscored the importance for educators and researchers to develop a stronger understanding of children's mathematical learning and the influences on that learning, in order to ensure our children's success in school and to advance on a global scale.

Within the realm of early childhood mathematics research, a great deal of focus has been placed on numeracy, computations, or number sense skills. However, "spatial thinking is an essential human ability" and a growing body of research has indicated that it contributes to mathematical ability (Ansari et al.,2003; Clements & Sarama, 2011, p. 134). Strong spatial abilities have been associated with increased mathematical achievement, higher performance on standardized achievement measures, and greater analytical abilities (Casey, Nuttall, & Pezaris, 1997; McGee, 1979; Sorby, 2009; Wai, Lubinski, & Benbow, 2009).

Spatial abilities however is not a single cognitive function, and is instead a highly complex and multi component system. It is these abilities that allow us to comprehend the arrangements of objects within a visual space, understand changing orientations, mentally manipulate the positioning of stimuli, and also to navigate ourselves within the physical realm (McGee, 1979). In their meta-analysis of research in spatial abilities, researchers Linn and Petersen classified spatial abilities into three areas: spatial perception, mental rotation and spatial visualization (Linn & Petersen, 1985). Of these 3 areas, mental rotation in particular has received considerable attention due to its strong association with gains in mathematics achievement and the consistent male advantage presented for this skill (Casey, Nuttall, Pezaris, & Benbow, 1995; Linn & Petersen, 1985). Mental rotation (MR) specifically refers to the process of mentally being able to rotate or transform an image on a particular axis, a given number of degrees.

Researchers of children's MR abilities have focused on understanding the normative developmental sequences and individual differences in MR performance (De Lisi & Wolford, 2002). In the first approach, researchers have focused on the age of emergence and children's progress in MR abilities. The second approach has been used extensively to study gender differences in MR performance. Numerous research studies have established that males outperform females on measures of mental rotation performance (Casey, Andrews, Shindler, Kersh, Samper, & Copley, 2008; Geary, 2007; Hoyek, Collet, Fargier & Guillot, 2012, Levine & Stern, 2002; Peters, 2005). Researchers have put forth a number of explanations for the gender difference in this spatial ability, ranging from biological to environmental and some in between that suggest a more interactionist framework. This interactionist framework suggests that there is a role of both biology and nurturing involved in the development of spatial abilities (Casey, 1996). In the category of nurturing it appears that environmental inputs may influence the development of spatial abilities (Moe, 2009). In particular, the role of experience with spatial activities is becoming increasingly important in the understanding of the early development of spatial skills (Baenninger & Newcombe, 1995; Newcombe, 2007).

In young children, spatial experiences are rooted in play activities. Research on children's choice of free play activities has shown that young children are deeply interested in activities that have connections to key mathematical ideas and that children's informal experiences may be highly influential in spatial abilities (Clements & Sarama, 2011; Copley, 2010; De Lisi & Wolford, 2002; Greenes, Ginsburg & Balfanz, 2004). In recent years, one of the experiences often associated with gains in spatial abilities is videogame playing. Considering the ubiquitous nature of technology and the increasing usage of videogame playing by young children, it is important for researchers to understand some of the potential impacts of this game playing and its impact on cognitive skills such as spatial abilities (Rideout, Vandewater, & Wartella, 2003). It is important here to note however, that within the research there is still a somewhat unspecified definition for video game playing. Video games are also referred to as *computer games* or *electronic games*. However, these terms are not synonymous as a *computer game* can be taken to refer only to games that can be played on a personal computer, an *electronic game* might also refer to toys, while *video games* may be used to refer to console games such as those on the X-Box 360 or Playstation 3 (Tavinor, 2008). Others have referred to video games in terms of *action game* versus *non-action games*, the emphasis being on the type of interaction required of the player (Feng, Spence, & Pratt, 2007). Researchers have also proposed a somewhat disjunctive definition, that a video game is one that is presented in a "digital visual medium, is intended primarily as an object of entertainment, and is intended to provide such entertainment through the employment of one or both of the following models of engagement : rule-bound game play or interactive fiction" (Tavinor, 2008, para 34) . Still others have referred to video games as *mini-games* versus *complex games.* Mini games referring to those that take two or less hours to complete, provide a single challenge, other than repetitive problems, are usually played alone, have players play as themselves, are mastered relatively quickly, and rarely require players to make important decisions. Complex games on the other hand, can take eight to over a hundred hours to complete, require players to learn a wide variety of new and difficult skills that can be mastered through advancing to harder and harder levels, often require players to assume alternate identities, and present players with ethical dilemmas or difficult decisions (Prensky, 2008) . Therefore, though the term video game playing is referred to often in research, its construct may vary from study to study. In most research studies involving video game play, the names of the specific games are mentioned and, for now, until a clear consensus on the use of the term is established, the specific games provide insight into the author's intent for the term *video game.* For this study, the specific construct for video game playing is provided in the definition of terms.

Need for Study

As stated earlier, mathematics achievement in the United States has consistently underperformed when compared with other nations on measures of math ability (Zhao, 2009). There is a growing need to understand how this condition can be improved and what the potential influences on mathematics achievements are.

Research has indicated that strength in mental rotation abilities may contribute to higher mathematics achievement (Casey et al, 1997; Klein, Adi-Japha, & Hakak-Benizri, 2010). Researchers have also established the importance of the younger years in the development of math abilities (Clements & Sarama, 2011). However, there remains limited empirical data on young children's mental rotation abilities. The majority of studies have been conducted with older children or adults.

In addition, research has indicated that experience with activities that are spatial in nature may contribute significantly to strength in mental rotation abilities (Baenninger & Newcombe, 1995; Terlecki, Newcombe, & Little, 2008). However, again, there remains very little empirical data on young children's early spatial experiences, particularly those that children engage in informally.

With the advent of technology, video gaming, which is considered a spatially oriented activity, has become an increasingly popular play activity with young children (Rideout et al, 2003). Empirical research in this area is almost nonexistent; we have very little data on the amount of video gaming young children engage in and if there are differences between genders in the amount of play.

Finally there are no studies that have examined the amount of informal video game playing of young children (ages 4-7) and its influence on mental rotation skills. There is a need for such information as there are an increasing number of children engaging in video game play at a young age, and it is important to understand whether or not that game playing has any influence on their spatial abilities.

Statement of the Problem

In addition to the overall problem of underachievement in mathematics of children in the United States discussed earlier, there is also the problem of gender differences in mathematics achievement and the underrepresentation of women in math and science oriented professions. This lack of achievement and underrepresentation of women in these particular areas of occupation may be related to findings that males outperform females in spatial abilities and most consistently in mental rotation tasks (Linn & Petersen, 1985; Voyer, Voyer, & Bryden, 1995). Recent research has suggested that one of the reasons for this difference may be due to experience with activities that are spatial in nature (Baenninger & Newcombe, 1995) . It has been suggested that males engage in more spatially oriented activities which in turn results in stronger spatial abilities potentially resulting in increased mathematics achievement and in later years, choice of courses and occupations that involve higher mathematics abilities for success. These experiences are often initiated in the early years and the difference in spatial abilities may be evident from a very young age. The problem of gender differences in mathematics achievement and the underrepresentation of women in math and science therefore, may have its roots in the early years of children's spatial abilities development.

Purposes of the study

The purpose of this study was to provide additional empirical data on young children's mental rotation abilities. In addition, the study examined kindergarteners' involvement with spatial play, specifically video game playing and whether or not gender differences were apparent even at the kindergarten level in these areas. Finally, the study examined the relationship between kindergarteners' gender, video game playing, and mental rotation abilities.

Research Questions

The research questions that guided this investigation were:

Research Question 1: Do boys and girls differ significantly in whether they play video games?

Research Question 2: How much time do kindergarten children spend playing video games, and are there gender differences in the amount of time spent playing?

Research Question 3: What is the relationship between kindergarten children's gender, amount of video game playing, and performance on mental rotation tasks?

Research Question 4: Which gaming devices are used by kindergarten children?

Significance of the Study

There remains a dearth of research related to young children and their mental rotation abilities. There are also a limited number of studies that have examined young children's informal play behaviors and the relationship of that play on the development of spatial abilities. There are no studies that have specifically examined young children's informal video game playing and its relationship to mental rotation abilities. This study will provide a basis for further experiments that may link early experiences with spatial abilities and inform the early childhood community of the possible influences these experiences can have in the development of mathematical knowledge.

Definition of Terms

Spatial Abilities - the abilities required for representing, transforming, generating, and recalling non-linguistic, symbolic representation (Linn & Petersen, 1985)

Mental Rotation - the process of mentally being able to rotate or transform an image on a particular axis a given number of degrees (Casey et al., 1995).

Video Games – an electronic game played by manipulating images on a video display utilizing a specific gaming console, requiring the use and skill of mental rotation of either the objects presented on the display or of the physical action required from the player to provide input.

Chapter II

Review of Literature

Introduction

The purpose of this study was to provide information on kindergarten children's mental rotation abilities and video gaming habits and to investigate possible relationships between videogame playing experiences and performance on mental rotations tasks. The research questions that guidee this investigation were 1) Do boys and girls differ significantly in whether they play video games? 2) How much time do kindergarten children spend playing video games, and are there gender differences in the amount of time spent playing? 3) What is the relationship between kindergarten children's gender, amount of video game playing, and performance on mental rotation tasks? 4) Which gaming devices are used by kindergarten children? This chapter will present the research in the areas of inquiry that are pertinent to this study and that provide the foundation for this study. This section begins with a general overview of spatial abilities, followed by specific information on mental rotation abilities, the area of focus for this study. Within the mental rotation research section the topic of gender differences, the age of emergence of gender differences, and potential causes of these differences will be discussed. This will be followed by a review of studies related to video game playing and its association with spatial abilities. The chapter will conclude with a summary.

Related Research

Spatial abilities.

Spatial abilities are considered an important component of human intellectual competence. It is these abilities that allow us, for example, to mentally manipulate visual stimuli, comprehend arrangements of elements within a visual stimulus pattern, understand changing orientations, and navigate and move within the world in relation to our body orientation (McGee, 1979; Terlecki et al., 2008). It is vital for everyday activities such as playing sports or parking your car. It is also required for technical tasks which are becoming increasingly pervasive in modern society, such as interpreting graphs, architectural drawings or X-rays, playing electronic games, and using navigational systems (Levine, Huttenlocher, Taylor, & Langrock, 1999). In academics, courses such as biology, geology, physics, chemistry and geography, require the ability to understand spatial relationships for success (Sorby, 2009). For young children spatial sense comes into play in art, science, social studies, movement and music, and reading (Copley, 2000).

Researchers are particularly interested in this area of cognition as studies have shown a strong relationship between spatial abilities and scientific and mathematical reasoning (Ansari et al., 2003; Ehrlich, Levine, & Goldin-Meadow, 2006; Linn & Petersen, 1985; McGee, 1979; Wai et al.,2009). As stated in the introduction chapter, children in the United States have consistently underperformed in the areas of mathematical achievement. The 1995 Trends in Mathematics and Science Study (TIMSS) showed that U.S. students outperformed students in only 2 of 21 countries in mathematics. On advanced mathematics tests, out of 15 countries participating, the U.S. was outscored by 11 countries (Zhao, 2009). In order to improve this situation, researchers and educators are focusing on spatial abilities as a logical area to investigate as studies have found positive correlations between spatial abilities and mathematics achievement (Casey, et al., 1995; Clements & Battista, 1992; Fennema, 1974).

In addtion to mathematics achievment scores, strength in spatial abilites correllates with success in a wide range of professional fields such as engineering, medicine, architecture, computer science, and airforce (McGee, 1979; Terlecki et al., 2008). Interestingly the majority of these careers are dominated by males, and enrollment in mathematical and science related academic courses after adolescents is much higher for males than females. These findings are important as the US faces shortages of scientists, engineers and mathematically-trained workers, reports Dunham (as cited in Terlecki et al., 2008). The underepresenstation of women in these fields is often associatied with lower levels of spatial skills (Ehrlich et al., 2006). The seminal work by Maccoby and Jacklin (1974), *The Pschology of Sex Differences*, was a massive literature review that concluded that males perform better than females on tests of mathematical and spatial abilities. Researchers therefore, in order to understand some of the differences in mathematical achievement and orientations toward more mathematically inclined activities and professions, have focused a great deal of research in the area of spatial abiliites.

One of the problems that is inherent to spatial abilities research however, is that the definition of what the term means is unclear (McArthur & Wellner, 1996) . Spatial abilities is referred to in the literature with many diffent names: visuospatial, spatial reasoning, spatial aptitidue, spatial literacy, spatial perception, spatial visualization and spatial sense. In addition, factor analytic studies have shown that spatial ability is not a unitary construct (Jancke & Jordan, 2007). For example, distinct activites such as the perception of horizonatality, mental rotation of objects, and location of simple figures within a complex figure are all referred to as measures of spatial ability (Linn & Petersen, 1985). Individuals may have an assortment of spatial skills rather than a single ability (Jancke & Jordan, 2007) . Researchers, Linn and Petersen, found that in order to characterize the nature and origin of observed sex differences there needs to be a differentiation of types of spatial abilities and a comprehensive meta-analysis including studies of spatial abilities published from 1974 to 1982. Prior to their meta-analysis, there was no consensus on the categorization of measures of spatial ability, and the only view that achieved agreement was that spatial ability involved multiple processes (Linn & Petersen, 1985). In their meta-analysis, Linn and Petersen (1985) partitioned the studies of spatial ability into homogeneous groups using psychometric and cognitive perspectives. Informed from those perspectives they identified three categories including (1) spatial perception, (2) mental rotation, and (3) spatial visualization. Spatial perception tests were those that required participants to determine spatial relationships with respect to the orientation of their own bodies, in spite of distracting information. Mental rotation tasks involved the ability to rotate a two or three dimensional figure rapidly and accurately. Finally, spatial visualization tasks were those that involved complicated, multistep manipulations of spatially presented information. They may involve the same processes required for spatial perception and mental rotations but are distinguished by the possibility of multiple solution strategies (Linn & Petersen, 1985). Subsequent studies have substantiated these distinctions and have referred to these three categories in spatial ability studies (Jancke & Jordan, 2007).

Of the three categories distinguished by Linn and Petersen, mental rotation has been the skill that is most distinctly associated with a strong male advantage (Linn & Petersen, 1985; Voyer et al., 1995). This consistent finding is present in studies of young children (Casey et al., 2008), adolescents (Voyer et al., 1995), and adults (Levine & Stern, 2002). Similar consistent findings of gender differences are not found in assessments of spatial visualization and spatial perception. The focus of this proposed study is therefore on mental rotation and the potential influences on this development. The following sections will explain why this particular ability is a critical area of cognitive development.

Mental rotation.

Mental rotation abilities are considered an important component within the realm of spatial abilities. The generation and manipulation of mental visual images is an important psychological function which is required for a broad range of cognitive tasks (Jancke & Jordan, 2007; Eisenegger et al., 2007). It is this ability that allows individuals to imagine or visualize how objects will appear when they are rotated in two or three dimensional space (Terlecki, Newcombe, & Little, 2008). It is an important ability suggested to predict success in topics such as geometry, mathematics, chemistry, and physics. It also significantly predicts how well people can perform on complex navigational tasks and for everyday activities such as orientation in unfamiliar places and finding routes on maps (Moe, 2009).

Shepard and Metzler (1971) were the first to explore this function systematically. They presented participants pairs of solid geometrical objects that were either identical or mirror images of one another. They timed participants as they judged whether the pairs were the same or different. It was found that the reaction time to make these judgments increased linearly as a function of the angle between the forms. This finding suggested that participants mentally rotated one form into congruence with the other in order to make their judgment (Mast & Jancke, 2007).

In recent years mental rotation abilities have received increased attention as a result of the correlation between mental rotation abilities and mathematics achievement. In 1995, Casey, Nutall , Pezaris and Benbow conducted an experiment with 760 participants. The participants were talented preadolescents (7th – 9th graders,) college students, and high and low ability college bound youths. Mental rotation abilities were assessed through the use of the Vandenberg and Kuse (1978) Mental Rotation Test (MRT). This assessment uses figures originally used by Shepherd and Metzler (1971) but in a paper and pencil format. To assess mathematics achievement the researchers used the Mathematics Scholastic Aptitude Test (SAT-M) scores developed by the Educational Testing Services. The researchers found a consistent correlation between mental rotation and SAT-M scores for females (with all correlations clustering between .35 and .38, a medium effect size). Their study also found that for the female students across all the samples, mental rotation skills predicted math aptitude scores even when verbal ability was statistically covaried out. Similarly for males in the both the high and low ability college bound subgroups, mental rotation ability significantly contributed to the prediction of math aptitude beyond the effects of verbal ability. The researchers also found that when mental rotation ability was statistically adjusted for, gender differences in math aptitude were eliminated for both the high-ability college bound students and the college students (Casey et al., 1995).

In a later study, involving only higher ability college-bound participants (age range = 13 years 3 months to 14 years 9 months) these same researchers found additional evidence of mental rotation skills mediating gender differences in math aptitude. The researchers assessed the participants' mental rotation abilities, math self-confidence and math anxiety. Data were collected at the end of the participants' sophomore year, and was collected from two cohorts over 2 consecutive years. At the end of the participants' senior year, SAT scores were obtained from student files. Using path analytic techniques the researchers made direct quantitative comparisons between the variables as mediators of gender differences. It was found that mental rotation skill was almost twice as influential a mediator of gender differences in SAT-M as was the measure of math self-confidence. (Internal feelings of anxiety did not serve as a mediator.) The findings therefore made a strong case for the role of mental rotation as a critical mediator of gender differences on the SAT-M. The results suggested that spatial strategies related to mental rotation skills may be a contributing factor to the different strategies used by boys and girls on the SAT-M. The researchers stressed the importance of both teachers and parents to facilitate spatial interests and to deepen girls' spatial experiences both in general and in the context of mathematics. The researchers stressed the importance of identifying girls with an interest in spatial activities at a very early age and to carefully foster this interest (Casey, Nuttall, & Pezaris, 1997).

Our knowledge of young children's mental rotation ability and what influences its development however, is limited. Within the studies of spatial abilities, there are very few studies that have been conducted with young children assessing specifically their mental rotation abilities. The reason for this dearth of research may be due to two factors. Firstly, the lack of developmentally appropriate measures to assess this ability limited the amount of research for younger children. Secondly, researchers felt that this sophisticated type of cognitive task would not be possible for young children based on developmental theories and therefore did not consider assessing for mental rotation at a very young age. Recent research, however using developmentally appropriate measures has been conducted with young children and has also consistently shown gender differences for this ability. The next section discusses the research related to gender differences followed by a discussion on the age of emergence of mental rotation abilities.

Gender differences in MR abilities.

Existing research generally suggests that there is a strong male advantage on mental rotation performance tasks. For example, two well-known meta-analyses have revealed that certain tests of mental rotation have consistently shown males significantly outperforming females. Most studies of mental rotation in their analysis involved either the PMA Space or the Vandenberg and Kuse MRT assessments. They found with PMA space assessments the youngest respondents were 10 year olds, and on the Vandenberg and Kuse, the youngest respondents were reported to be 13 years old. From these young ages through adults, the researchers found large sized effects for sex as measured by the Vandenberg test, and moderate sized effects as measured by PMA space. They concluded that males outperform females on mental rotation amongst all measurable age groups (Linn & Petersen, 1985).

These findings were supported by the meta- analysis conducted by Voyer , Voyer, and Bryden (1995). Their analysis spanned nearly 50 years of research and included 286 studies, the majority of which were not included in Linn and Petersen’s analysis which only considered studies between 1974 and 1982. The findings were similar and provided further compelling evidence for the existence of sex difference in favor of males on tests assessing mental rotation. In addition to assessing gender differences by task performance these researchers also partitioned the effect sizes of the studies they analyzed by the age of the participants. They classified the participants into three age groups (under 13years, between 13-18 years, and above 18 years). They did not find evidence of significant gender differences in the age group of under 13 years.

It is important to note here that both of these meta-analysis research studies have emphasized the importance of the stimulus material used to assess MR abilities. The studies noted that the materials used were designed primarily for adults and the lack of evidence of gender differences in very young children in their meta-analysis may be due to the fact that these tasks were too difficult for children which produced floor effects that may have masked the sex difference. Sex differences in MR tasks in early childhood therefore were not convincingly established through these meta-analyses, however it was clearly established for older children and adults (Linn & Petersen, 1985; Voyer et al., 1995).

Later studies have confirmed the importance of an appropriate measure to assess mental rotation abilities (Hoyek, et al.,2012, Klein et al., 2010). Researchers have reiterated that the use of traditional paper and pencil tests for mental rotation abilities in young children may result in inaccurate results.

With younger children, new research has emerged using more developmentally appropriate measures that suggest that gender differences do present themselves even at the preschool level (Casey, et al., 2008).

Recent innovations in technology have also presented new methods in assessing mental rotation skills (Waller, 2005). Some have not yielded the same consistent gender difference (Parsons et al., 2004) , others have shown the gender difference appearing at a later age (Roberts & Bell, 2000) and some have even yielded gender differences in infancy (Moore & Johnson, 2008; Quinn & Liben, 2008).

At what age this distinct male advantage appears and what are the potential causes for this advantage remains a critical area of inquiry. The next section discusses the findings related to the age at which gender differences emerge in mental rotation tasks.

Age of emergence of gender differences in MR tasks.

The age at which gender differences in mental rotation abilities emerge has been a matter of debate. Although a number of studies have indicated that the male advantage on mental rotation tasks does not emerge until age 10 or later (Linn & Petersen, 1995; Maccoby & Jacklin, 1974; Roberts & Bell, 2000; Voyer et al., 1995), recently researchers have found gender differences in children below the age of 10 (Geiser, Lehmann, & Eid, 2008), as early as the preschool years (Casey et al., 2008; Ehrlich et al., 2006; Levine et al., 1999; Pruden, Levine, Huttenlocher, 2011) and perhaps even as early as young infants (Moore & Johnson, 2008; Quinn & Liben, 2008). As stated in a previous section of this paper, studies involving young children and mental rotation are limited, however the few that were conducted also interestingly reported gender differences in performance.

Researchers Moore and Johnson (2008) and Quinn and Liben (2008) conducted experiments designed to assess if mental rotation abilities present themselves in infants and if gender differences exist at that young age. Moore and Johnson's study involved 5 month old infants. The children were presented three-dimensional images on a two-dimensional video screen and recordings were made of the children as they viewed the images. Observers recorded indications of habituated and novel stimulus through infant's visual fixation on the objects presented. The results indicated that only male infants were able to recognize a familiar object from a new perspective, a feat which according to the researchers, required mental rotation. Researchers Quinn and Liben (2008) conducted a similar experiment with 3-4 month old infants using two-dimensional illuminated stimuli. Again, these researchers found that male infants were more likely to "recognize as equivalent a figure rotated in the same way as were figures shown during familiarization… and to perceive a mirror image of that figure as novel" (p.1069). These two studies suggest that gender differences in mental rotation may emerge very early in development.

A study by Levine et al. (1999) involving 288 children between the ages of 4 and 7 years found a significant male advantage on spatial transformation tasks by 4.5 years of age. Their study used a two dimensional mental rotation task in which children were shown two halves of an image. The halves were either rotated or torn apart and the children were asked which of four whole shapes the two pieces would make if put together. Boys significantly outperformed females on all ages from 4 years 6 months to 6 years 11 months.

Researchers using a newly developed three-dimensional mental rotation task (Casey et al., 2008) found gender differences in task performance for kindergarten children. In their study, 100 kindergarten students from diverse urban communities were administered an age-appropriate mental rotation measure as part of a focused intervention. The measure developed in this study was considered age appropriate as it involved the use of concrete objects. Children were asked to move an object into congruence with a presented object which was rotated and positioned in a different orientation. The task required both flipping (three-dimensional rotation) and turning (two-dimensional rotation). The children however, were asked to first think, and mentally visualize how they needed to reposition the object prior to touching it and were only given 10 seconds to complete each of 10 tasks. Results of the mental rotation task indicated kindergarten boys significantly outperforming the girls.

In 2010, researchers Tzuriel and Egozi measured mental rotation skills of 116 first grade children as part of an experimental study aimed at improving representation and transformation of visuospatial information. The results indicated initial gender differences, with males significantly outperforming females.

A recent review by Geiser et al (2008) assessed MR abilities on participants ranging in ages 9-23 years. The researchers assessed the size and significance of sex differences in overall MRT scores in each age group. For young ages, they found a large effect size for both the 9 year old and 10 year old age groups with males significantly outperforming females.

The research with young children however is limited and still remains unclear. There is a need for more empirical data on young children's mental rotation abilities and the age at which gender appears to mediate differences in MR abilities. Some researchers have suggested that the age of emergence must be later as the differences in spatial ability are related to puberty and hormonal changes. The limited studies that have been conducted with young children however provide some evidence that the emergence of sex differences in MR abilities is not linked to the onset of puberty but perhaps other factors that play a role earlier in development. This introduces another important area of investigation in the area of gender differences in MR abilities, which is the *cause* of gender differences in MR abilities.

Potential causes of gender differences in MR abilities.

Gender differences have been consistently found in numerous studies related to spatial abilities. Whether the reason for the differences is due to nature or nurture or a combination of nature/nurture factors is still an issue of debate. Interaction theory suggests that it may be a combination of both an inherent spatial strength and the subsequent increased disposition towards spatial activities that leads to stronger spatial abilities. Whether as a combined effect as in the theory of the interactionist framework, or simply the result of nurturing, research has indicated that experience with activities that are considered spatial appears to be stronger in males than females (Caldera et al., 1999, Sorby 2009). In their review of literature Baenninger and Newcombe (1995) found that boys and girls are differentially exposed to spatial training and activities. They found that these differences are robust and that males are more likely to participate in activities that are more spatially oriented. In evaluating sex-differentiated experiences, the researchers noted that both formal and informal experiences may facilitate spatial and mathematical abilities.

The finding of Baenninger and Newcombe (1995) that boys are differentially exposed to spatial activities was recently supported by a study conducted by Terlecki (2008). Her study involved 1, 278 undergraduate students, (370 Males, 908 females), who completed a survey of spatial activities called the Survey of Spatial Representation and Activities (SSRA), developed by the investigators for their study. The survey asked participants their current level of involvement in selected spatial activities and perceived efficacy related to the activity. The assessment focused on current level of activities related to spatial experience such as playing certain sports, use of computers, use of maps, and video game playing. The survey however did not specify the period of time when involvement with such activities began. Knowledge of how early the involvement with spatial activities began would have further explained the variances that were found. An independent *t*-test confirmed significant differences in spatial experiences between males and females, with males exhibiting greater spatial experience than females (Terlecki, 2008).

The study by Voyer et al. (2000) similarly found greater spatial experiences for males, however their study focused on experiences that adults reported engaging in *when they were children*. Their study also investigated whether these reported experiences during childhood influenced their performance on mental rotation tasks. Two hundred and ninety adults (mean age 19.5 years) completed a questionnaire that required them to rank the top ten toys they played with as children. The toys listed were later classified as either spatial on non-spatial. They were then given the MRT to measure their mental rotation abilities. The results of the study indicated that participants who preferred spatial toys as children performed significantly better than those who preferred non-spatial toys. It is important to note here that the survey requires that participants recall their involvement with spatial toys and therefore may not include experiences that occurred at very young ages, beyond their recollection as adults. This study however does illustrate the potential impact of early experiences on later development of mental rotation skills.

Researchers Roberts and Bell (2000) found differences in brain EEG readings for adult males and females when performing mental rotation tasks. They did not however, find similar differences between 8 year olds using the same technology. The researchers suggest that the difference may be the result of brain plasticity "with a malleable brain forming to the needs of the body… as boys begin to differentially participate in activities that require the use of spatial skills" (p. 220). They suggest that the brain adapts to the task and develops specialization to spatial tasks.

In the experiment mentioned earlier conducted by Tzuriel and Egozi (2010), 116 first grade children were provided experience with activities aimed at improving mental rotation skills through interpretations and discussions of visual materials. The study revealed the expected initial gender differences in mental rotation tasks however after the intervention girls improvement was greater than boys such that the girls closed the initial gap in achievement. Overall girls showed a higher performance on the spatial task than boys after the spatial activities.

The above mentioned studies provide support for the notion that formal or informal experiences during childhood years may be contributing to spatial ability development. It is important to note however that experience with certain types of spatial activities may impact different spatial skills. For example, in the study conducted by Casey et al., (2008) mentioned earlier, the researchers administered a focused intervention involving block play. Their experiment revealed a beneficial impact of the intervention on block building and spatial visualization skills however no significant impact on mental rotation skills. The researchers suggested the possibility that the experiences provided by the intervention did not transfer to the skills required for the mental rotation task.

One of the experiences that is often specifically associated with gains in mental rotation abilities and which is becoming increasingly prevalent in young children's lives is video game playing. The following section discusses the recent trends in video game playing and how video game playing may influence spatial skills development.

Video game playing.

Researchers have found that certain aspects of video games are conducive to the development of spatial ability. Playing video games requires a coordination of perspectives, the physical and mental manipulation of two and three dimensional objects, the coordination of the horizontal and vertical axes, and the holistic processing of images (McClurg & Chaille, 1987).

One of the reasons that video game playing may be so attractive to children is its alignment with play theories. Contemporary theories such as Lewin's Infantile Dynamics (Herron and Sutton-Smith, 1971) suggest that the child passes into a region of playful unreality where things are changeable and arbitrary because the cognitive life space of the child is still unstructured, which may explain the attraction for young children to video game play. Attraction to video games may also be explained by Stimulus-Arousal Theory which suggests that play is chosen to seek stimuli both to gain knowledge and to satisfy a need for excitement, risk, surprise, and pleasure (McLean & Hurd, 2012). Competence-Effectance Theory holds that play is motivated by the player to solve problems and gain a sense of mastery and accomplishment and finally, Catharsis

Theory suggests that young children may choose play activities that allow them to express painful emotions in a harmless way (McLean & Hurd, 2012).

In addition, video game playing also aligns with models of motivation, such as Keller's (1987) attention, relevance, confidence, and satisfaction (ARCS) model (Chuang & Chen, 2009). Video games generate multiple sensory stimuli that keep *attention* focused, and create an active learning environment by using simulation and role-playing. The games often address topics that are *relevant* to children's life and connect with their prior knowledge and skills. *Confidence* is developed as most video games contain a variety of options according to the learner's competence levels, and finally most video games provide some sort of end report that gives statistics on accomplishments and encourage *satisfaction* with performance and motivation to improve and play again (Chuang & Chen, 2009).

Although empirical research with children in this area is scarce, studies have found that mental rotation abilities can be improved through video game playing. In their study of 5^{th}, 7^{th} and 9^{th} graders, researchers McClurg and Chaille (1987) found that students who played with three dimensional video games ("The Factory" and "Steller") for 90 minutes a week (45 min x 2) for a period of six weeks significantly improved their performance on the MRT compared to students in a control group that did not play video games. The study found that both boys and girls benefitted from the treatment across all three grade levels. The play of games however did not negate the gender difference favoring males in MR performance. Similarly Subrahmanyam and Greenfield (1994) found that after three 45 minute sessions, children ranging in age from 10.5 to 11.5 years, improved their performance on spatial tasks after playing a computer game (Marble

Madness), compared to students who played a computerized word game (Conjecture.) As with McClurg and Chaille's (1987) study the videogame playing did not negate the gender difference, however the magnitude of the difference was reduced.

In 2002, researchers DeLisi and Wolford investigated the impact of playing the computer game "Tetris" with third graders (n= 47, 24 boys and 23 girls) on their mental rotation abilities. The participants were between the ages of eight and nine years and were from a small public urban school. They used a revised version of the French Kit Card Rotation Test (French, Ekstrom, & Price, 1963) for the study to measure MR accuracy. The researchers found performance on the MR assessment was significantly and positively associated with the playing of the video game. This study also found that the largest pretest to posttest increase in MR scores were the girls who played the game. In this study, the girls performed as well on the MR post test as the boys who had initially significantly outperformed the girls on the prettest. Contrary to the studies mentioned earlier, this study found that the videogame playing did erase the gender difference on the posttest (DeLisi & Wolford, 2002).

The majority of studies related to video game playing have however, been with older children and adults. Cherney (2008) found that 61 undergraduate students improved their mental rotation scores after just four hours of computer game play (3-D Antz Extreme Racing and the 2-D Tetris). Playing with the games improved both men's and women's performance. Similar to DeLisi and Wolford's (2002) study with young children, female gains were significantly greater than male gains. Ogakaki and Frensch (1994) found that six hours of playing the video game Tetris improved both male and female college students' performance on mental rotation tasks, however in their study there was not a significant difference in improvement between males and females.

Another study with undergraduate students found that the type of video game played was influential in its impact on mental rotation performance. Twenty students (age ranging 18-32) were recruited for a study by Feng and colleagues (Feng et al., 2007). All of the subjects reported that they did not have any video game playing experience during the preceding four years from the experiment. Ten same gender pairs were formed by matching performance as closely as possible on pre-test spatial abilities tasks. One member was allocated at random to an "action game" group and one to the control "non-action" group. The researchers found that both the males and females in the experimental group improved their scores, but there was no significant change for the control group. Again, in this study gender differences favoring males was noted, however as with Chuang (2009) and DeLisi and Wolford (2002) the improvement in scores was larger for the females, and the size of the differences between the genders was reduced from the pre-test (Feng et al., 2007; Spence et al., 2009).

A recent adult non-experimental study by Terlecki and Newcombe (2005) assessed whether self-reported video game usage mediated the gap between the sexes in mental rotation ability. The study involved approximately 1,300 undergraduate students (370 males and 908 females). The researchers empirically assessed gender differences in video game usage using the Survey of Spatial Representation and Activities (SSRA.) Mental rotation abilities were assessed using the MRT. The study found that there was a significant difference in computer/videogame experience between male and females. In addition, both men and women's computer/videogame experience was correlated with

MRT performance. The results of the study indicated that spatial experience with computer/videogame was shown to behave as a mediator of the observed gender differences in mental rotation ability, especially for women. In other words, women with computer/videogame experience scored higher on the MRT. This finding along with the previously mentioned experimental studies provides strong evidence for the relevance of gender differences in the use of videogames in creating, maintaining or perhaps increasing the size of any pre-existing gender differences in mental rotation ability (Terlecki & Newcombe, 2005).

A similar non-experimental study by Quaiser-Pohl and colleagues (2006) however did not find the same type of gender effect. This study examined how computer game preference related to MRT performance. Eight hundred and sixty-one participants (mean age = 14.67, range 10-20 years) completed a self-report questionnaire which asked participants to rate how often they played different types of computer-games. The frequency of each category had to be rated on a 4-point scale ("never," "rarely," "often," and "very often,") in addition to a single item worded "I never play computer games at all" which participants could check. A cross-tabulation analysis showed a strong association between computer-game preference and gender. Specifically, girls were overrepresented in the group of non-players (81.9 % of this group were females), while they were strongly underrepresented in the class of action and simulation game players. In total 63.6% of all females were in the class of non-players, while only 19.9% of males were found in this group. The results of the MRT scores showed that males who played computer games had higher MRT scores than males who were assigned to non-player groups. This association however, was not found for females, computer game playing preference was unrelated to MRT performance.

These non-experimental studies have however focused on adults; there are no similar studies that have examined home video game playing habits and its relationship to young children's mental rotation abilities.

Summary

Research has shown that there is a strong correlation between spatial abilities and mathematical achievement. Within the realm of spatial abilities, mental rotation has been consistently shown to have a male advantage and may be a contributing factor in the overrepresentation of males in math and science fields of occupation. Experience with particular types of spatial activities, specifically video game playing, has been shown to improve mental rotation abilities in studies of adults and older children. It is not known if younger children's mental rotation abilities would benefit from video game playing experiences as the older children and adults did considering the developmental nature of spatial cognition. However, what is known is that the popularity and presence of video games with young children is ever growing and yet research has not kept up with these changes. A report by the Kaiser Family Foundation found that 49% of young children's homes have a video game player, and of children under the age of six, one in four have played video games, and one in ten have their own video game console in their room. The report stated that in a typical day, one in every six children between the ages of four and six play video games and for an average of little over an hour at a time. This study was conducted in the spring of 2003, and was done using a nationally representative random survey of more than one thousand parents (Rideout et al., 2003). With the rapid growth of this industry and the fact that this survey was conducted several years ago, it is likely that these representative numbers are lower than the current situation. Despite the increasing use of video games by young children, very little is known about its impact on their cognitive development. The authors of the Kaiser Family Foundation report have stated in their conclusions the need for studies that investigate whether playing video games helps young children's visual and spatial skills (Rideout et al., 2003). This study addressed this need and provided information on the relationship of kindergarten children's informal video game playing habits and their scores on mental rotation tasks.

Chapter III

Methods

Introduction

This chapter outlines the methods used in this study. The primary purpose of this study was to investigate the relation of children's gender and video game playing habits to their performance on mental rotation tasks. The study also provides information on kindergarten children's video game playing habits differentiated by gender. This chapter describes the research design, research questions, participants, instruments, data collection procedures, and data analysis procedures. The chapter will conclude with a summary.

Research Design

The research design for this study was a causal comparative design using archival data. According to Gall, Gall, and Borg (2003), the causal comparative design is used for nonexperimental investigations where researchers try to find possible cause and effect relationships by forming groups of individuals in whom the independent variable is present or absent, or present at different levels, and then determining whether the groups differ on the dependent variable. The critical feature, they say, is that the independent variable is measured in the form of categories which can form a nominal scale (such as male/female) or an ordinal scale. This is a critical feature as it is noted that if the variables were in ratio scale then a correlational research design would be more appropriate. It is the scaling of the variables that is the only true distinction between these two types of studies. For example, if time spent video game playing was measured in minutes per day, then a correlational study would be more appropriate; however, if time is artificially divided into groups–none, less than 30 minutes, 30 minutes to 1 hour- a causal-comparative design results. Neither correlational nor causal-comparative investigators manipulate any variables (there is no assignment of participants to treatment and control groups); and they are similar in that both are used to examine relationships among variables (Johnson, 2000). Causal-comparative is sometimes called *ex post facto* research in that the presumed cause has taken place prior to the initiation of the study (Goodwin & Goodwin, 1996), and in a natural setting (Wiersma, 2000). The disadvantage of the causal-comparative research design is that inferences about causality are necessarily tentative (Gall et al., 2003).

The data that were used in this study were originally collected by Andrews (2009) as part of an experimental study designed to examine the development of spatial skills and reasoning in kindergarten students. Permission to use these data was obtained from the principal investigator.

Research Questions

This study addressed the following research questions:

Research Question 1: Do boys and girls differ significantly in whether they play video games?

Research Question 2: How much time do kindergarten children spend playing video games, and are there gender differences in the amount of time spent playing?

Research Question 3: What is the relationship between kindergarten children's gender, amount of video game playing, and performance on mental rotation tasks?

Research Question 4: Which gaming devices are used by kindergarten children?

Participants

For the original study conducted by Andrews (2009), 96 kindergarten students were randomly selected from two public elementary schools in a large urban school district in southeast Texas. Schools with similar socioeconomic level and previous math performance, based on state ranking awards, on the Texas Assessment of Knowledge and Skills (TAKS) were selected. The sample included 51 girls and 45 boys. The participants ranged in age from 5.6 to 6.5 years of age. Ethnicity of the students included (71%) Caucasian, (17%) Hispanic, (9%) African American and (9%) Asian. The socioeconomic make-up of the participants was varied and included students who were in the free and reduced lunch programs (6%), students who were classified as bilingual (1%), and students who were English Language Learners (ELL) (2%). This sample was representative of the school district's population.

Instruments

Two instruments were used in this study. The first was a parent questionnaire designed to measure kindergarten children's home play activities (Appendix A), and the second was the "Mental Rotation Task," an assessment used to measure young children's spatial abilities (Appendix B & C). Details of the two instruments are described below.

Questionnaire.

For the purposes of the Andrews (2009) study, the researcher developed a 12-item parent questionnaire to examine the home play behaviors of kindergarten students. The researcher developed the questionnaire because no published questionnaire could be identified which adequately measured the behaviors the study sought to examine. The study was primarily focused on young children's block play; however, the questionnaire also included items related to young children's video game playing. This questionnaire consisted of 12 items. Of the 12 items, 3 required a yes/no response, and 6 were formatted as a checklist. The checklist items allowed parents to indicate out of five levels, the amount of time their child spent playing each activity. The remaining 3 items were open-ended and requested parents to list the types of materials used by their child. For the questions related to video game playing, parents were asked whether or not their children played with video games, how often they played, and what types of gaming devices they used (Appendix A). As stated earlier, in the introduction chapter of this study, the term for video game playing can have many interpretations. In the questionnaire that was provided to parents, prior to the questions related to video game playing, parents were asked in a similar format, if their child played computer games or internet games. The intent of the distinction was to ensure that parents distinguished between the different types of games. By making this distinction, parents would not for example, put games such as the *webkinz* which is an internet based game or *solitaire, a* game that is typically presented on a computer. In order to further ensure that only games that most likely involve some type of mental rotation are included in the analysis of data, the responses to the open-ended questions where parents listed the games and gaming devices used were examined. The Cronbach's alpha reliability for the questionnaire was .70.

Mental Rotation Task.

Participants were assessed using a reformatted Vandenberg and Kuse (1978) Mental Rotation Task. The task was designed by Casey and colleagues (2008) and was determined to be an age-appropriate measure for young children. This task involved the use of concrete three-dimensional figures instead of the two-dimensional paper based Vandenberg and Kuse assessment. The assessment consisted of 14 test items. The task was administered following the protocol designed by Casey and colleagues (2008) (Appendix C). Details of testing procedures are outlined later in this chapter under data collection procedures.

Cronbach's alpha for the Mental Rotation Task was $r = .82$ in the Casey et al. (2008) study. Data collectors for the Andrews (2009) study were given training and testing in the proper administration and scoring of the assessment. Training was continued until inter-rater reliability for all three raters together was achieved at r = 99. During the data collection period, videotaping of the testing administration was also conducted to ensure continued reliability.

Data Collection Procedures

The data used for this study were archival data that were collected as part of the Andrews (2009) study. The principal investigator of that study gave permission to use these data. Permission to conduct the original investigation was obtained from the University of Houston's Committee for the Protection of Human Subjects as well as the participating schools and district.

The following describes the data collection procedures that were conducted that are relevant to this study. Prior to the collection of data, parents of the randomly-selected participants were sent letters, consent forms, and the questionnaire (Appendix A). Parents were informed, through the written consent form, that all information collected from them and their children would remain confidential and only the project staff would have access to individual student assessments. They were informed that all assessments would be coded to ensure confidentiality and that the computer and paper-based data would be stored in a secured locked location. Consent was obtained from the parents for the data to be analyzed and published. Parents were informed that any publications from the study would not identify the specific schools the participants attended or the names of any participants.

Parents were given two weeks to return the forms and the questionnaire to the student's teacher. Those children who did not return forms were not included in the study. Participation was voluntary. The forms and questionnaire data were collected by the research team and entered into a database for later analysis. Testing dates were then arranged at the schools. Four data collectors conducted the administration and simultaneous scoring of the tests. Two were professors in the early childhood department of a large university in southeast Texas and two were graduate research assistants from the same university.

Testing was conducted individually in multi-purpose rooms at each of the school locations. Video cameras were set up in the room before the children entered the classroom. Children were not identified by name on the tapes. Identification numbers were held up to the camera before each session began to identify the children. Participants were taken individually from their classrooms by the data collector and brought to the testing area. They were seated across from the data collector and facing the camera. Data collectors reviewed each child's folder to confirm they included the signed parent consent forms. Children were read a statement from an assent form (Appendix D) and asked if they would like to participate. Once verbal assent was obtained the task was explained to them and testing began.

The Mental Rotation Task was administered following a specific step-by-step protocol designed for this assessment (Appendix C). The protocol details the exact phrasing, directions, and scoring for the test to ensure that the tests were conducted with fidelity. For each item two identical 3D block designs arranged in different orientations were presented to the child. The children were asked to first look at the figure and think how it needed to be moved in order to match the other. The children were given as much time as needed to mentally make this judgment. Once they were ready, they were asked to move the figure into the matching position. The assessment required the measurement of time needed to complete this task from the moment the child touched the figure. Children who were able to move the figure into the correct matching position within 10 seconds were given a score of one. No score was given if the time exceeded 10 seconds. Fourteen items were scored for this assessment, and the items progressed in difficulty as the complexity of the figures increased. When a child answered three successive items incorrectly, the task was completed. Practice items were first modeled to the student to ensure they understood the task. The maximum score for this assessment is 14. A score sheet was utilized to record the amount of time taken by the child and whether the task was completed correctly (1) or incorrectly (0) within a 10-second time frame (Appendix B). In order for the attempt to be considered accurate, the child needed to place the figure in the exact same position as the other test figure; it did not matter if the child manipulated the object more than once, however, it had to be completed within ten seconds.

Each child's file had an assigned number, and the testing materials also had that number: no names were used on the testing materials. Data were entered into a database and permission to use that data for this study was obtained from the principal investigator.

Data Analysis Procedures

In order to answer the research questions, descriptive and inferential statistical techniques were used.

Research Question 1: Do boys and girls differ significantly in whether they play video games? For this question, the variables of interest were gender and whether or not the child played video games. The independent variable "gender" was categorical and nominal and the "playing of video games" was also categorical and nominal as the response categories were "yes" or "no." Descriptive analyses were conducted to report frequencies and percentages. An inferential analysis was conducted using a chi-square test of independence. The chi-square test is considered appropriate if both variables are categorical and nominal or ordinal (Lehman, O'Rourke, Hatcher, Stepanski, 2005).

Research Question 2: How much time do kindergarten children spend playing video games, and are there gender differences in the amount of time spent playing? The variables of interest for this question were gender and the amount of time spent playing video games per week. The independent variable was "gender" (categorical, nominal) and the dependent variable was "amount of video game playing" (continuous, ordinal). The data were considered continuous as they represented time intervals. The intervals are not equal; however the response numbers indicate the rankings of the items relative to one another and therefore are considered ordinal data. The variable consisted of five levels: none, less than 30 minutes, 30 minutes to 1 hour, 1 hour to 3 hours, and more than 3 hours. Descriptive analyses were conducted to report mean, median, mode, frequencies and percentages. Inferential analyses were conducted using independent sample t-tests. A t-test is considered appropriate with a single nominal or ordinal independent variable that assumes only two values and a single continuous dependent variable (Lehman et al., 2005) typically represented in an interval scale (Gardner, 1975). The decision to use this parametric statistical method on the ordinal data was made due to the fact that researchers have found that “because of the robustness of parametric techniques, treating ordinal data as if they were interval would be unlikely to lead to improper conclusions” (Gardner, 1975, p.51, Norman, 2010). Research has indicated that “probabilities estimated from the t-distribution are little affected by the kind of measurement scale used” (Havlicek, 1972, p. 6). In addition, in the social sciences, most of the central constructs are conceptualized as continuous and often represented in some type of rating scale (Borgatta & Bohrnstedt, 1980; Norman, 2010). Limiting the use of parametric procedures to strictly interval and ratio level data would effectively prevent most researchers in the behavioral sciences from using parametric statistics (Gardner, 1975, Norman, 2010). More importantly, distribution free tests have the disadvantage of being relatively low powered compared to parametric tests. In other words they are not as powerful for avoiding type II errors (Gardner, 1975; Havlicek, 1972), therefore, though the data was represented in an ordinal categorization, parametric methods were used to conduct a robust analysis.

Research Question 3: What is the relationship between kindergarten children’s gender, amount of video game playing, and performance on mental rotation tasks? The variables of interest were gender, amount of video game playing and performance on the Mental Rotation Task. The independent variable was gender (categorical, nominal). The dependent variables were amount of video game playing (continuous, ordinal) and performance on the Mental Rotation Task (continuous, interval). Descriptive analysis was conducted to report minimum and maximum values and means and standard deviations. An inferential analysis was conducted using a multivariate analysis of variance (MANOVA). MANOVA is appropriate when the analysis involves a single nominal or ordinal independent variable that defines groups, and multiple continuous dependent variables. MANOVA can be used to discuss research questions related to the importance of the dependent variables, and to assess the strength of association between dependent variables. The MANOVA yielded a significant F value, therefore further univariate analysis was conducted to identify the specific dependent variables on which the groups were different (Lehman et al., 2005)

Research Question 4: Which gaming devices are used by kindergarten children? The variables of interest were gender (categorical, nominal) and type of video game system played (categorical, nominal). Descriptive analysis was used to report frequency and percentages.

Summary

This chapter described the methods used for this study. Information on the research design, participants, instrumentation, data collection, and data analysis procedures was provided.

Chapter IV

Results

Introduction

The purpose of this study was to provide empirical data on young children's mental rotation abilities. In addition, the study examined kindergarten children's involvement with videogame playing and possible gender differences in this spatial play activity. Finally, the study explored the relationship between kindergarteners' gender, video game playing, and mental rotation abilities. The data used for this study were archival data collected by Andrews (2009) as part of an experimental study designed to examine the development of spatial skills and reasoning in kindergarten students. Results from a mental rotation assessment and a parent questionnaire were analyzed to answer the research questions. Research questions were answered using both descriptive and inferential analyses. The following research questions guided this investigation:

Research Question 1: Do boys and girls differ significantly in whether they play video games?

Research Question 2: How much time do kindergarten children spend playing video games, and are there gender differences in the amount of time spent playing?

Research Question 3: What is the relationship between kindergarten children's gender, amount of video game playing, and performance on mental rotation tasks?

Research Question 4: Which gaming devices are used by kindergarten children?

Missing Data and Data Adjustments

From the original study conducted by Andrews (2009) data were collected for 96 participants. One student, however, was absent on the day of the mental rotation task assessment and therefore, this student's data were excluded from the analysis. In addition, three children included in the original data set were triplets and came from the same household. These children's data were also excluded from the analysis. The rationale for the exclusion was to not violate the *assumption of independence of observations*, which is the assumption that there is no relationship between the scores for one person and those of another person. Members of the same family would likely lead to non-independence of observations as participants are likely to have a relationship to another member of the family's value on a particular variable (Leech, Barrett, & Morgan, 2005).

Data sets were adjusted for item 11 on the parent questionnaire. Item 11 on the parent questionnaire asked parents if their child played video games, and the second part of the question (11a) asked if the child did play video games, how much time during the week they played (Appendix A). Item 12 on the questionnaire asked the parents to provide the name of the gaming system(s) used by the child. Based on responses to item 12, both parts of item 11 were adjusted where necessary. If parents did not list the gaming system or listed only a gaming system that typically presents educational programs that do not involve the skills and imagery associated with the construct of video games defined in this study, their responses were changed to a "no" for the first part of the item 11 and "none" in time per week for the second part. Item responses that were adjusted included the gaming system *Leapster*, *IPhone* applications, *v-tech*, and specified educational games. Eleven cases were adjusted.

Research Question One

The first research question addressed in this study was, "Do boys and girls differ significantly in whether they play video games?" Descriptive analysis was conducted to report frequencies and percentages, and a chi-square test of independence was conducted to analyze the differences between the groups. Table 1 and Charts 1 and 2 display the results of the descriptive analyses.

Table 1

Descriptive Statistics for Response to Question "Does Your Child Play with Video Games at Home?"

Response	Girls (n = 47)		Boys (n = 45)		Total (N = 92)	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
No	16	34.0%	5	11.1%	21	22.8%
Yes	31	66.0%	40	88.9%	71	77.2%

Chart 1

Total: Descriptive Statistics for Response to Question "Does Your Child Play with Video Games at Home?"

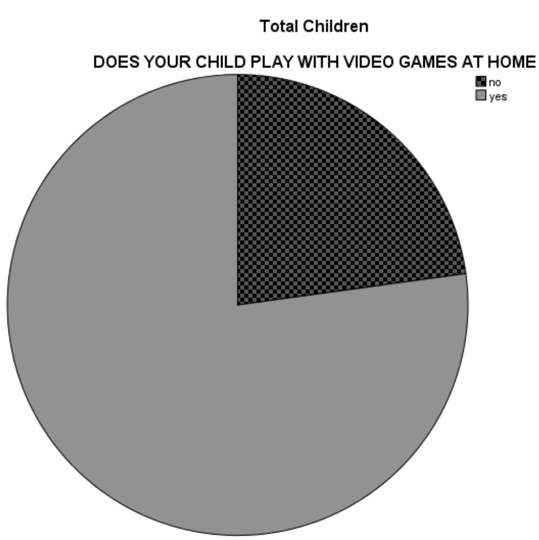
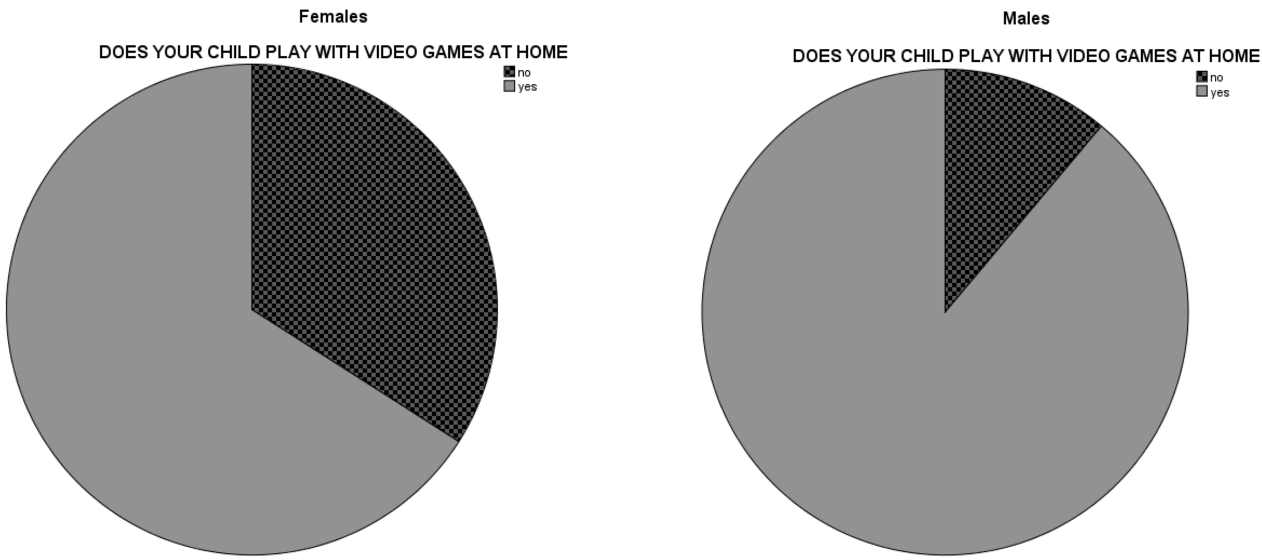


Chart 2

Gender comparison for Response to Question "Does Your Child Play with Video Games at Home?"



The results, as shown in Table 1 and Chart 1, indicated that from the total sample (N = 92) the majority of children (77.2 %) played video games at home. The results as shown in Table 1 and Chart 2 also indicated that there was a greater percentage of boys who reported playing (88.9%) than girls (66.0 %). To test whether these differences were significant, a chi-square test of independence was conducted. Table 2 describes the results of that analysis.

Table 2

*Chi-square Test of Independence Results for Girls (*n *= 47) and Boys (*n *= 45) Playing of Video Games*

Response	Girls		Boys			
	Frequency	Percent	Frequency	Percent	$X^2(1)$	*p*
Plays Video Games	31	66.0%	40	88.9%	6.86	.009

The results of the analysis, as shown in Table 2, indicate that the relation between these variables was significant and that kindergarten males are more likely to play video games than females, X^2 (1, N = 92) = 6.863, *p* = .009.

Research Question Two

The second research question addressed in this study was "How much time do kindergarten children spend playing video games, and are there gender differences in the amount of time spent playing?" Descriptive analysis was conducted to report mean, median, mode, frequencies and percentages and an independent samples t-test was conducted to analyze the differences between the groups. Tables 3 and 4 and Chart 3 provide the results of the descriptive analyses.

Table 3

Mean, Median, and Mode for Time Kindergarten Children Spend Playing Video Games Per Week

Item	N	Mean	Median	Mode
Time spent playing video games per week	92	1.86	2.00	3

Note. 0 = none, 1 = less than 30 minutes, 2 = 30 minutes to 1 hour, 3 =1 hour to 3 hours, and 4 = more than 3 hours.

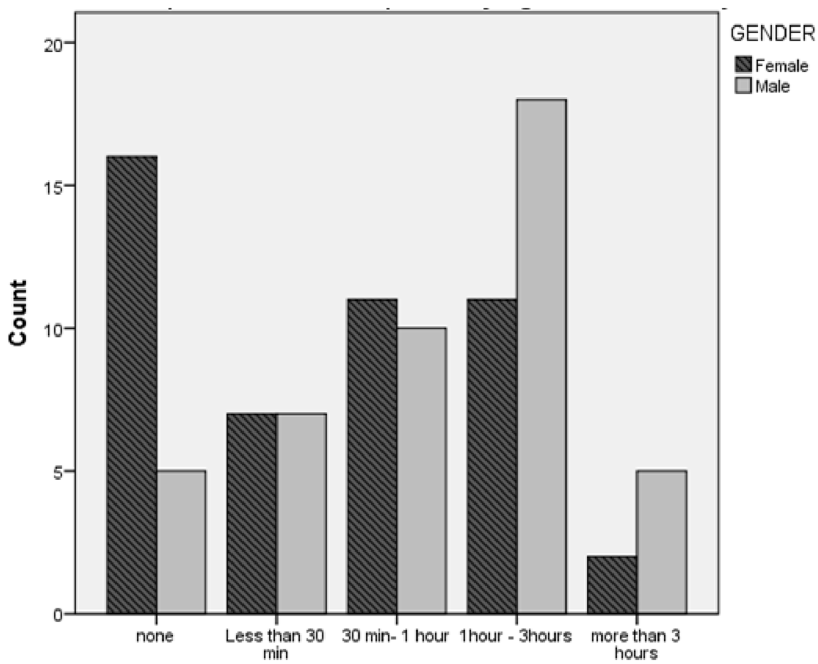
Table 4

Frequencies and Percentages for Length of Time Per Week Playing Video Games

	Girls (n = 47)		Boys (n = 45)		Total (N = 92)	
Response	Frequency	Percent	Frequency	Percent	Frequency	Percent
None	16	34.0%	5	11.1%	21	22.8%
Less than 30 min	7	14.9%	7	15.6%	14	15.2%
30 min. to 1 hour	11	23.4%	10	22.2%	21	22.8%
1 hour to 3 hours	11	23.4%	18	40%	29	31.5%
More than 3 hours	2	2.2%	5	11.1%	7	7.6%

Chart 3

Gender Differentiated Display of Frequencies for Length of Time Per Week Playing Video Games



The results from the descriptive analyses as displayed in Table 3 indicated that from the total sample (N = 92) the average reported amount of time children spent playing video games per week was less than 1 hour. (*M* = 1.86). The results as displayed in Table 4 and Chart 3 indicate that overall, the highest percentage of children (31.5%) were reported as playing between 1 hour to 3 hours per week. The lowest percentage of children (7.6%) reported playing for more than 3 hours per week. A greater percentage of girls (34%) play no video games per week than boys (11.1%). In addition, a greater percentage of boys (11.1%) play video games for more than 3 hours per week than girls (2.2%). Within the group of girls, the highest percentage of girls played no video games (34%) and the lowest percentage of girls played for more than 3 hours per week (2.2%).

Within the group of boys, the highest percentage of boys (40%) played from 1 to 3 hours a week, and the lowest percentage of boys (11.1 %) did not play at all or played for more than 3 hours a week. To test if these differences were significant a t-test of independence was conducted. Table 5 displays the results of the inferential analysis.

Table 5

T-test: Group Differences for Length of Time Per Week Playing Video Games

	Girls		Boys				
Response	*M*	*SD*	*M*	*SD*	*t*(90)	*p*	Cohen's *d*
Length of time playing per week	1.49	1.30	2.24	1.19	2.90	.005	.602

Note. 0 = none, 1 = less than 30 minutes, 2 = 30 minutes to 1 hour, 3 =1 hour to 3 hours, and 4 = more than 3 hours

The results of the t-test as presented in Table 5 revealed that there was a significant effect for gender indicating that boys spend significantly more time than girls playing video games, $t(90) = -2.90$, $p=.005$.

Research Question Three

The third research question addressed in this study was "What is the relationship between kindergarten children's gender, amount of video game playing, and performance on mental rotation tasks?" Descriptive analysis produced minimum and maximum values and means and standard deviations. An inferential analysis was conducted using a multivariate analysis of variance (MANOVA).

Table 6 presents the descriptive analysis for the mental rotation task. The descriptive analysis for the time spent playing video games was presented earlier in Table 5.

Table 6

Descriptive Analyses for The Mental Rotation Task

	Girls (n = 47)				Boys (n = 45)				Total (N = 92)			
Item	Min	Max	*M*	*SD*	Min	Max	*M*	*SD*	Min	Max	*M*	*SD*
Mental Rotation Task	1	13	5.13	2.80	0	12	5.49	3.25	0	13	5.30	3.02

The results from the descriptive analysis presented in Table 6 indicate that the average score for the participants as a whole on the Mental Rotation Task was less than half correct. The range of scores however, was high, with students scoring as low as 0 and as high as 13 and a large standard deviation within all participants (M = 5.30, SD = 3.02). Results show that boys scored on average slightly higher than girls (M = 5.49, SD = 3.25) on the Mental Rotation Task. Again, however, there is a large standard deviation and large variability within both groups. An inferential analysis was conducted to assess the strength of the differences in the groups on the dependent variables.

The MANOVA examined gender as the independent variable (IV) and scores on the Mental Rotation Task and time spent playing video games as the dependent variables (DVs). One of the assumptions of the MANOVA is homogeneity of covariances, which is tested for by Box's Test of Equality of Covariance Matrices. The assumption of homogeneity of covariances was not violated as the result was not significant (p =.57).

In addition, because MANOVA is sensitive to outliers, exploratory analyses were conducted using boxplots, and no outliers were identified. Also, an examination of trimmed means was conducted, and it was determined that the outliers did not greatly affect the mean scores for either group. The MANOVA, therefore, was conducted using all participants' scores. There was a significant multivariate effect of gender $F(2, 89) = .017$, $p = .017$; Wilks' $\lambda = .913$, partial $\eta^2 = .087$. The partial η^2 is an effect size measure that shows the proportion of the variance in the dependent variable that is accounted for by the independent variable (George & Mallery, 2008). In this case 9% of the variance is due to gender. A follow-up univariate test was conducted to determine how the dependent variables differed for the groups. The Levene's Test of Equality of Error Variances was conducted; both the Mental Rotation Task and the length of time playing video games have homogeneity of variances because the result was not significant ($p > .05$). Table 7 presents the results from the MANOVA and ANOVA.

Table 7

Multivariate and Univariate Analyses of Variance F Ratios for Gender Effects for the Mental Rotation Task and Length of Time Playing Video Games

				Univariate					
	Multivariate			Mental Rotation Task			Time Spent Playing Video Games		
Variable	F^a	p	partial η^2	F^b	p	partial η^2	F^b	p	partial η^2
Gender	4.26*	.017	.087	.327	.569	.004	8.42**	.005	.086

Note .Multivariate F ratios were generated from Wilks' Lambda statistic.
[a] Multivariate $df = 2, 89$, [b]Univariate $df = 1, 90$.

The results of the ANOVA indicate that there was a significant univariate main effect for gender for time spent playing video games, *F* (1,90) = 8.42, $p < .01$, partial $\eta^2 = .087$. This is consistent with the results of the t-test conducted earlier in response to question two of this study and displayed in Table 5, indicating that boys spent significantly more amount of time playing video games than girls. A significant effect for gender for the Mental Rotation Task scores, *F* (1,90) = .327, $p > .05$, partial $\eta^2 = .004$, was not indicated in the univariate test.

In order to further investigate any potential interaction between the variables, a two-way -ANOVA was conducted as an exploratory analysis. The independent variables were gender and time spent playing video games. For this analysis, the variable of *Length of Time Playing Per Week* was used as a categorical grouping variable. This grouping made it possible to analyze the interaction of gender and video game playing on mental rotation skills.

Table 8 presents the descriptive statistics for the groups and their mental rotation scores.

Table 8

Mean Scores and Standard Deviations for Mental Rotation Task Scores as a function of Gender and Time Spent Playing Video Games Per Week

	Girls			Boys			Total		
Length of Time Playing Video Games per Week	*M*	*SD*	n	*M*	*SD*	n	*M*	*SD*	*N*
None	4.50	2.92	16	5.80	3.11	5	4.81	2.94	21
Less than 30 minutes	5.14	1.95	7	5.00	3.12	7	5.07	2.62	14
30 minutes – 1 hour	6.00	2.97	11	5.90	3.75	10	5.95	3.28	21
1 hour – 3 hours	5.00	2.93	11	5.61	3.41	18	5.38	3.20	29
More than 3 hours	6.00	4.24	2	4.60	2.60	5	5.00	2.83	7

The results of the descriptive analysis indicate that overall children who did not play video games at all (*M* = 4.81, *SD* = 2.94) scored lower than children who did play video games. Within the group of girls, this was also the case, with girls who played no video games (*M* = 4.50, *SD* = 2.92) having a lower average score than girls who did play video games. Interestingly, the same was not true for boys, in fact, boys who did not play video games had a higher average score than some boys who did play (*M* = 5.80, *SD* = 3.11) . It is important to note here that the standard deviations among the scores is quite high in some categories and cell counts within the groups are low particularly in the category of playing for more than 3 hours. The Levene's Test of Equality of Error Variances was conducted across the groups and the result was not significant (p > .05). Table 9 presents the results of inferential analysis on the relationship of these variables.

Table 9

Summary of Two-Way Analysis for Mental Rotation Task Scores as a Function of Gender and Time Spent Playing Video Games Per Week

Source	*df*	*SS*	*MS*	*F*	*p*
Amount of Time Playing Video Games Per Week (T)	4	9.10	2.28	.233	.919
Gender (G)	1	.045	.045	.005	.946
T x G	4	10.12	2.53	.259	.903
Within Cells	82	800	9.76		
Total	92	3416			

The results of the analysis indicate that there was no significant main effect for amount of time playing video games per week, F (4, 82) = .233, p > .05, partial η^2= .011. There was no significant main effect for gender, F (1, 82) = .005, p > .05, partial η^2= .000, and there was no significant interaction effect for gender and video game playing, F (4, 82) = .259, p > .05, partial η^2= .012.

Research Question Four

The fourth research question addressed in this study was "Which gaming devices are used by kindergarten children?" Descriptive analysis was conducted to report frequency and percentages.

Table 10

Frequencies and Percentages for Types of Video Gaming Devices Used

	Girls (n = 47)		Boys (n = 45)		Total (N = 92)	
Response	Frequency	Percent	Frequency	Percent	Frequency	Percent
Nintendo	17	36.2%	22	48.9%	39	42.4%
Wii	19	40.4%	27	60%	46	50%
PlayStation	8	17.0%	10	22.2%	18	19.6%
X-box	1	2.1%	3	6.7%	4	4.3%

The results from the descriptive analysis displayed in Table 10 indicate that the gaming device that is used most by both boys and girls in kindergarten is the Wii (50%). The next most popular device was the Nintendo (42.4 %) followed by PlayStation (19.6%). The device used least by kindergarten children is the X-box (4.3%).

Summary

This study provided empirical data on young children's mental rotation abilities, examined children's involvement with video game playing, and explored the potential relationship between gender, video game playing and performance on mental rotation tasks. The following chapter will discuss the findings for each of these questions and address the limitations of the study as well as the implications of the study for future research and practice.

Chapter V

Discussion

Introduction

The objective of this study was to investigate young children's spatial abilities and play activities. Specifically, this study looked at kindergarten children's mental rotation abilities, their involvement with video game playing, and the relationship between these two variables, differentiated by gender.

The decision to examine children's mental rotation abilities and video game playing arose from the fact that research has indicated that mental rotation abilities are associated with gains in mathematical achievement and have consistently been found to be stronger in males than females (Casey, Nuttall, & Pezaris, 1997, Linn & Peterson, 1985). Research with young children and their mental rotation abilities is, however, limited. Research has also indicated that males tend to engage more in spatially oriented play than females do (Terlecki & Newcombe, 2005), and video game playing is one of the modern forms of spatial play. Finally, multiple studies of adults and adolescents have examined the relationship of video game playing and mental rotation abilities; however, no studies have examined the relationship of home video game playing among kindergarten children and its potential impact on their mental rotation skills. This study, therefore, was designed to address this dearth of information and provide empirical data to further the research and understanding of young children's spatial abilities and the potential influences on these abilities.

The study had a causal comparative design, using archival data collected by Andrews (2009) as part of an experimental study designed to examine the development of spatial skills and reasoning in kindergarten students. Responses collected from a parent questionnaire and results from a mental rotation assessment were analyzed for this study. Both descriptive and inferential analyses were used. Results from the analyses were provided in chapter 4.

This chapter will provide a discussion and a summary of findings from the analyses organized by the research questions that guided this investigation, followed by a discussion on the limitations and the implications of the study towards future research and practice, and will conclude with a summary.

Summary of Findings

Research question one.

The first question this study addressed was, "Do boys and girls differ significantly in whether they play video games?" In order to answer this question, the data collected from item 11 on the parent questionnaire (Appendix A) was analyzed. This item asked parents, "Does your child play with video games at home?" and required parents to check off a "yes" or "no" response. The results from an inferential analysis indicated that boys are significantly more likely to play video games than females.

This finding is consistent with earlier research conducted with adults and adolescents (Quaiser-Pohl & Lehmann, 2002). It is an interesting finding in that the gender differentiation in the choice of this type of play is evident at even the kindergarten level. The reasons for this trend may be the popularity of playing video games amongst older boys and adult males and the marketing of more games that are relevant to boys' interests. In 2006, for example, the top selling video games were *Madden NFL 07,* a football simulation game, and *New Super Marios Brothers,* a game whose main character is male (Entertainment Software Association, 2007).

The findings from the descriptive analysis also showed that overall the majority of kindergarten children (77%) played video games at home. This result indicates a growing trend in video game playing for young children as it is a higher percentage than those reported in earlier studies, which showed (50%) of children within the ages of 4 and 6 years having played video games (Rideout et al., 2003). The video game playing industry has recognized this increasing trend of video game playing by young children and have included in their rating systems the category of *Early Childhood*, which identifies games that have content suitable for ages 3 and *Everyone* which identifies content suitable for ages 6 and older ("Game Ratings and Descriptor Guides," 2012). In fact, in 2006, the greatest percentage of computer and video games sold were in the rating of *Everyone* (Entertainment Software Association, 2007) which shows this increasing trend and is supported by the findings from this study.

Research question two.

The second question addressed in this study was, "How much time do kindergarten children spend playing video games, and are there gender differences in the amount of time spent playing?" This question was asked to investigate in more detail, from those children that played video games, how often did they play? In order to answer this question, the data collected from the second part of item 11 on the parent questionnaire (Appendix A) was analyzed. This item asked parents to check off one of five possible categories of time frames for the amount of time their child spent playing video games per week. The options were: none, less than 30 minutes, 30 minutes to 1 hour, 1 hour to 3 hours, and more than 3 hours.

Descriptive analysis yielded some interesting findings. Despite the increasing presence of video game playing in children's lives, the majority of children were reported as playing for less than 3 hours *a week* (that is, averaged to less than 26 minutes a day). This finding is not consistent with earlier research which suggested that for young children between the ages of four and six who played video games, the average amount of time they played was a little over one hour *per day* (Rideout et al, 2003). The Rideout et al. study was conducted in 2003 and involved a nationally representative telephone survey of more than 1000 parents. It would be expected that the amount of time spent playing would increase and not decrease considering the increasing number of games and devices that have become more accessible for young children. The data collection for the Rideout et al. (2003) study was conducted using a telephone interview of random samples, whereas for this study parents were required to return the questionnaire to their child's teacher. Although parents were aware that the responses were confidential and no one but the researchers would have access to the data, parents may still have been uncomfortable giving fully accurate reports because the questionnaires were returned to the schools. It is possible that parents in this study may have underrepresented the amount of time their child spent playing per week so as to not reveal a negative parenting style. Most parents consider video gaming to be a negative influence, and media has typically represented video game playing as detrimental for young children (Prensky, 2008; Rideout, 2003). Parents, therefore, may have been hesitant to admit to their child's playing more than three hours per week, the maximum indicated on the survey.

The inferential analysis indicated that boys played video games for a significantly longer amount of time per week than girls. This is consistent with earlier research with young children (Rideout, 2003) and adults (Terlecki & Newcombe, 2005). There are several factors that may contribute to this finding. From a biological perspective, this finding supports the notion that there may be an innate gender disposition towards more spatially oriented play and that this disposition is stronger in males than females. From a more environmental perspective, this finding may be due to the types of video games available for young children to play and the prevalence of more boy oriented games. In addition, research indicates that 93% of parents who play computer and video games have children who also play them (Entertainment Software Association, 2007). As adult research has indicated that men tend to play video games more than woman (Quaiser-Pohl & Lehmann, 2002), boys may be playing more male oriented games at home with their fathers. Boys also may be more likely to play video games due to peer interactions as children are beginning to form social bonds at this age and the video gaming experience may be one of the ways that children engage socially (Prensky, 2008).

Research question three.

The third question addressed in this study was, “What is the relationship between kindergarten children’s gender, amount of video game playing, and performance on mental rotation tasks?” In order to answer this question, the data collected from the second part of item 11 on the parent questionnaire (Appendix A) described above in the *Research question two* section, and scores from the *Mental Rotation Task* were analyzed. The results from this analysis yielded some interesting findings.

First, the descriptive analysis of the mental rotation task scores indicated a high range of scores varying from a score of 0 to a near perfect score of 13. This finding is consistent with developmental theories that suggest that the development of mental processes is highly individualized and that there may be multiple influences on the development of these skills. Developmental theories have suggested that children typically below the age of 7 are not able to "mentally reverse a physical action to return an object to its original state" (Labinowicz, 1980, p.86). The findings from this study may therefore be explained in that regard; some of the children who were not able to perform this task may not be developmentally ready to perform this task. On the other hand, the findings also indicate that the age range developed by these theorists for this type of thinking may not be accurate, because on average the children in this study, who were below seven years old, were able to complete five out of 13 mental rotation tasks.

The other area that was explored was the suggestion from research that there may be some inherent strength in mental rotation abilities, and this inherent strength is stronger in males than females. Results from the inferential analysis indicated that gender did have an effect on the amount of time children played video games as reported earlier under *Research question two;* however, there was no significant effect of gender on the mental rotation scores. This finding was not consistent with some of the earlier research conducted with young children that showed significant gender effects on mental rotation task performance at even a young age (Casey et al., 2008; Ehrlich et al., 2006; Levine et al., 1999; Moore & Johnson, 2008; Pruden, Levine, Huttenlocher, 2011; Quinn & Liben, 2008). As stated earlier, however, the amount of research conducted with young children, using developmentally appropriate measures, is limited, and the representativeness of the data collected in this study will ultimately be determined by future continuing research.

Research has indicated that engagement in spatially oriented play activities may strengthen mental rotation abilities. To further investigate the possibility that the variation of scores on the mental rotation task in this study may be due to individual experiences with spatial play activities, an analysis of variance was conducted to examine if reported home video game playing had an effect on the mental rotation scores.

Participants were grouped by gender as well as by the amount of time they reported playing video games. One of the most interesting findings within this study was the non-significant effects found for group comparisons. It was thought that as in experimental studies done with older children and adults, the more time children spent engaged in video game playing, the higher their scores would be on a mental rotation assessment, and that this effect would be stronger for males than females. Inferential analysis of the results indicated that there was no main effect for the amount of time children played video games on mental rotation skills, no main effect for gender, and no significant interaction effect of gender and video game playing. One possible explanation for the lack of differences may be, as stated earlier, related to the developmental nature of this ability and that the development of these skills is a gradual process. At the kindergarten level, the experiences gained from this type of spatial play may not yet be influential enough to develop strong mental rotation skills, and that the effect of the playing may become more evident in later years.

Alternatively, it may be the particular type of video game played by the children that influenced the results. If knowledge is constructed as a result of experiences, then the type of experience the game provides would affect the type of knowledge constructed. Therefore, though an effort was made to only include the data that indicated the gaming devices that typically present games that involve mental rotation skills, it is possible that the children who played video games may not have been playing those games that helped them to construct these abilities.

However, it may be that the development of the mental rotation abilities gained by the game play may not have been provided in a context that would transfer the learning to successfully complete the task that was presented. Some theories of learning suggest that a *near transfer* of learning would take place only if two tasks contained similar or common elements. *Far transfer* tasks on the other hand involve skills and knowledge applied in situations that change and are considered more difficult for the transfer of learning (Cree & Macaulay, 2000). Some of the earlier studies conducted with young children involved the use of block play as part of the intervention to improve mental rotation task performance (Casey et al., 2008). It is possible that this type of play is more closely related (near transfer) to the mental rotation task than those presented in the video games played by the children. The playing of the video game *Tetris*, for example, has been shown to improve mental rotation skills (Cherney, 2008; DeLisi & Wolford, 2002), possibly because of the similarity in task performance between the game and the mental rotation assessment. Therefore, though there may have been an influence of the game playing on the development of mental rotation abilities, it may not have occurred in a context that allowed for a *near transfer* of the learning. Clearly, more research is needed to investigate these possibilities.

Research question four.

The final research question addressed in this study was, "Which gaming devices are used by kindergarten children?" In order to answer this question, the data collected from item 12 on the parent questionnaire (Appendix A) was analyzed. This item asked parents to list which games and which gaming system their child played with. The results from the descriptive analysis indicated that the most popular gaming device used by kindergarten children is the *Wii* and the least popular gaming device was the *X-box*. The most likely explanation for the *Wii* being most popular with young children is that numerous games for this gaming device involve movement and activity, which young children naturally prefer. In addition, this particular device has many games rated *Early Childhood* compared with the other gaming systems that have few or none in that category (GameStop, 2012).

Limitations of the Study

As stated in the Methods section of this study, there are disadvantages to the use of a causal-comparative research design. The study is not experimental: there is no assignment of participants to treatment and control groups. In this type of design, presumed causes for effects have taken place prior to the initiation of the study and in a natural setting. The results from this study and any inferences to causality are markedly tentative (Gall et al., 2003).

In addition, this study used archival data, and therefore the methodology for data collection and instrumentation were not specific to the objectives of this investigation. The parent questionnaire, for example, did not include items that would have provided a more detailed and clear distinction of the types of games that are classified as video games. In addition, the questionnaire instrument was newly designed and was specifically developed for the primary purpose of examining block play behaviors of young children in addition to other spatial oriented play behaviors and included a very limited number of questions pertaining to video game play.

Another possible limitation of this study relates to the accuracy of reporting video game playing behaviors by parents who completed the survey. As stated earlier, video game playing is not considered as a positive play experience by most parents, particularly if the game played by young children involves any form of aggression (Prensky, 2008). Parents, therefore, may have understated the amount of time their child plays with video games.

Implications

Implications for further research.

As the results of this study must be approached with caution due to the causal-comparative design, future research with an experimental design is warranted. This study clearly demonstrated that young children are actively engaged in video game playing; however, very little is still known on what effects the game playing has on their cognitive development. Because this study showed no effect of game playing on spatial abilities evident at the kindergarten level, additional studies involving a longitudinal design would provide further information on whether the effects of the home video game playing present themselves in later years. Researchers that include a parent survey will be cautioned to use wording that encourages parents to more honestly report their child's video game playing habits, because results from this study may have been affected by the hesitation of parents to disclose extensive video game play. In addition, research is needed that more specifically investigates the amount of time and type of games young children play, because the choice of games may be a factor in the type of cognitive processes it influences. Finally, research that more closely examines the cognitive processes required and developed through the games that are specifically played by young children is required to further investigate how this type of play influences spatial skills development.

Implications for practice.

This study demonstrates that children at the kindergarten level are able to perform mental rotation tasks. Educators should consider providing activities to strengthen these abilities for both boys and girls and incorporate activities that require children to mentally visualize and transform objects or images into the kindergarten curriculum. Particular attention should be made for activities that capture young girls' interests; as this study shows that at this age the mental rotation abilities do not significantly differ between genders. Research has clearly indicated that in later years a differentiation in abilities is evident (Linn & Peterson, 1985), therefore, educators should try to ensure that at a young age both genders gain experiences that may strengthen their mental rotation skills.

This study also clearly indicates that the majority of kindergarten children play video games and that this is a growing trend. This information suggests that it is important for educators to try and understand and incorporate this interest into the curriculum. According to Prensky (2008), the easiest way to bring video games into the classroom, and the way that will bring the biggest reward, would be to introduce the games the children play at home and discuss them in the classroom, allowing the children to guide the discussion and share their experiences. He suggests to use the principles behind good, complex games and make teaching more game like or to play a class video game designed for education, or give a homework assignment that involves game playing. Finally, he suggests playing a commercial, off the shelf game not specifically designed for education, in class as a whole, projected in front of the class. These suggestions may help our educational system be redesigned for the modern world and modern children (Prensky, 2008).

Summary

The results from this research study provided useful empirical data on children's mental rotation abilities, adding to the limited studies within the realm of early childhood research. This study's finding that at the kindergarten level, there appears to be no differentiation between genders on mental rotation task abilities is telling in that it suggests that this is a developing skill and that at least at this young age, there is no significant male advantage. The results from this study also provided empirical data on young children's video game playing differentiated by gender. The findings of this study indicated the strong prevalence of this type of play in young children's lives. This information can be used by teachers and game developers to find better ways of making the game playing experience one that positively affects both boys' and girls' development. Finally, the study provided empirical data not yet explored in previous research, related to the interaction of home video game play and mental rotation abilities for kindergarten children

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APPENDIX A

PARENT CONSENT AND QUESTIONNAIRE

CONSENT:
I HAVE READ (OR HAVE HAD READ TO ME) THE CONTENTS OF THIS CONSENT FORM AND HAVE BEEN ENCOURAGED TO ASK QUESTIONS. I HAVE RECEIVED ANSWERS TO MY QUESTIONS.

I give my consent for (PLEASE CHECK WHERE APPROPRIATE):

(1) My child's participation in the assessment sessions with the interviewer.
YES ____ **NO** ____

(2) Videotaping of my child in the assessment sessions with the interviewer. These individual videotapes will be kept strictly confidential.
YES ____ **NO** ____

(3) Potential use of the videotapes for scientific presentation and as teaching tools
YES ____ **NO** ____

First and last name of my child (print name):______________________________

Parent/Guardian (print name): ______________________________

Signature of Study Subjects Parent/Guardian: ______________________________

Date: ______________________________

Thank you for your participation in this study.

PLEASE RETURN TO YOUR TEACHER

Parent Consent and Questionnaire Packet

Children's Block Play

University of Houston

Early Childhood Research

The purpose of this consent and questionnaire is to give the University of Houston Early Childhood Research Group permission for your child to participate in the study and to provide us with information about your children's at home block play. Please complete the following 12 questions and return the questionnaire and consent form to your child's teacher by _______________________________________. The letter and extra consent form in the first set of documents are meant for your own records. The consent form and questionnaire attached to this document are to be returned to us.

Thank you for your participation.

Child's Name: ____

Child's Teacher's Name: ____

PLEASE RETURN TO YOUR TEACHER

Question 1
Does your child play with blocks at home? *Please check.* **Yes ___** **No ___**
If yes, how much time per week? *Please check.* **None _____** **Less than 30 minutes_____** **30 minutes to 1 hour_____** **1 hour to 3 hours_____** **More than 3 hours______**

Question 2
Does your child play with LEGO blocks at home? *Please check.* **Yes ___** **No ___**
If yes, how much time per week? *Please check.* **None _____** **Less than 30 minutes_____** **30 minutes to 1 hour_____** **1 hour to 3 hours_____** **More than 3 hours______**

Question 3
Does your child play with blocks or LEGO blocks with a sibling? *Please check.* **Yes ___ No ___**
If yes, how much time per week? *Please check.* **None _____** **Less than 30 minutes_____** **30 minutes to 1 hour_____** **1 hour to 3 hours_____** **More than 3 hours______**

Question 4
Do you own a computer? *Please check.* **Yes ___ No ___**

Question 5
Does your child use the computer? *Please check.* **Yes ___ No ___**

Question 6
Does your child play games on the computer? *Please check.* **Yes ___ No ___**

Question 6
If yes, how much time per week? *Please check.* **None _____** **Less than 30 minutes_____** **30 minutes to 1 hour_____** **1 hour to 3 hours_____** **More than 3 hours______**

Question 7
What games does your child play on the computer? *Please list all.* ______________________________ ______________________________ ______________________________ ______________________________ ______________________________ ______________________________ ______________________________ ______________________________ ______________________________ ______________________________ _________________________

Question 8
Do you have internet access at home? *Please check.* **Yes ___** **No ___**

Question 9
Does your child play internet games on the computer? *Please check.* **Yes ___** **No ___**
If yes, how much time per week? *Please check.* **None _____** **Less than 30 minutes_____** **30 minutes to 1 hour_____** **1 hour to 3 hours_____** **More than 3 hours______**

Question 10
Which internet games? *Please list all.* ____ ____ ____ ____ ____ _________________________ ____ ____ ____ _______________

Question 11
Does your child play with video games at home? *Please check.* **Yes ___** **No ___**
If yes, how much time per week? *Please check.* **None _____** **Less than 30 minutes_____** **30 minutes to 1 hour_____** **1 hour to 3 hours_____** **More than 3 hours______**

Question 12
Which video games and which video game systems (Nintendo, Wii, Play Station, Other?) *Please list all.*

APPENDIX B

MENTAL ROTATION TASK

3-D Mental Rotation Scoring Sheet

Date: ___________ `

Pre-test: _____

Post-test:_____

Tester: ___________________

Note to receive a **correct score the child must complete the move within 10 sec**. from when they touched the shape. **Record # seconds**, and whether the response was a **first try or trial and error**.

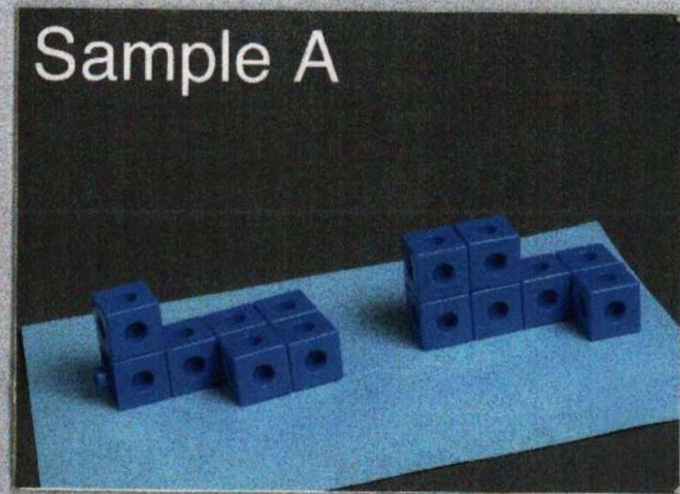
Stop testing when the child reaches **3 items in a row incorrect** (based on the 10 sec. time limit).

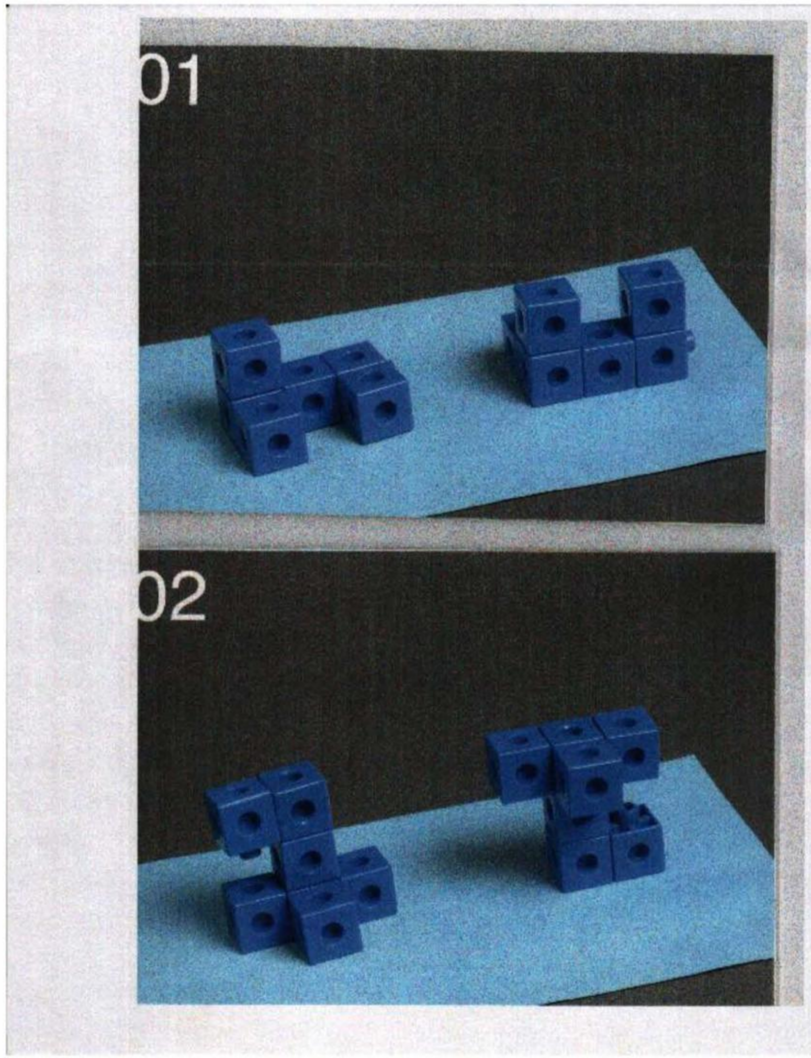
Sample ____

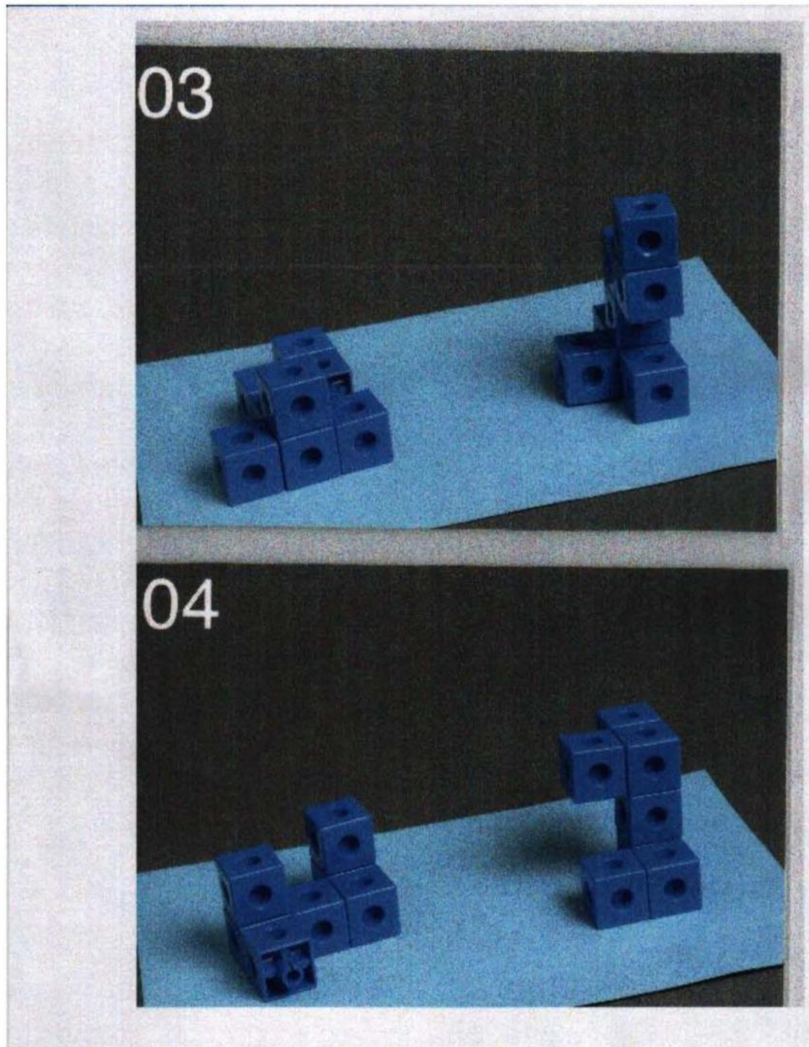
	Sec	Score_		Correct in Time
		(1=correct	**0=incorrect)**	
1.	______	1	0	_____
2.	______	1	0	_____
3.	______	1	0	_____
4.	______	1	0	_____
5.	______	1	0	_____
6.	______	1	0	_____
7.	______	1	0	_____
8.	______	1	0	_____
9.	______	1	0	_____
10.	______	1	0	_____
11.	______	1	0	_____
12.	______	1	0	_____
13.	______	1	0	_____
14.	______	1	0	_____

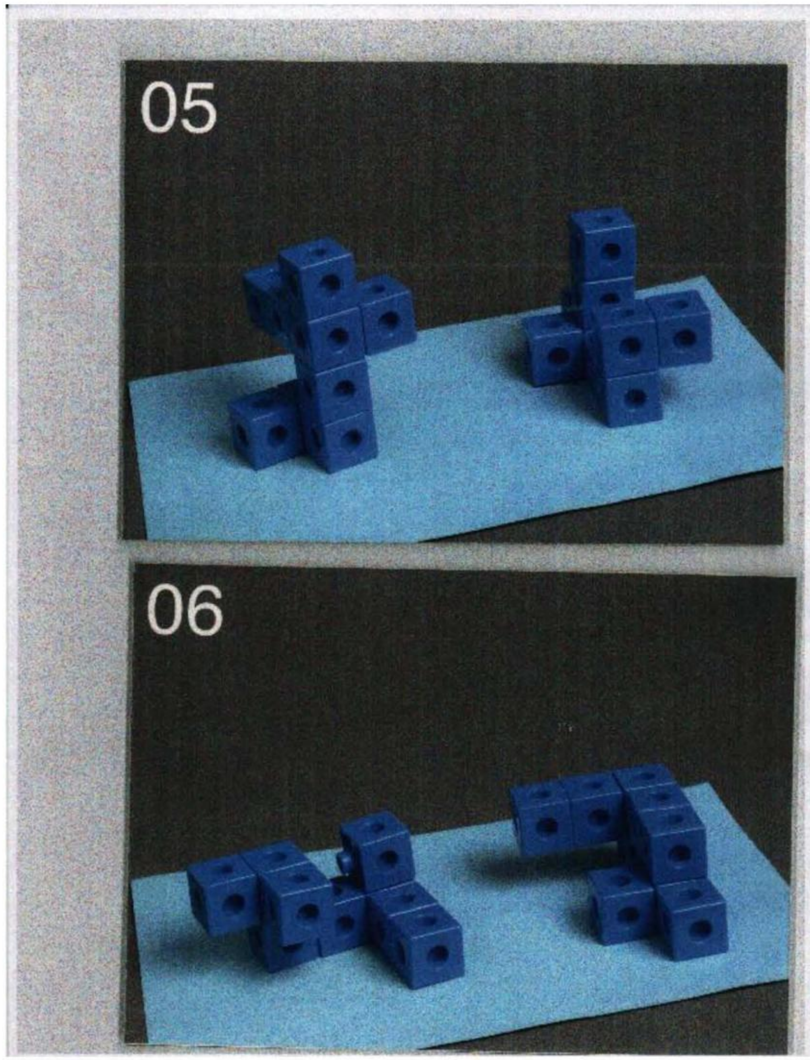
Notes:

3D Mental Rotation Set-Ups




01
02


03
04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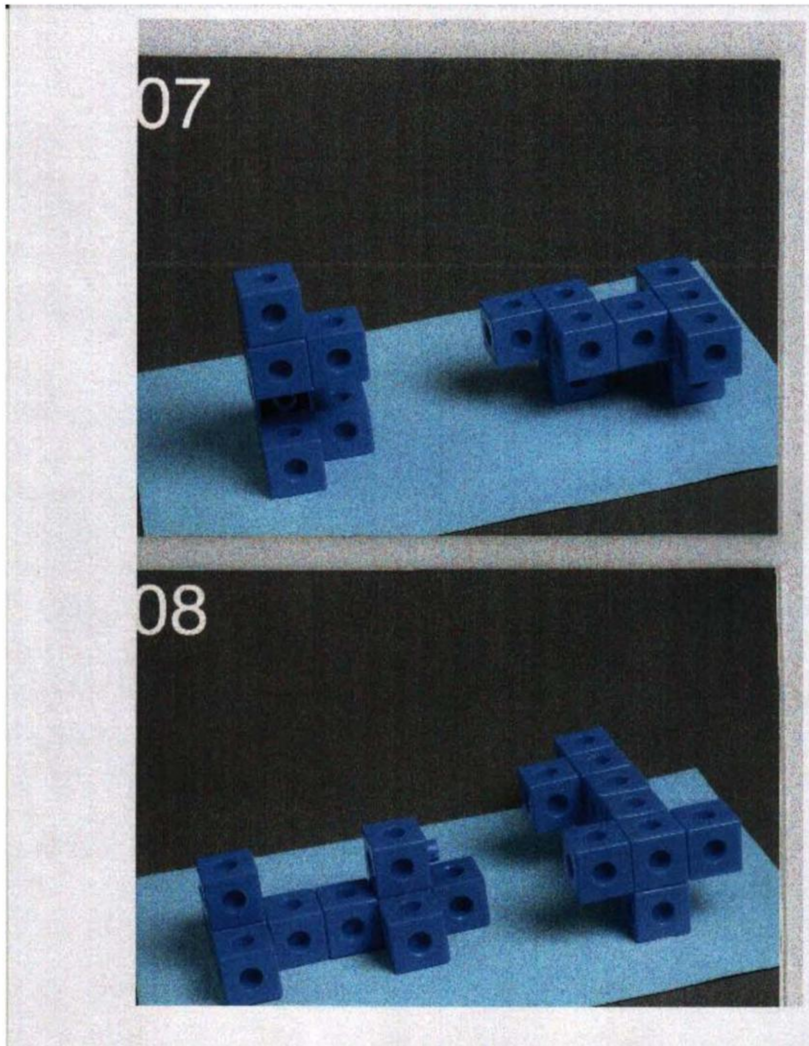
06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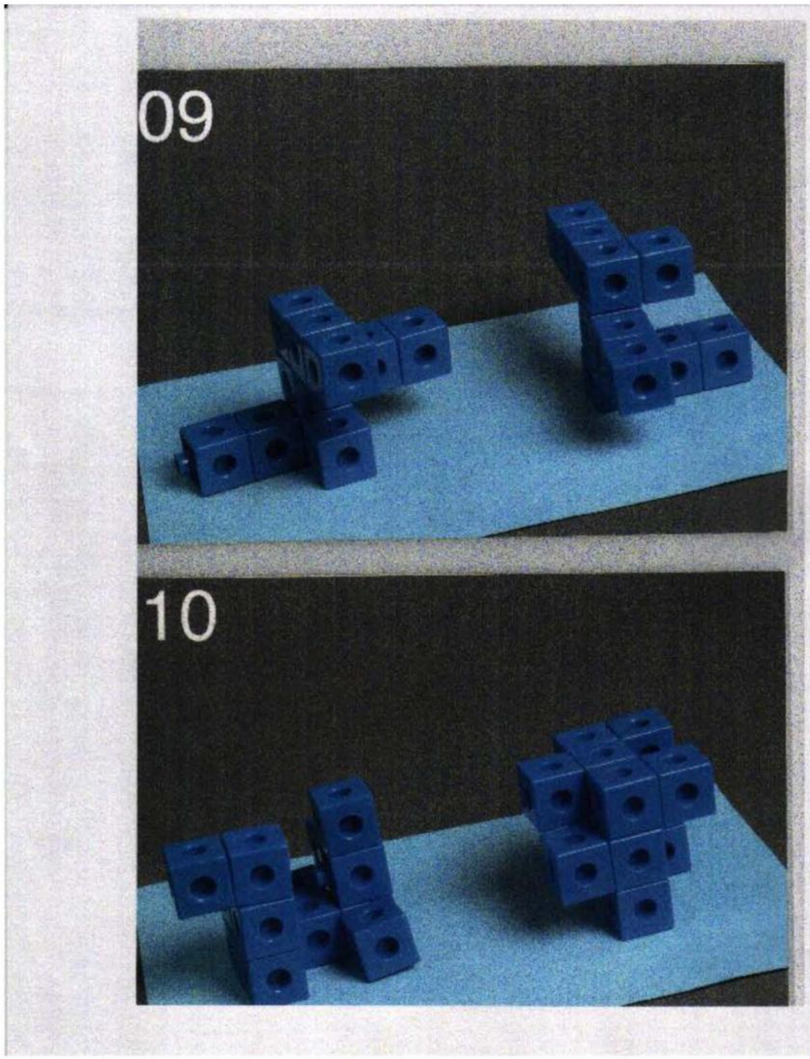
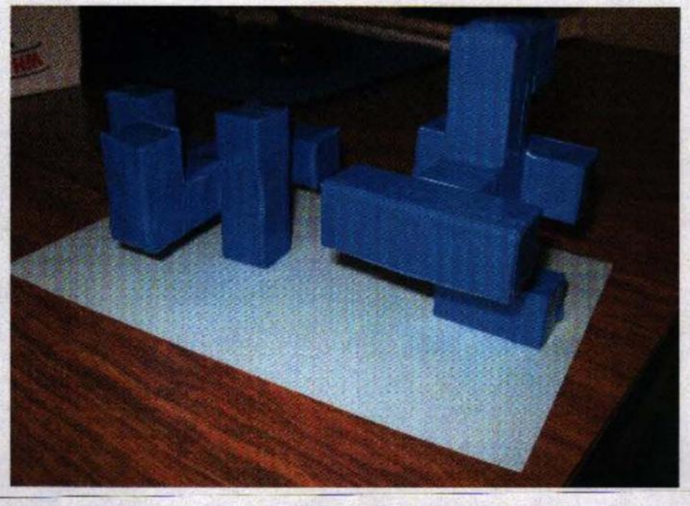
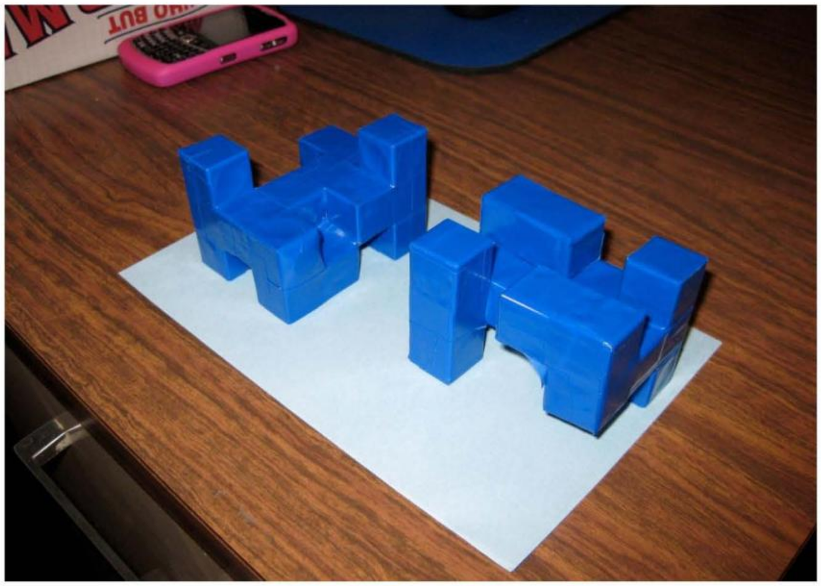

09
10





APPENDIX C

MENTAL ROTATION PROTOCOL

3-D Mental Rotation Task -Transformations Using Multi-Link Cubes

Notes to Tester

- Set up all the shapes in the box on a chair in advance and display them in their correct orientation (for sample and problems 1-14).
- Use photos to determine orientation of each shape for each item.
- Cover display of shapes and/or make sure child cannot see them.
- For each trial, take out the correct shapes for that item from the box and place on blue cardstock in the correct orientation and placement.
- Student will have **10 sec. for completing** each item.
- **Start timing** from the moment the child **touches shape**.
- **Stop timing** when he/she **lets go** of the shape **and** child clearly indicates she/he is finished (or 10 sec. up). **However if the child places the shape in the correct orientation by 10 sec., but doesn't remove their hand until after, record it as 10 sec.**
- **If child says he/she can't figure it out**, ask to try again. (e.g., ***Try again. I bet you can do it.***). If still says no, go to next problem.
- **If student asks you to show how**, say, ***I am trying to see what you can do with shapes. I want to see how you play the game.***
- **End item** if the child indicates, verbally or non verbally, that rotation is completed. If you are unsure, be sure to ask if he/she is done.
- **End item** if child is responding randomly or nonproductively. (Indicate in the Scoring Sheet).
- **If child wants to stop the TEST** and return to the classroom, encourage child to stay and finish (e.g. ***Try again, I bet you can do it or ask if they want to try another one.***). If the child still says no, then stop the testing.
- **The sample problem** will not be scored. Feedback is given for correct and incorrect responses.
- **For problems 1-14, do NOT** give any feedback to the student indicating whether the structure is correct or incorrect.
- **Get the hand preference of the child from the teacher in advance and set up the blocks in the L-R position based on handedness.** If the child switches hands, note it on the score sheet, but count the response even if they move the wrong object. If they use the wrong object on 3 consecutive trials, then switch the objects around, so they are selecting the choice object. If they constantly change, note this, and use your best judgment.

Scoring

- **Record number of seconds** to complete task.
- **Record from time child touches shape to when child lets go** and clearly indicates she/he is finished (or 10 sec. up). If not clear, ask if finished. If not, let child continue until 10 sec. up.
- **Stop after 10 sec**. If child finishing up, let them continue briefly, **but count this item as an error**.
- Record whether correct (1) or incorrect (0) within 10 sec. time limit. **However if the child places the shape in the correct orientation by 10 sec., but doesn't remove their hand until after, record it as 10 sec.**
- If child does get correct response **after time limit, record in notes, but count item as incorrect.**

Instructions

- Behind screen, take shapes from display and place the shapes for that item on blue cardstock. Cover/hide display again.

- Remove screen, and place cardboard with shapes place in front of child.
- Shape that child will move is the one on the right of the child (or on the left if left-handed).
- **Sample Problem** researcher gives feedback and models for child if needed. Researcher does not record child's performance in recording sheet.
- During Test (Problems 1-10) **researcher** does not model responses, does not give feedback**, and RECORDS student's performance in scoring sheet.**
- See Photo Cards for correct placement of shapes. Set up shapes in boxes. Put the first box on the table in front of the child and the second box on a chair.

Sample:
We are going to play two games. During these games you can sit in the chair or stand, whatever is more comfortable.

Now, we are going to practice together on the first game. This is how it works. These two shapes are exactly the same.

Place sample shapes on the cardboard next to each other, in the same position/orientation.

Do you see how they look exactly the same and go the same way? I am going to hide these, and I am going to move one so it looks different.

Put shapes behind the box and change the position of one, based on sample photo.

Here they are.

Move shapes in front of child. Shape with new orientation is to the right of the child, shape with original orientation is to the left of the child (unless the child is left-handed).

Model: ***Now I'm going to make them look the same again. But, I'm not going to touch it, until I know how to move it to make the shapes go the same way. Ok, I'm thinking hard, and imagining in my mind how to move this shape*** (point to the shape in the new orientation).

When I'm ready, then I can touch the shape and move it. Pause for a couple of seconds, and think. Then say

Ok, I'm ready.

Move shape back to original position using a two-step process (i.e., flip and turn).

See how the two shapes look the same again?

Now you try, I am going to move one so it looks different again.

After a moment, move the shape again so it is in the orientation shown on the photo to give the child a chance to solve the problem.

I want you to move this one (point to shape to the right of the child) ***so it goes the same way as this one*** (point to shape on the child's left).

Before you touch it, look all over both shapes carefully. Then, think real hard about how you are going to move it. When you're done thinking, then you can touch it and move it.

If you are not sure if child is finished, ask:

Are you finished? Wait for response.

If student is correct, say:

I think you are right.

If student is incorrect, say:

I think that you need to move the shape a different way to make it the same as this one (point***).***

For a second time, model the correct placement of the shape in front of child.

Return shape to incorrect position again and ask child:

Try again. How can you make this one (point) ***go the same way as this one*** (point***)?***

Do not record student performance for sample. However, if child is **incorrect a second time** move on to problem 1, but note this on the score sheet.

Instructions for Problem 1
Great, now let's try the first one. Take out Item 1 from the box and place in front of student.

I want you to move this one (point to shape on the child's right) ***so it goes the same way as this one*** (point to shape on child's left).

Look at it carefully before you move it.

Try to move this one (point to shape on the child's right) ***so it goes the same way as this one*** (point to shape on child's left).

Take as much time as you need. Move it when you're ready and tell me when you are done.

Time from the moment child touches the structure until child lets go of it. Stop timing when the child indicates verbally or nonverbally (e.g., removes hand from structure) he/she is finished. If unsure, ask child:

Are you finished? Wait for response.

Instructions for Problems 2-14
Ok, let's try the next one. (get shapes)

Between each item, say ***Okay***.

Beginning with the 2nd item, just say ***Move this one.***

If the child keeps touching the object too soon, say ***Remember to think real hard before you touch it.***

APPENDIX D

CHILD ASSENT

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Informed Assent From for
The Development of Spatial Skills through
an Intervention involving Virtual Block Building
Project Director: Dr. Nicole Andrews

Child Name: ________________________ Tester name: ________________________

School/Teacher: _____________________ Date: ______________________________

Procedure for acquiring
ASSENT FOR PARTICIPATION

"Today I would like to play some games with you. I want to understand how children see blocks when they are turned or flipped. After we play, I will come back and show you how to use blocks on the computer and you will have time during the day to play. I will come back and we will play this game again in about 2 months. You can play the games only if you want to. Also, if you decide you don't want to continue to play with me, you can stop any time you would like. No one will get mad at you if you don't want to play the games. Please ask questions if there is anything you don't understand."

"Do you want to play some games?"

Record child's answer: ______ Yes ______No

If the answer is NO, thank the child and escort her/him back to the class.