University of Alberta

PASS Theory of Intelligence and Giftedness

by

Mariam Abougoush

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Abstract

The purpose of the present study was twofold: (a) to examine what PASS processes differentiate gifted children from chronological-age controls and (b) to examine what PASS processes predict reading and mathematics achievement. Twenty-six gifted children (13 females; mean age = 10 years and four 4 months, *SD* = .94) and 26 controls (10 females; mean age = 10 years and 7 months, *SD* = .94) were assessed on Cognitive Assessment System (Naglieri & Das, 1997), Broad Reading, and Broad Mathematics (Woodcock, McGrew, & Mather, 2001). Results showed that the groups differed significantly on simultaneous and successive processing. Whereas planning, simultaneous, and successive processing were unique predictors of reading, planning and simultaneous processing were unique predictors of mathematics. These findings suggest that gifted children have a more efficient information processing system that influences how fast they encode incoming information and recode existing information.

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Chapter 1: Introduction

The Planning, Attention, Simultaneous and Successive (PASS) processing theory of intelligence (Das, Naglieri, & Kirby, 1994), which claims that human cognitive functioning is the product of four interdependent but separate cognitive processes, has received considerable attention over the last few decades (see Naglieri & Otero, 2011, for a review). Guided by the PASS theory, several researchers have examined the cognitive profile of different groups of children such as those with dyslexia, dyscalculia, and Attention Deficit Hyperactivity Disorder (ADHD) (Das, Janzen, & Georgiou, 2007; Deng, Liu, Wei, Chan, & Das, 2011; Huang, Bardos, & D'Amato, 2010; Naglieri, Salter, & Edwards, 2004). A group of children that has not been studied to the same extent is that of gifted children. Therefore, the present study aims to address this gap in the literature by first examining how gifted children perform on the four PASS cognitive processes relative to chronological-age controls. Examining the cognitive profile of gifted children not only adds to the existing knowledge of PASS theory, but also provides educators and practitioners with an indication of which processes need to be fostered in order to enhance learning in gifted children (Das & Janzen, 2004). This will ultimately lead to better educational experiences for gifted children and assist in the movement towards reducing the high prevalence of underachievement within gifted children (Reis & McCoach, 2000).

Based on the findings of previous studies examining the role of problem solving, working memory, and attention in gifted children (Calero, García-Martín, Jiménez, Kazén, & Araque, 2007; Chae, Kim, & Noh, 2003; Georgiou, Das, &

Hayward, 2009; Naglieri & Das, 1997; Shi, Tao, Chen, Cheng, Wang, & Zhang, 2013; Sriraman, 2003; Threlfall & Hargreaves, 2008), we hypothesized that gifted children would perform significantly better than controls on planning, simultaneous, and successive processing.

The second goal of this thesis was to examine which PASS processes predict reading and mathematics ability in our group of high achievers. To date, the few studies that have examined the relation between PASS and reading or mathematics ability have shown mixed findings (Das, Georgiou, & Janzen, 2008; Georgiou, Manolistis, & Tziraki, in press; Joseph, McCahran, & Naglieri, 2003; Naglieri & Rojahn, 2004; Papadopoulos, 2001; Wang, Georgiou, & Das, 2012). The findings are expected to clarify which processes predict reading or mathematics and which ones predict both.

Chapter 2: Literature Review

PASS Theory of Intelligence

The Planning, Attention, Simultaneous and Successive (PASS) theory of intelligence was formally developed in 1994 (Das et al., 1994) and is based on the work of Alexander Luria, a Soviet psychologist who examined the functional organization of the human brain and its operations (see Das, 2002, for the history of PASS theory). According to Luria (1966, 1973), intelligence is built upon three separate functional units that provide support to four cognitive processes. The first functional unit is responsible for the maintenance of attention; the second is responsible for receiving, processing, and storing information through simultaneous and successive processing; and the third is responsible for programming, regulating, and directing mental activity through planning. Human cognitive functioning is accomplished through the integration of the four PASS processes, each of which is described in greater detail below.

Planning. When presented with a problem, the course of action is to determine how the problem can be solved. Ultimately, this relies on the cognitive process of planning (Das et al., 1994). Planning involves setting goals and determining, selecting, and using efficient plans to attain the desired goal. Once goals are set and the need for a plan is determined, the individual either searches his or her prior plans as an approach to solve the problem or the development of a new plan is established. Prior to implementation, the plan must be examined to determine whether it is suitable and reasonable to solve the present problem. Once an acceptable plan is established, the individual then begins the process of implementation. Continuous modification and implementation of the plan takes place until the task is successfully completed.

Attention. At the base of human mental processing lies the cognitive process of attention. It is said that attention is supported through the maintenance of appropriate arousal levels; in which arousal is defined as the state of being active (Das et al., 1994). Furthermore, provided an appropriate state of arousal, the two broad classes of attention, namely selective and divided attention (Kahneman & Treisman, 1984) may take place. Whereas selective attention directs the individual to focus or act on relevant stimuli while ignoring other irrelevant stimuli, divided attention helps the individual to successfully focus or act on multiple stimuli while still maintaining efficiency. According to Das (2003), once a person has been appropriately aroused and their attention is sufficiently focused, the individual can then utilize the rest of the cognitive processes. It is recognized that poor functioning of attention leads to problems with both information coding (simultaneous and successive processing) and planning, since these cognitive processes can become underaroused or overaroused (Das et al., 1994).

Simultaneous and successive processing. Exposure to the external world requires individuals to receive, process, and retain information. The cognitive processes responsible for this are simultaneous and successive processing. Simultaneous processing involves organizing stimuli into groups and recognizing that these stimuli share common features/characteristics (Das et al., 1994). The hallmark of simultaneous processing is that the elements of the stimuli are interrelated (considered in relation to each other) and viewed as a whole. The ability to comprehend language relies on simultaneous processing. For example, we would rely on simultaneous processing to answer the question “how many windows do you have on the second floor of your home?”

Although it also involves organization of stimuli, successive processing requires a different type of arrangement. To distinguish successive from simultaneous processing we must take a look at the way the stimuli are coded. As noted earlier, in simultaneous processing each piece of information poses some relationship with one other, whereas in successive processing the stimuli are arranged in a specific series in which the elements are only linearly related (Das et al., 1994). An individual will rely on successive processing when he or she performs tasks requiring information to be remembered or completed in a specific order such as remembering the sequence of a telephone number.

PASS and Reading

Several studies have shown that PASS processes are related to reading ability (e.g., Crawford, 2002; Das et al., 2008; Das, Mishra, & Kirby, 1994; Kirby & Das, 1977; Naglieri & Das, 1987, 1990, 1997; Naglieri & Rojahn, 2004; Wang et al., 2012). Naglieri and Rojahn (2004), for example, examined the relationship of PASS processes with different reading measures in a large scale study with 1559 children ages 5 to 17. The correlations of Broad Reading (Letter-Word Identification and Passage Comprehension) with planning, attention, simultaneous, and successive processes were .48, .43, .55, and .50, respectively.

Despite the plethora of studies documenting that PASS processes correlate well with reading, the findings of studies that examined the unique contribution of PASS processes to reading are mixed (e.g., Das et al., 2008; Joseph et al., 2003; Leong, Cheng, & Das, 1985; Naglieri & Rojahn, 2004; Papadopoulos, 2001; Wang et al., 2012). For example, Joseph et al. (2003) showed that the PASS processes together accounted for 36% of the variance in basic reading skills (Word Identification and Word Attack). However, only simultaneous processing among the PASS processes was a significant predictor of reading. On the other hand, Das et al. (2007) found that the PASS processes accounted for 26% of the variance in Word Identification and 29% of the variance in Word Attack, but only successive processing was a significant predictor of both reading skills.

Some researchers have argued that the relationship between successive processing and word reading is mediated by phonological recoding (Das et al., 2007; Kirby & Das, 1990; Papadopoulos, 2001; Wang et al., 2012). The strong relationship between successive processing and phonological recoding would be expected because in phonological recoding the individual sounds in a word must be retrieved from memory and blended together in a specific sequence. In turn, researchers have argued that the relationship between simultaneous processing and word reading is mediated by orthographic processing (Das et al., 2007; Papadopoulos, 2001; Wang et al., 2012). The strong relationship between simultaneous processing and orthographic knowledge would be expected given that orthographic knowledge involves the correct spelling of words that could be achieved only if children process the words as whole units.

Although a theoretical link between simultaneous/successive processing and word reading has been proposed, the way planning and attention may relate to reading still remains unclear. According to Janzen (2000), planning is understood to be an important process underlying reading achievement in general, while attention is understood to be a requirement for any cognitive task.

The connection between PASS processes and reading has also been shown through intervention studies. For example, PASS Reading Enhancement Program (PREP; Das, 1999) was designed with the intention of improving simultaneous and successive processing. Several studies have shown that children's reading ability improved as a result of PREP training (e.g., Boden & Kirby, 1995; Carlson & Das, 1997; Das, Mishra, & Pool, 1995). Carlson and Das (1997), for example, examined the effects of PREP on reading ability between two groups of 25 fourth grade children with documented reading difficulties. The remediation group received PREP and the comparison group received traditional classroom instruction. Grade level comparisons showed that whereas the remediation group increased from 2.9 years to 3.6 years on Word Identification, the comparison group went from 3.0 years to 2.9 years. Additionally, whereas the remediation group increased from 2.6 years to 4.4 years on Word Attack, the comparison group went from 2.0 years to 2.4 years.

PASS and Mathematics

The relationship between PASS processes and mathematics has not been studied to the same extent as reading and no theoretical framework has been provided linking PASS processes to mathematics. Despite the dearth of research in this area, a few studies have examined the relationship between PASS processes and mathematics ability (Georgiou et al., in press; Kroesbergen, Van Luit, & Naglieri, 2003; Kroesbergen, Van Luit, Naglieri, Taddei, & Franchi, 2009; Naglieri & Rojahn, 2004). Naglieri and Rojahn (2004), for example, have reported that the correlations of Broad Mathematics (Calculation and Applied Problems) with planning, attention, simultaneous, and successive processes were .54, .47, .58, and .45, respectively.

Similar to reading, the results of the studies examining the unique contribution of PASS processes to mathematics are mixed (e.g., Georgiou et al., in press; Kroesbergen et al., 2009). For example, Kroesbergen et al. (2009) found that PASS processes jointly accounted for 46.5% of the variance in early mathematics, but only planning and simultaneous processing were significant predictors. In contrast, Georgiou et al. (in press) reported that PASS processes jointly accounted for 36% of the variance in mathematics at the end of Kindergarten and 30% of the variance at the end of Grade 1, but none of them was a unique predictor of early mathematics ability.

Intervention studies that focused exclusively on planning have also shown a positive outcome on children's mathematics ability (see Hald, 1999; Naglieri & Gottling, 1995, 1997; Naglieri & Johnson, 2000). Naglieri and Gottling (1997), for example, found that when two groups of students (poor in planning and high in planning based on D-N CAS) were given eight weeks (half hour blocks either two or three times a week) of instruction in planning the poor planning group improved in their mathematics performance more than students who did not score poorly in planning.

Giftedness

Definition of giftedness. Decades of research exploring the study of giftedness have resulted in a handful of theories and definitions (see Sternberg, Jarvin, & Grigorenko, 2011, for a review). These theories and definitions hold importance because they play a significant role in shaping how children are identified as gifted (Flanagan & Harrison, 2012). For the purpose of this thesis, I will provide next a short review of the most prominent theories and definitions of giftedness and then discuss where Alberta Education’s definition falls within these theories. A common feature of these theories is the movement towards broad definitions of giftedness, which recognize giftedness as encompassing many abilities and traits, rather than solely high intellectual ability (Flanagan & Harrison, 2012).

The three ring conception of giftedness. Renzulli (1978) identified gifted behavior as an interaction between three human traits. These three traits are above average abilities, high levels of task commitment, and high levels of creativity. ‘Above average abilities’ refers to students who are in the top fifteen percent of intellectual aptitude, while ‘high levels of task commitment’ refers to abilities such as focusing on a specific task or commitment towards reaching a goal. Finally, ‘high levels of creativity’ refers to the ability to construct innovative, original, and unique ideas or products in a fluent and flexible manner. According to Renzulli (1978), the interaction among these three traits is what allows for creative/productive accomplishment.

The triarchic theory of human intelligence. Sternberg (1985, 1999) identified three kinds of giftedness: analytic giftedness, which involves the ability to analyze, critique, compare and contrast, evaluate, and assess; synthetic giftedness, which involves the ability to be inventive, imaginative, insightful, intuitive and creative; and practical giftedness, which involves being able to apply/implement/employ analytic and synthetic abilities in everyday practical situations. Sternberg (1985) argued that intelligent behavior is accomplished through a balance between analytic, synthetic, and practical abilities.

Theory of multiple intelligences. Gardner's (1983, 1993, 1999) theory of multiple intelligences identifies nine different intelligences: logical-mathematical, linguistic, spatial, bodily-kinesthetic, musical, interpersonal, intrapersonal, naturalistic, and existential. According to Gardner (1999), these nine intelligences reflect the different ways that individuals interact with the world. Gardner argued that although each individual has these nine intelligences present within them, there exist no two individuals with the exact same configuration. Furthermore, according to Gardner (1983), gifted students demonstrate patterns of development that exceed their peers in one or several of the intelligences.

Marland's report. Marland (1972) made the following claim in his report:

> Children capable of high performance include those with demonstrated achievement and/or potential ability in any of the following areas, singly or in combination:

1. general intellectual ability
2. specific academic aptitude
3. creative or productive thinking
4. leadership ability
5. visual and performing arts
6. psychomotor ability (p. 2).

It is worth noting that not only does this list cover a broad and inclusive set of abilities, but also highlights that to be gifted the child only needs to display any one of these abilities. This ultimately recognizes that any group of gifted children will display a diverse range of abilities.

The Alberta Education definition of giftedness. Specified under the *Special Education Coding Criteria 2012/2013* (Alberta Education, 2012), code 80 refers to how gifted and talented children (gifted and talented are terms used interchangeably by Alberta Education) are defined. Code 80 indicates that "Giftedness is exceptional potential and/or performance across a wide range of abilities in one or more of the following areas: general intellectual, specific academic, creative thinking, social, musical, artistic and kinesthetic" (Alberta Education, 2012, p. 6). This set of criteria recognizes that to be identified as gifted, the child can display excellence in any of the listed areas, therefore taking on a broad and inclusive conception. This conceptualization of giftedness is closely related to Marland's report.

Identification of gifted children. Given the plethora of theories and definitions, the way children are identified as gifted is expected to vary.

Nonetheless, once schools have adopted a definition of giftedness, the next most important consideration is to determine how the children will be selected and identified for entrance into their gifted programs (Flanagan & Harrison, 2012). It is argued that the schools must ensure the definition they adopt and the program they have set in place parallels with the identification and selection procedures they choose. For example, if a school adopts a narrow definition encompassing only intellectual giftedness then an intelligence test should be implemented. In contrast, if a broad and inclusive definition is chosen, then the selection/identification services should also be varied; such as the use of achievement measures, nominations (teachers, parents, students, and peers), rating scales, checklists, performance assessments (portfolios and auditions), leadership skills, and motivation measures in addition to intelligence tests (Flanagan & Harrison, 2012).

Despite the general movement away from defining giftedness through a single measure of intelligence, many schools continue to rely on a narrow definition of giftedness. Likewise, the screening of children for entrance into gifted programming typically includes a single measure of standardized intelligence, such as the use of Wechsler Intelligence Scale for Children (Flanagan & Harrison, 2012). The use of such tools is the single most commonly used identification procedure relied on by schools today (Flanagan & Harrison, 2012). These schools decide also on a "cutoff" score to qualify as a gifted child. For example, Karnes and Brown (1980) suggested a cutoff score of 119 and

Hollinger (1986) a cutoff score of 130. The details are left up to the schools to decide.

Given that the use of intelligence tests is the most commonly relied upon method, Flanagan and Harrison (2012) suggested the following in terms of appropriately using them. First, schools should generate operational definitions of giftedness that specifically address the role of intelligence tests in relation to other measures (i.e., rating scales, nominations). Second, specific procedures should be put in place addressing the referral, screening and placement concerns. Third, schools must be aware of the advantages and disadvantages of using such intelligence measures. Fourth, theory-driven intelligence tests should be selected. Fifth, a cross-battery approach of assessment should be considered to avoid the use of relying on a single measure of cognitive ability.

The cognitive profile of gifted children. Researchers have examined the performance of gifted children on a wide range of cognitive processes (e.g., Arffa, 2007; Steiner & Carr, 2003; Vaivre-Douret, 2011). For the purpose of this thesis, I will review the literature on problem solving, working memory, and attention, because they are closely connected to PASS processes.

Problem solving has been identified as an area in which gifted children excel (e.g., Anderson, 1986; Davidson, 1986; Keating & Bobbitt, 1978; Klausmeier & Laughlin, 1961; Krutetskii, 1976; Parkinson, 1990; Sriraman, 2003; Swanson, 1992; Threlfall & Hargreaves, 2008). Threlfall and Hargreaves (2008), for example, examined how a group of 457 9-year-old gifted children compared to a group of 230 average-attaining 13-year-old children on the same mathematical problem-solving questions. They found that the two groups performed similarly on the way they approach solving the problems. Based on this finding, Threlfall and Hargreaves (2008) concluded that the 9-year-old gifted children are precocious problem solvers. In addition, Anderson (1986) has argued that gifted children are more proficient in identifying the problem and utilizing problem-solving strategies such as reasoning. Given that using a strategy and finding a solution to a problem is part of planning (as operationalized in PASS theory), we would expect gifted children in our sample to perform better than controls in planning.

Working memory, defined as the ability to store information for a short period of time and process it, has been found to be related to giftedness (e.g., Ackerman, Beier, & Boyle, 2005; Alloway & Elsworth, 2012; Calero et al., 2007; Conway, Cowan, Bunting, Therriault, & Minkoff, 2002; Kane, Hambrick, & Conway, 2005; Suss, Oberauer, Wittmann, Wilhelm, & Schulze, 2002). Calero et al. (2007), for example, found that a group of 6- to 11-year-old high IQ children scored significantly higher than a group of average IQ children on working memory. Georgiou et al. (2009) and Georgiou and Das (in press) have argued that there is nothing in working memory (particularly when operationalized with the Daneman-Carpenter) that cannot be explained by successive processing (when operationalized with Word Series and Sentence Repetition). Therefore, we would expect gifted children in our sample to perform better than controls on successive processing.

A final cognitive process that has caught the attention of researchers is that of attention. However, the findings of previous studies with gifted children are mixed. Some studies have shown that gifted children display better attention than controls (Liu, Xiao, Shi, & Zhao, 2011a; Liu, Xiao, Shi, & Zhao, 2011b; Liu, Xiao, Shi, Zhao, & Liu, 2011; Shi et al., 2013), whereas others have found that some gifted children often experienced problems with sustained attention (Chae et al., 2003; Gordon, 1990; Webb & Latimer, 1993). Shi et al. (2013), for example, compared 24 intellectually-gifted children to a group of 26 average IQ children on measures of sustained attention. They defined sustained attention as the ability to maintain efficient levels of response to demanding tasks over a given period of time. Results showed that the intellectually-gifted children had lower rates of omission errors than their controls, which suggests they are able to concentrate their attention much better and subsequently demonstrate higher levels of sustained attention. In contrast, Chae et al. (2003) reported that 10 out of 107 (9.4%) intellectually-gifted children in their study also had ADHD (assessed with the Test of Variables of Attention (T. O. V. A). This percentage is higher than the prevalence of ADHD in the general population, which has been estimated to be 5.29% (Polanczyk, Lima, Horta, Biederman, & Rohde, 2007, as cited in the Diagnostic and Statistical Manual of Mental Disorders, 4th edition). Clearly, this area requires additional research.

PASS and Giftedness

To date, and to the best of our knowledge, only two studies have examined the relationship between PASS processes and giftedness. Schofield and Ashman

(1987) examined the performance of 75 gifted children (IQ>124), 146 above average children (IQ=105-124), and 102 below average children (IQ<105) on planning, simultaneous, and successive processing. IQ scores were obtained through the use of the short form of Wechsler Intelligence Scale for Children-Revised (WISC-R). Results showed that the gifted children performed significantly better than the above and below average children on measures of planning and simultaneous processing.

The performance of gifted children has also been examined during the standardization of the D-N CAS (Naglieri & Das, 1997). Reported in the D-N CAS manual is a table with descriptive statistics of 173 gifted children ages 8 to 15 on the PASS processes. The participants were identified as gifted on the basis of state and federal definitions of giftedness by multidisciplinary teams in their schools. These teams used teacher referrals, achievement test scores, and intelligence test scores as the criteria for identification. As a group, the gifted children obtained a standard score of 111.9 in planning, 111.0 in attention, 117.7 in simultaneous processing, and 115.8 in successive processing. The gifted children scored one standard deviation above the mean in simultaneous and successive processing, and about two-thirds of a standard deviation above the mean in planning and attention. Naglieri and Das (1997) suggested that the high scores in simultaneous and successive processing scales could be attributed to the fact that these D-N CAS scales are most similar to the traditional IQ tests used to identify these children.

Unfortunately, both studies have some limitations. First, in Schofield and Ashman's (1987) study some children were included in the gifted group solely on the basis of their teacher nomination. This is problematic given that the researchers did not take appropriate measures to ensure all teachers were using the same criteria to nominate children as gifted. Likewise, Naglieri and Das (1997) did not select their gifted children through a rigorous screening process. Rather, they included children who were already identified as gifted on the basis of school criteria that could vary depending on the definition of giftedness adopted by each school. Second, the measures used to examine the PASS processes in Schofield and Ashman's (1987) study were different than those included in the D-N CAS, as D-N CAS was not yet developed at that time. Importantly, attention (one of the components of PASS theory) was not measured at all. Finally, in Naglieri and Das' (1997) study, no control group was included.

The Present Study

The purpose of the present study was twofold: (a) to examine what PASS processes differentiate gifted children from chronological-age controls and (b) to examine what PASS processes predict reading and mathematics achievement in the whole sample (gifted and controls). In this study, giftedness was defined as high intellectual ability (full-scale IQ score higher than 125). PASS theory does not make a specific claim as to what cognitive processes a gifted children would need to display excellence in to qualify as gifted. Naglieri and Kaufmann (2001), in their single-case study, showed that a child would qualify as gifted having high scores in planning, attention, and successive processing. Therefore, any combination of high scores in PASS processes would allow a child to qualify as gifted.

Based on the findings of previous studies examining the cognitive processes of gifted children (Naglieri & Das, 1997; Schofield & Ashman, 1987) and how PASS processes have been found to relate to reading and mathematics ability (Das et al., 2008; Kroesbergen et al., 2009; Papadopoulos, 2001; Wang et al., 2012), it was hypothesized that:

1. Gifted children will perform significantly better than controls on planning, simultaneous, and successive processing.
2. Simultaneous and successive processing will predict reading ability and simultaneous processing and planning will predict mathematics ability.

The findings of this study add to the existing literature in a number of important ways. First, it is the first study to examine all four PASS processes in gifted children. Notably, to control for the possible effects of school environment and instruction, we selected the children for the control group from the same classes as the gifted children. Second, given that these findings will reveal the cognitive skills in which gifted children excel, educators will have an indication as to the cognitive processing skills they can target in acceleration programs in order to boost the learning of gifted children. Finally, the findings of this study will fill a gap in the literature of PASS theory since it has traditionally focused on children with different kinds of conditions involving cognitive weaknesses (see studies on dyslexia or ADHD; Das et al., 2008; Deng et al., 2011; Huang et al., 2010; Naglieri et al., 2004) rather than cognitive strengths.

Chapter 3: Method

Participants

To select the participants for my study I first sent a letter of information to the parents of 108 children attending accelerated programs in two elementary schools in Edmonton (Canada). Eighty-one children with parental consent (25 grade 4, 30 grade 5, and 26 grade 5) were then tested on Matrix Reasoning and Vocabulary from Wechsler Abbreviated Scale of Intelligence-II (WASI-II; Wechsler, 2011). Twenty-six children with an IQ score of 125 and above were included in the gifted group (13 girls, 13 boys; 9 from grade 4, 9 from grade 5, and 8 from grade 6; mean age = 10 years and 4 months, *SD* = .94). In turn, 26 children with an IQ score of 119 and below were included in the control group (10 girls, 16 boys; 7 from grade 4, 11 from grade 5, and 8 from grade 6; mean age = 10 years and 7 months, *SD* = .94). The two groups did not differ on age.

Materials

General Intelligence. To assess general intelligence, the WASI-II (Wechsler, 2011) was used. WASI-II is individually administered for subjects between ages 6 and 90. For the purpose of this study a full-scale IQ score was obtained by administering two subtests: Vocabulary and Matrix Reasoning (FSIQ-2). FSIQ-2 has been reported to correlate .94 with FSIQ-4 (Wechsler, 2011).

The Vocabulary subtest is designed to measure children's vocabulary knowledge. Items required the children to orally provide definitions of words (e.g., *bird, transform,* and *enthusiastic)* that were presented to them both orally and visually. Wechsler (2011) reported the split-half reliability coefficient for

Vocabulary to be .91. In addition, Vocabulary correlated .84 with FSIQ-4, which demonstrates good construct validity evidence.

Matrix Reasoning is designed to measure the children's visual information processing and abstract reasoning skills. Children were required to view an incomplete matrix or series and select from five options the missing portion that completes the matrix or series. Wechsler (2011) reported split-half reliability coefficient for Matrix Reasoning to be .87. In addition, Matrix Reasoning correlated .80 with FSIQ-4, which demonstrates good construct validity evidence.

Academic Achievement. Woodcock Johnson III (WJ-III; Woodcock et al., 2001) was used to assess academic achievement. WJ-III is an individually administered battery of tests for subjects ages 2 to 90 plus. For the purpose of this study, two areas were of interest: reading and mathematics. To obtain a Broad Reading and a Broad Mathematics score three subtests were administered for each area. The three reading subtests are Letter-Word Identification, Reading Fluency, and Passage Comprehension. The three mathematics subtests are Calculation, Math Fluency, and Applied Problems. According to McGrew and Woodcock (2001), the test-retest reliability for Broad Reading is .93 and the test-retest reliability for Broad Mathematics is .92. To obtain standard scores for Broad Reading and Broad Mathematics based on age the WJ III Compuscore and Profiles Program was used. A description of the six subtests follows below.

Broad Reading. Letter-Word Identification measured the children's word identification skills. Children were required to read words (e.g., *and, together, acrylic,* and *gouache)* in isolation (list form) rather than in context. The words were listed in increasing difficulty. McGrew and Woodcock (2001) reported test-retest reliability for Letter-Word Identification to be .85.

Reading Fluency assessed the children’s ability to silently read simple sentences quickly. Children were required to read a series of true or false sentences such as *“A cow is an animal”,* and circle “*yes*” or “*no*” after each sentence. They were given three minutes to complete as many of these items as possible. McGrew and Woodcock (2001) reported test-retest reliability for Reading Fluency to be .78.

Passage Comprehension measured the children’s understanding of written text. Children were asked to supply a missing word to a short passage they read (e.g., *The man ran over and began to ______. He dug and dug.*). These passages progressed in terms of difficulty. McGrew and Woodcock (2001) reported test-retest reliability for Passage Comprehension to be .86.

Broad Mathematics. The Calculation subtest assessed the children’s ability to perform paper and pencil math computations. Children were required to complete numerical operations (addition, subtraction, multiplication and division), as well as geometric, trigonometric, logarithmic, and calculus operations where appropriate (e.g., *“2+3=” and “if* $x = -2$, *then* $x^2 + x =$*”*). McGrew and Woodcock (2001) reported test-retest reliability for Calculation to be .83.

The Math Fluency subtest measured the children’s ability to solve simple math facts quickly. This subtest required children to rapidly calculate single-digit addition, subtraction and multiplication facts. They were given three minutes to do as many calculations as possible. McGrew and Woodcock (2001) reported test-retest reliability for Math Fluency to be .86.

Applied Problems assessed the children's ability to analyze and solve math problems. Children were presented with math problems of increasing difficulty. They were required to listen to a problem, recognize the appropriate mathematical procedure that must be followed and finally perform the appropriate calculations (e.g., *"Terrell and Sue each earn five dollars an hour and Dave earns four dollars an hour. How much money will Terrell, Sue, and Dave earn together in three hours?"*). McGrew and Woodcock (2001) reported test-retest reliability for Applied Problems to be .85.

Cognitive Measures. The Das-Naglieri Cognitive Assessment System (D-N CAS; Naglieri & Das, 1997) is an individually administered assessment that measures four cognitive processes (planning, attention, simultaneous, and successive processing). It is appropriate for children between the ages of 5 years and 17 year 11 months. Administrators have the option of choosing between the standard battery (12 subtests - 3 per PASS scale) or the basic battery (8 subtests - 2 per PASS scale). For the present study, the basic battery was chosen. Naglieri and Das (1997) reported reliability coefficients for Planning, Attention, Simultaneous and Successive processing to be .85, .84, .90 and .90, respectively. The administration and scoring of the tasks was done according to the manual. A description of the eight CAS subtests follows.

Planning. Planning was assessed with two measures: Matching Numbers and Planned Codes. In Matching Numbers, children were presented with four pages, each consisting of eight rows of numbers with six numbers per row. The numbers ranged in length from one to six digits. Children were directed to underline as fast and accurately as possible the two numbers that were the same in each row. Naglieri and Das (1997) reported test-retest reliability coefficient for Matching Numbers to be .75.

In Planned Codes, children were required to fill in empty boxes with a combination of Os and Xs that correspond to a letter that was printed on the top of each box (e.g., A=XO, B=XX, C=OX, D=OO) as quickly as possible and also in which ever manner they choose. This subtest included two pages with each having its own set of codes arranged in seven rows and eight columns. Children were given one minute to fill in as many boxes as possible. Naglieri and Das (1997) reported test-retest reliability coefficient for Planned Codes to be .82.

Attention. Attention was assessed with two measures: Expressive Attention and Number Detection. In Expressive Attention, children were provided with three pages. The first page consisted of the color words Blue, Yellow, Green and Red, which were presented in a quasi-random order and arranged in eight rows of five. The children were asked to read these words as fast and as accurately as possible. Next, they were asked to name the colors of a sequence of rectangles (printed in blue, yellow, green, and red). On the last page, the children were presented with the words Blue, Yellow, Green and Red, however the ink color of the words was different from the name of the color. Children were asked to call out the name of the ink color rather than to read the word. Naglieri and Das

(1997) reported test-retest reliability coefficient for Expressive Attention to be .80.

In Number Detection, pages were presented to the children, which contained numbers appearing in several formats. Children were instructed to locate and underline a particular stimulus (numbers 1, 2, and 3) on a page that contained several distractors. The distractors included the same numbers printed in different font styles. Children were given three minutes to complete the task. Naglieri and Das (1997) reported test-retest reliability coefficient for Number Detection to be .77.

Simultaneous processing. Simultaneous processing was assessed with two measures: Nonverbal Matrices and Verbal Spatial Relations. In Nonverbal Matrices, children were presented with a pattern of shapes/geometric designs that had a missing piece. Children were asked to choose from six options the missing piece that would best complete the matrix. Naglieri and Das (1997) reported the split-half reliability coefficient for Nonverbal Matrices to be .89.

In Verbal Spatial Relations, children were presented with six drawings (objects and shapes that were arranged in specific spatial manners) and a printed question (e.g., *Which pictures shows a circle to the left of a cross under a triangle above a square*?). After the question was read to the children, they were instructed to select the picture that best answered the question. A 30-second time limit was applied. Naglieri and Das (1997) reported the split-half reliability coefficient for Verbal Spatial Relations to be .83.

Successive processing. Successive processing was assessed with two measures: Word Series and Sentence Repetition. In Word Series, the examiner would say a set of words to the children, and the children were asked to repeat the words in the exact same order. The following high frequency, single-syllable words were used: *book, car, cow, dog, girl, key, man, show,* and *wall*. As the children progressed through the items, the number of words lengthened from two to nine. Naglieri and Das (1997) reported split-half reliability coefficient for Word Series to be .85.

In Sentence Repetition, the examiner read aloud sentences and the children were directed to repeat each sentence exactly as it was said. The sentences were composed of color words (e.g., *The blue is yellowing*) and increased in length from four to nineteen words. Naglieri and Das (1997) reported split-half reliability coefficient for Sentence Repetition to be .84.

Procedure

Data collection for the present study was completed in two separate phases. Phase one included the administration of WASI-II FSIQ-2 as well as the WJ-III Reading and Mathematics. All assessments in phase one began with the IQ measures, followed by the reading measures, and ended with the mathematics measures. Phase one took approximately one hour to complete per child. Once phase one was completed, those who fit the selection criteria were then assessed on the D-N CAS measures. The D-N CAS subtests were administered in the order they have been described above. D-N CAS took approximately forty minutes to administer per child. All of the assessments were administered individually in a quiet room by the author and two graduate students with extensive training in test administration.

Chapter 4: Results

Preliminary Analyses

Before running any analyses we examined the distributional properties of each measure and for each group separately. All measures were normally distributed, with the exception of two. This was due to the presence of an outlier in each measure. An outlier from the gifted group was found in the high end of the distribution of Broad Mathematics, and a second outlier from the control group was found in the low end of the distribution of Planning. The scores of these outliers were winsorized to normalize the distribution of the variables (Tabachnick & Fidell, 2001). The winsorized data were used in all further analyses.

Table 1 presents the mean, standard deviation, minimum and maximum scores for each measure used in the study separately for each group. A look at Table 1 shows that the gifted group performed higher than the control group on all measures. Scores in WASI-II reveal that the gifted group performed nearly two standard deviations above the standardized mean, which classifies them as very superior whereas the control group scored one standard deviation above the standardized mean, which classifies them as high average (Wechsler, 2011). The gifted group performed in the very superior range in Broad Reading and in the high average range in Broad Mathematics. Taking a look at the D-N CAS scores, the gifted group performed in the high average range in planning, attention and successive processing, and in the superior range in simultaneous processing.

Table 1

Descriptive Statistics on all Measures for Each Group Separately

	Gifted Group N=26				**Control Group N=26**			
	M	**SD**	**Min**	**Max**	**M**	**SD**	**Min**	**Max**
WASI- II (FSIQ-2)	129.58	4.52	126	145	115.12	3.09	109	119
WJ-III								
Broad Reading	131.27	15.11	105	166	116.65	12.23	97	147
Broad Mathematics	120.00	10.99	104	143	110.12	9.35	95	136
CAS								
Planning	112.04	13.50	85	146	105.81	10.28	77	121
Matching Numbers	12.35	2.56	8	18	10.54	2.73	5	16
Planned Codes	11.73	2.78	4	19	11.38	1.88	7	15
Attention	114.19	13.73	85	141	108.42	10.80	88	124
Expressive Attention	12.35	2.97	5	17	10.92	2.43	6	16
Number Detection	12.04	2.51	6	18	11.88	2.23	8	16
Simultaneous	126.46	13.58	103	152	112.69	15.50	91	140
Nonverbal Matrices	14.69	2.65	9	19	12.15	2.72	5	17
Verbal Spatial Relations	14.50	3.28	7	19	12.38	3.61	7	19
Successive	114.19	10.30	92	134	106.85	8.56	84	120
Word Series	12.88	1.95	9	17	11.31	2.05	6	14
Sentence Repetition	12.19	2.12	8	16	11.15	1.71	8	14

Note. WASI-II= Wechsler Abbreviated Scale of Intelligence-II; FSIQ-2= Full Scale Intelligence Quotient-2 subtest; WJ III= Woodcock Johnson III; CAS= Cognitive Assessment System. The CAS subscales have a mean of 100 and a standard deviation of 15, whereas the subtest scale scores have a mean of 10 and a standard deviation of 3.

Group Comparisons on PASS Cognitive Processes

Four separate MANOVAs with group as a fixed factor and the PASS processes as dependent variables were performed to examine possible differences between the two groups on the PASS cognitive measures. Results showed that there was a main effect of group in Simultaneous (Wilk's $\lambda = .796$, $F(2, 49) = 6.294$, $p = .004$, partial $\eta^2 = .204$) and Successive processing (Wilk's $\lambda = .855$, $F(2, 49) = 4.163$, $p = .021$, partial $\eta^2 = .145$). Follow-up univariate statistics showed significant differences between the two groups on both Nonverbal Matrices ($F(1, 50) = 11.605$, $p = .001$, partial $\eta^2 = .188$) and Verbal Spatial Relations ($F(1, 50) = 4.891$, $p = .032$, partial $\eta^2 = .089$). In addition, follow-up univariate statistics showed significant differences between the two groups in Word Series ($F(1, 50) = 8.074$, $p = .006$, partial $\eta^2 = .139$).

The Cognitive Profile of Gifted Children

Given that group comparisons may not provide information regarding whether a group is heterogeneous, a performance profile for each gifted child was performed. Table 2 summarizes the number of gifted children who exhibited assets in the PASS processes. An asset was defined as a score that was at least 1.5 SDs above the mean score of the control group. The results indicated that 26.92% of the gifted children had an asset in at least one PASS process, with the most common being in Successive processing (15.38%). Furthermore, results showed that 19.23% of the gifted children displayed a double asset, with the most common being between Simultaneous and Successive processing (7.69%). Two children (7.69%) displayed a triple asset and one child (3.85%) had a quadruple asset.

Table 2

Number of Gifted Children Exhibiting Assets in PASS Processes

	Subtotal		Total	
Cognitive Assets	n	%	n	%
No Asset	11	42.31	11	42.31
Single Asset			7	26.92
Planning (Pl)	0	0		
Attention (Att)	1	3.85		
Simultaneous (Sim)	2	7.69		
Successive (Suc)	4	15.38		
Double Asset			5	19.23
Sim + Suc	2	7.69		
Pl + Suc	1	3.85		
Pl + Att	1	3.85		
Att + Suc	1	3.85		
Triple Asset			2	7.69
Plan + Sim + Suc	1	3.85		
Plan + Att + Suc	1	3.85		
Quadruple Asset			1	3.85
Plan + Att + Sim + Suc	1	3.85		

Note. An asset on a task was defined as a score at least 1.5 SDs above the control group's mean.

Correlations Between PASS Processes and Academic Achievement

Table 3 demonstrates the Pearson *r* correlations between the reading and mathematics scores and each of the four PASS processes in the whole sample (*n* = 52). Broad Reading correlated significantly with Planning, Simultaneous and Successive processing, the highest correlation being with Planning (*r* = .58). In turn, Broad Mathematics correlated significantly with Planning and Simultaneous processing, the highest correlation being with Simultaneous processing (*r* = .48).

Table 3

Pearson Correlations Between Achievement and PASS Processes

	1.	2.	3.	4.	5.
1. Broad Reading					
2. Broad Mathematics	.37**				
3. Planning	.58**	.37**			
4. Attention	.23	.13	.46**		
5. Simultaneous	.43**	.48**	.26	.20	
6. Successive	.45**	.24	.36**	.42**	.29*

Note. N=*52.* * *p* <.05; ** *p* <.01.

Predicting Academic Achievement

Two separate multiple regression analyses were performed to examine the predictors (among the PASS processes) of Broad Reading and Broad Mathematics using the whole sample (n=52). Table 4 shows the results with Broad reading as the criterion variable and Table 5 shows the results with Broad Mathematics as the criterion variable.

Table 4

Regression Analyses Predicting Broad Reading

Variable	B	SE(B)	ß	Sig. (p)
Planning	.616	.154	.489	.000
Attention	-.197	.153	-.160	.205
Simultaneous	.249	.108	.257	.025
Successive	.418	.185	.272	.029

Note. N=52.

Table 5

Regression Analyses Predicting Broad Mathematics

Variable	B	SE(B)	ß	Sig. (p)
Planning	.262	.130	.286	.050
Attention	-.098	.130	-.109	.455
Simultaneous	.285	.091	.405	.003
Successive	.074	.157	.066	.639

Note. N=52.

The results indicated first that Planning, Simultaneous and Successive processing were unique predictors of reading achievement accounting for 43.7% of the variance. In turn, Planning and Simultaneous processing were unique predictors of mathematics accounting for 26.9% of the variance.

Chapter 5: Discussion

For many years and partly because of the "No Child Left Behind" policy the area of giftedness did not receive much attention by researchers. As a result, very little is known about the cognitive profile of gifted children (Sternberg et al., 2011). To address this gap in the literature my thesis aimed to examine the performance of gifted children on four cognitive processing skills, namely planning, attention, simultaneous and successive processing. We hypothesized that gifted children would perform significantly better than controls on planning, simultaneous and successive processing. Results partly confirmed our hypothesis showing that the gifted children performed significantly better than the controls only on simultaneous and successive processing.

Naglieri and Das (1997) argued that superior performance of gifted children on simultaneous and successive processing should be expected because these measures are similar to the traditional IQ tests used to select the gifted children. For example, Nonverbal Matrices parallels Matrix Reasoning. Likewise, Verbal Spatial Relations requires understanding of logical-grammatical relationships between concepts (i.e., *Which picture shows a boy wearing the man's hat?*), which, in turn, relies on vocabulary knowledge. It should therefore be of no surprise that children selected because of their high performance in Matrix Reasoning and Vocabulary outperform controls on measures of simultaneous processing.

However, the findings may also suggest that gifted children are better at information processing. This is also supported by the results of the performance profile conducted for the gifted group (see Table 2). The highest single assets were found in successive and simultaneous processing. Additionally, the most common double asset was found in simultaneous and successive processing. Das et al. (1994) claimed that the two processing systems (simultaneous and successive processing) are the two most important processes in the PASS model of information processing. This is because simultaneous and successive processing are responsible for receiving, combining, and transforming incoming information. This finding would be in line with Lubinski and colleagues' (e.g., Lubinski & Benbow, 2000; Lubinski & Benbow, 2006) work which showed that gifted children are precocious learners with faster learning rates of different materials. A more efficient information processing system, which in PASS terms means better simultaneous and successive processing, could reflect not only faster processing times, but also better capacity (e.g., larger working memory span). The work of Kranzler, Whang, and Jensen (1994) provides support to this argument. Kranzler et al. (1994) found that intellectually gifted children performed better than controls in the speed and efficiency of cognitive processes. This suggests that gifted children are proficient at speed of processing, a skill closely linked to simultaneous and successive processing (Cai, Li, Deng, 2013; Das et al., 1994).

In contrast to our expectation, gifted children did not perform significantly better than controls in planning. A reason for this finding could be the fact that we did not administer high-level planning tasks (e.g., Tower of London). The previous studies in which gifted children were found to perform better than controls on planning had all used tasks that required more than just developing and executing a plan (which is what Planned Codes and Matching Numbers involve) (e.g., Schofield & Ashman, 1987; Sriraman, 2003; Threlfall & Hargreaves, 2008). Parrila, Das, and Dash (1996) showed that there are two clusters of planning measures, simple and complex, and that the relationship of planning with the rest of the PASS processes as well as with reading varies as a function of the complexity of the planning tasks. Das, Snart, and Mulcahy (1982) found a positive relationship between planning and reading comprehension, when planning included complex tasks, such as planned composition and syllogistic reasoning. These tasks are no longer included in the CAS (Naglieri & Das, 1997).

Given that previous research displayed mixed results in terms of gifted children's performance on attention measures (e.g., Chae et al., 2003; Gordon, 1990; Liu et al., 2011a; Liu et al., 2011b; Liu et al., 2011; Shi et al., 2013; Webb & Latimer, 1993), we did not form a directional hypothesis in relation to attention. Our results demonstrated that there were no differences between the two groups in attention as assessed by D-N CAS. This could reflect that attention is a skill achieved by most above-average children and for this reason it does not differentiate gifted children from high achieving controls.

The second goal of this study was to examine which PASS processes predict reading and mathematics ability. We hypothesized first that simultaneous and successive processing would predict reading ability (see Das et al., 2008; Georgiou & Das, in press; Papadopoulos, 2001; Wang et al., 2012). The results confirmed our hypothesis. However, planning was also found to be a significant predictor of reading. An explanation could be that the Broad Reading cluster included Passage Comprehension as one of its tasks; the other two being Word Identification and Reading Fluency. Previous studies examining the contribution of PASS processes to reading assessed only word reading skills (e.g., Word Identification, Word Attack). In order to answer questions in Passage Comprehension children would need to develop some action plan and deploy comprehension monitoring strategies, both of which rely on planning.

In terms of mathematics ability, it was hypothesized that simultaneous processing and planning would be unique predictors. Our findings confirmed this hypothesis and were in line with Kroesbergen et al.'s (2009) findings. These findings are also theoretically supported. For example, the Applied Problems subtest of Broad Mathematics requires children to solve mathematical problems, which relies on planning. Moreover, the ability to comprehend the math problems in Applied Problems would rely on the ability to view the problem as a whole and link the pieces of the problem together, ultimately relying on simultaneous processing.

There are a few limitations of the present study. First, some could argue that an IQ cutoff score of 125 and above is not high enough for the selection of gifted children. For example, some researchers have used 130 and above in their studies (Hollinger, 1986; Wasserman, 2003). Unfortunately, using a cutoff score of 130 would leave us with only 8 children, in which case we would not be able to perform the analyses we did in our study. Certainly, future studies should replicate our findings selecting gifted children with a more stringent cutoff score. Second, only two measures were used to obtain a full-scale IQ score. However, FSIQ-2 has been found to correlate .94 with FSIQ-4 (Wechsler, 2011) and it has been used widely in the literature to select children with disabilities (e.g., dyslexia, see Hoeft et al., 2007; Krafnick, Flowers, Napoliello, & Eden, 2011; Miller, Hynd, & Miller, 2005). Given the nature of the two IQ tasks and their similarity to the simultaneous processing subtests, this may have confounded the question of difference between our groups. Third, there was a restriction of range in the FSIQ-2 scores. This may have impacted the observed differences in the PASS processes. Finally, the sample size could have been larger. A larger sample size would allow us to run regression analyses within each group.

Given that previous research on PASS theory and giftedness is limited, the results of this study increased our knowledge of PASS theory and how it relates to academic achievement. It seems that the information processing system (operationalized by simultaneous and successive processing tasks) holds the key not only in the low end of the ability spectrum (in the case of poor readers and poor problem solvers; see Cai et al., 2013; Das et al., 2008; Deng et al., 2011; Iglesias-Sarmiento & Deaño, 2011), but also among high achievers. Importantly, our results indicate that attention should be paid on simultaneous and successive processing if we want to enhance the learning of gifted children. Currently, not much is known about how to accelerate gifted children's performance (Sternberg et al., 2011). Perhaps an intervention program focusing on simultaneous and successive processing skills could help in this direction. Future studies should also examine if the cognitive profile of gifted children in mathematics differs from that of gifted children in reading. Our small sample size did not allow this kind of analyses, but it is possible that different groups of gifted children may have different cognitive strengths, which means that possible intervention programs should be tailored to match their strengths.

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