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The Planning, Attention, Simultaneous, and Successive (PASS) model of cognitive processing and its relationship to academic achievement

Flanagan, Dawn Patricia, Ph.D.

The Ohio State University, 1992

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The Planning, Attention, Simultaneous, and Successive (PASS) 
Model of Cognitive Processing and its Relationship to 
Academic Achievement

DISSERTATION

Presented in Partial Fulfillment of the Requirements for 
the Degree of Doctor of Philosophy in the Graduate 
School of The Ohio State University

By

Dawn Patricia Flanagan, B.S., M.A.

********

The Ohio State University
1992

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CHAPTER I

INTRODUCTION

Current measures of intellectual ability are virtually inseparable from the construct of intelligence (Naglieri, 1991). Because these instruments have remained essentially the same since the early 1900's with the publication of the Binet in 1905, the Stanford-Binet in 1916, and the Wechsler-Bellevue in 1939, it is difficult to conceptualize intelligence without making reference to the tests used to measure this construct (Naglieri, 1991). Advances in the field of intellectual assessment will be slow or perhaps stagnant if improvement in these instruments mainly consist of revising old tests and reconceptualizing tasks included on old instruments (Das, Naglieri, & Kirby, 1992). Thus, an expansion of the concept of intelligence as well as the scope of what current intelligence tests measure is needed in order to influence a paradigmatic shift in the field of human intellectual assessment (Das et al., 1992).

CURRENT INTELLECTUAL ASSESSMENT INSTRUMENTS

At present, the most commonly used measures of intellectual ability include such tests as the Wechsler Intelligence Scale for Children-Revised
(WISC-R; Wechsler, 1974), the McCarthy Scales of Children’s Abilities (MSCA; McCarthy, 1972), the Stanford-Binet: Fourth Edition (SB:FE; Thorndike, Hagen, & Sattler, 1986), and the Kaufman Assessment Battery for Children (K-ABC; Kaufman & Kaufman, 1983). Upon close inspection of these assessment instruments, it is evident that they are essentially the same despite differing outward appearances (Naglieri, Das, & Jarman, 1990).

The Wechsler Intelligence Scale for Children - Revised (WISC-R) contains the identical 12 subtests (six on the Verbal Scale and six on the Performance scale) that comprised the 1949 WISC. It is an individually administered instrument for assessing the intellectual ability of children aged 6 years through 16 years, 11 months. The IQs are calculated on the basis of five Verbal (Information, Similarities, Arithmetic, Vocabulary, Comprehension) and five Performance (Picture Completion, Picture Arrangement, Block Design, Object Assembly, Coding) subtests. The WISC-R, like its predecessor, maintains a subdivision of the Scale into Verbal and Performance tests. This dichotomy represents two principal modes by which human abilities express themselves (Wechsler, 1974).

Wechsler conceptualized intelligence as an aggregate and global entity rather than a particular ability, that is, the "capacity of the individual to act purposefully, to think rationally, and to deal effectively with his or her environment" (1944, p. 3). Consistent with this concept of intelligence, the subtests of the WISC-R were aggregated to represent an overall or general
intellectual ability.

The McCarthy Scales of Children's Abilities (MSCA) is a well-constructed instrument suitable for children between the ages of 2 years, 6 months to 8 years, 6 months. These scales were developed to satisfy the need for an instrument to facilitate the assessment of intellectual functioning of young children, particularly at the preschool level (McCarthy, 1972). The McCarthy Scales consist of 18 subtests which are grouped into six overlapping scales: Verbal, Perceptual-Performance, Quantitative, General Cognitive, Memory, and Motor. The MSCA yields a General Cognitive Index (GCI) which is the sum of all subtests, with the exception of three Motor subtests, and may be conceptualized as the "traditional global measure of intellectual development" (Anastasi, 1988, p. 277). Thus the McCarthy Scales yield a general measure of intellectual functioning (GCI) as well as a profile of abilities including Verbal, Perceptual-Performance, Quantitative, Memory, and Motor measures.

The Stanford - Binet Intelligence Scale: Fourth Edition (SB: FE) is a revision of the 1960 Stanford - Binet Intelligence Scale: Form L - M. The authors of the SB:FE have "strived to maintain historical continuity" with the 1960 scale by building on its strengths as well as developing nine of its 15 tests from item types used in Form L - M (Thorndike, Hagen, & Sattler, 1986, p. 3).

The authors of the SB:FE adopted a three-level hierarchical model of the structure of cognitive abilities in order to guide the construction of the fourth
edition. A general reasoning factor, $g$, lies at the apex or first level of the model. Crystallized abilities, fluid-analytic abilities, and short-term memory represent three broad factors that comprise the second level of the model. Finally, three additional factors (i.e., verbal reasoning, quantitative reasoning, and abstract/visual reasoning) lie at the base or third level of the model (Thorndike et al., 1986).

General ability, or $g$, located at the first level of the model, is defined by Thorndike et al. (1986) as "consisting of the cognitive assembly and control processes that an individual uses to organize adaptive strategies for solving novel problems" (p. 3). That is, $g$ is what individuals use when they attempt to solve any given problem that they have not previously been taught to solve (Thorndike et al., 1986).

Three factors comprise the second level of the model. The crystallized abilities factor "represents the cognitive skills necessary for acquiring and using information about verbal and quantitative concepts to solve problems" (p. 4). These abilities are influenced by schooling as well as general life experiences that are acquired outside of school. These verbal and quantitative skills (i.e., crystallized abilities) have strong positive correlations with academic achievement and could therefore be referred to as a scholastic- or academic-ability factor (Thorndike et al., 1986).

The fluid-analytic-abilities represent the cognitive skills that are necessary to solve novel problems involving nonverbal stimuli. General experiences are considered more important in solving these types of problems than schooling. In short, "this factor involves the invention of new
cognitive strategies or the flexible reassembly of existing strategies to deal with novel situations" (Thorndike et al., 1986, p. 4).

Short-term memory typically has a high positive correlation with the total score on the Binet Scales. Short-term memory provides an information-processing emphasis and serves two functions. First, short-term memory acts to retain newly received information until it can be stored in long-term memory; and second, to hold information that is drawn from long-term memory so it can be used for an ongoing task. According to Thorndike et al. (1986), "an individual's choice and use of short-term memory strategies determine what information is stored, how it is stored, and how it is later retrieved form long-term memory" (p. 4).

Verbal reasoning, quantitative reasoning, and abstract/visual reasoning, or the three factors located at the third level of the cognitive-abilities model, are "more specific and more content-dependent than factors at the first and second levels" (Thorndike et al., 1986, p. 5). Although the authors do not deny that other factors may exist at the third level, the inclusion of these three factors in the model is justified "because they have special meaning to clinicians and educators" (Thorndike et al., 1986, p. 5).

The Kaufman Assessment Battery for Children (K-ABC) is an individually administered test of intelligence and achievement and is intended for children between the ages of 2 years, 6 months to 12 years, 5 months. This multi-subtest battery contains four scales (Sequential Processing Scale, Simultaneous Processing Scale, Achievement Scale, and Nonverbal Scale).
and is designed for use in school and clinical settings. Composite scores are derived from different combinations of subtests, depending on the age of the child. The Sequential and Simultaneous Processing Scales are intended to reflect the individual's style of problem solving and information processing. These two scales are combined to yield the Mental Processing Composite which is the measure of intelligence on the K-ABC (Sattler, 1988).

Kaufman and Kaufman (1983) are among the first authors who have attempted to change the direction of the field of intellectual assessment by focusing on the assessment of underlying cognitive processes rather than the measurement of abilities (Das, 1984a). Intelligence, as measured by the K-ABC, has a strong theoretical foundation in the domains of both neuropsychology and cognitive psychology (Kaufman & Kaufman, 1983). According to Kaufman and Kaufman (1983), "the Sequential Processing and Simultaneous Processing Scales represent two types of mental functioning that have been identified independently by cerebral specialization researchers (Bogen, 1975; Gazzaniga, 1975; Kinsbourne, 1978), by Luria (1966, 1970, 1973) and his followers (Das, Kirby, & Jarman, 1975, 1979), and by cognitive psychologists (Neisser, 1967)" (p. 2).

On the K-ABC, tasks involving Sequential Processing (Hand Movements, Number Recall, Word Order) require the individual to solve a problem by arranging the input in sequential or serial order; by contrast, tasks involving Simultaneous Processing (Gestalt Closure, Triangles, Matrix Analogies,
Spatial Memory, Photo Series) require that input be integrated and synthesized holistically. Thus, inherent in the development of the K-ABC was greater emphasis on the process rather than the nature of the content to be processed. Whereas intelligence tests like the Wechsler appear to be content-oriented and are defined by the content of their stimuli (verbal or nonverbal), the K-ABC is process-oriented and focuses on whether the stimuli require the arrangement of information in sequential order or the integration and synthesis of discrete elements into holistic arrangements, regardless of item content (Kaufman & Kaufman, 1983).

Although current tests of intelligence appear to vary in terms of their adherence to a theoretical model or orientation, abilities measured, and content, they are essentially the same (Naglieri, Das, & Jarman, 1990). For example, each of these instruments has a scale consisting of tasks that are nonverbal/spatial in nature and therefore require the individual to assemble puzzles, copy designs using colored materials, or solve a matrix. In addition, there is consistency regarding the demands of a given task as well as the nature of the subtest design. Perhaps the most salient example is the similarity between the WISC-R Block Design, SB:FE Pattern Analysis, and K-ABC Triangles. Similarities are also apparent between K-ABC Matrices and SB:FE Progressive Matrices, as well as MSCA Puzzle Solving and WISC-R Object Assembly. Thus, these scales are measuring "highly similar cognitive functions in similar ways" despite the different names that have been assigned to the scales by the test authors in which these subtests are included (i.e., Performance Scale on the WISC-R, Simultaneous Scale on
the K-ABC, Perceptual-Performance Scale on the MSCA, and Abstract/Visual Reasoning Scale on the SB:FE) (Naglieri et al., 1990, p. 424).

Current tests of intellectual functioning also contain similar measures of Verbal/Achievement (WISC-R Verbal Scale, K-ABC Achievement Scale, MSCA Verbal Scale, SB:FE Verbal Reasoning Scale), Memory/Sequential (WISC-R Third Factor, K-ABC Sequential Scale, MSCA Memory Scale, SB:FE Short-Term Memory Scale), and Quantitative (WISC-R Arithmetic Subtest, K-ABC Arithmetic Subtest, MSCA Quantitative Scale, SB:FE Quantitative Reasoning Scale) abilities. Although the scale names on these instruments differ as well as the arrangement of the subtests into groups, these tests measure similar Verbal/Achievement, Nonverbal/Simultaneous, Memory/Sequential, and Quantitative abilities in similar ways (Naglieri et al., 1990).

Studies of criterion validity further substantiate the claim that these tests are similar despite the fact that they appear different. Naglieri and Jensen (1987) found a correlation of .87 between the WISC-R Full Scale IQ and the K-ABC Mental Processing Composite and Achievement Composite combined in a sample of 172 normal students in the fourth and fifth grades. They also found a close relationship (r = .85) between the WISC-R Verbal Scale and the K-ABC Achievement Composite. Similarly, Naglieri (1985) found a correlation of .55 and .79 between the MSCA and the K-ABC Mental Processing Composite and Achievement Scales, respectively. Finally,
Thorndike et al. (1986) reported that the SB:FE correlated .83 with the WISC-R Full Scale IQ, and .89 with the K-ABC Mental Processing and Achievement Composites (Naglieri et al., 1990).

Although current assessment instruments are widely used to describe the cognitive abilities of normal and handicapped children and youth and have proved useful in identifying high, average, and low functioning individuals according to their overall ability levels, they are not effective in measuring many characteristics of atypical children (Das, Naglieri, & Kirby, 1992; Kavale & Forness, 1984; McDermott, Fantuzo, & Glutting, 1990). For example, attentional problems that are frequently associated with children who are hyperactive are usually addressed anecdotally rather than directly by current intelligence instruments (Naglieri et al., 1990). Likewise, poor planning and strategic behavior often characteristic of mentally retarded individuals are not directly assessed by these tests (Naglieri et al., 1990). Overall, current intelligence tests have been shown to be ineffective for differential diagnosis (Hale & Landino, 1981; Hale & Saxe, 1983; Henry & Wittman, 1981; Kavale & Forness, 1984; Mueller, Dennis, & Short, 1986; Naglieri, 1985; Naglieri & Haddad, 1984), they employ too narrow a concept of intelligence (Naglieri et al., 1990), and they are typically not based on a single, well-researched psychological theory of intelligence (Naglieri et al., 1990).
A RECONCEPTUALIZATION OF INTELLIGENCE

Despite increasing recognition of the limitations of current assessment tools there has been a resistance to change (Naglieri, 1991). Naglieri and Das (1990) suggest that "better intelligence tests can be obtained only through the development and operationalization of better theories of cognitive functioning, based on new, experimentally discovered information" (p. 304). In order to develop more comprehensive measures of intelligence, a consideration of recent research on metacognition and executive functioning as well as attention and arousal is necessary and the utilization of improved technology is warranted (Naglieri & Das, 1990). Naglieri (1991) suggests that the field of intellectual assessment is at a "critical crossroad" (p. 5). That is, "we may choose to continue to use traditional technology based on the view of intelligence as general ability or look to improved theories and their operationalization" (Naglieri, 1991, p. 5).

Naglieri and Das (1987, 1988, 1990) have attempted to move beyond traditional views of intelligence by adopting a theoretical model (Planning, Attention, Simultaneous, Successive; PASS) that provides a broader and more integrative perspective of human cognitive functioning. The PASS cognitive processing model is based on A.R. Luria's (1966, 1973, 1980, 1984) broad conceptualization that the cognitive activity of the brain is divided into three functional units. The first functional unit is associated with the subcortex and brain stem and maintains an optimal level of cortical tone or arousal (i.e., provides a general state of readiness or focus of attention).
The second functional unit is associated with the lateral regions of the neocortex and is responsible for obtaining, processing and storing information as it arrives from the outside world. The third functional unit is associated with the anterior regions of the hemispheres, anteriorly to the precentral gyrus, and is responsible for programming, regulating and verifying mental activity. Each of these units has a distinct role to play in mental processing. However, the collective participation of these structures is necessary for any type of mental activity. This concept of a functional system provides a framework from which to view different cognitive activities that may be utilized given the demands of a particular task or situation.

Naglieri and Das (1990) state several reasons for the development of the PASS model. First, it provides a constructive theory for understanding many of the cognitive processes essential for human functioning. Second, it has a neuropsychological and cognitive basis. Third, Luria's work has been the subject of much scientific scrutiny. Fourth, the conceptual framework underlying this model has received some support in the scientific literature. Fifth, it provides a theoretical basis for a conceptualization of human cognitive functioning that is not as constrained as the models offered by current intelligence instruments. Thus, it provides a theoretical perspective that may be used to evaluate traditional IQ tests as well as academic and job tasks. Finally, it gives a theoretical perspective that may be used to develop intervention plans and remedial programs.

Luria's work was first conceived as an information processing model (Das, 1973; Das, Kirby, & Jarman, 1975) and later called the Information-
Integration model (Das, Kirby, & Jarman, 1979). Recently, researchers such as Das and Varnhagen (1986), Kirby and Das (1989), Naglieri (1989), and Naglieri and Das (1988, 1990) have elaborated and refined the model (Naglieri & Das, 1990). Consequently, the Das-Naglieri: Cognitive Assessment System (DN: CAS) was developed and is currently being prepared for standardization. This model has been the focus of several recent research investigations.

Evidence of the construct validity of the tasks used to operationalize the Planning, Attention, Simultaneous, and Successive (PASS) model of cognitive processing (Naglieri, 1989; Naglieri & Das, 1988; Naglieri, Das & Jarman, 1990) was demonstrated through both exploratory (Naglieri & Das, 1988; Naglieri, Prewett, & Bardos, 1989) and confirmatory factor analyses (Naglieri, Braden, & Warrick, 1992; Naglieri, Das, Stevens, & Ledbetter, 1991). Studies using PASS tasks have also provided discriminant validity evidence which indicates that these may be useful to distinguish between exceptional and nonexceptional populations (see Bardos, 1988; Snart, Das, & Mensink, 1988). Thus, the model appears to have diagnostic utility and may be used as a theoretical framework for developing new assessment techniques.

**PASS AND ACHIEVEMENT**

The prediction of academic achievement represents one purpose of intelligence testing (Das, Kirby, & Jarman, 1979). However, traditional
intellectual assessment instruments have been of limited use in the prediction of achievement since a large part of what they test is achievement (Sternberg, 1984). Therefore, a comprehensive theory-based measure of cognitive processes, such as that developed by Das and Naglieri (1989), should provide greater insight into the cognitive processes underlying various areas of academic achievement as well as useful information for the remediation of learning problems (Naglieri et al., 1990). Although a vast majority of the literature on cognitive processes and academic achievement has focused on simultaneous and successive processes only and their relationship to reading achievement, some research investigations have demonstrated that all four components of the PASS (i.e., Planning, Attention, Simultaneous, Successive) model are related to various areas of academic achievement.

Researchers have conducted numerous investigations on the relationship between simultaneous and successive processes and academic performance (see Das et al., 1979 and Das, 1988). In general, these findings indicate that successive processing is important for initial reading decoding skills (Cummins & Das, 1977, 1980; Das & Cummins, 1978, 1982; Das, Cummins, Kirby, & Jarman, 1979; Kirby & Das, 1977) whereas simultaneous processing is important for more advanced stages of reading comprehension (Das & Cummins, 1982; Kirby, 1982; Kirby & Robinson, 1987; Leong, 1984; Stutzman, 1986). In regard to mathematics achievement, many studies have reported strong correlations between

With the development of tasks that measure planning (Das et al., 1979) and attention (Naglieri & Das, 1987, 1988), however, a more complete understanding of the intricate relationship between cognitive processes and academic achievement emerges. For example, a number of researchers have demonstrated a relationship between planning tasks and mathematics computation and written composition (Ashman & Das, 1980; Das & Heemsbergen, 1983; Garofalo, 1986; Warrick, 1989). Also, among elementary school aged children, planning correlated significantly with achievement in the areas of reading decoding and reading comprehension (Das, 1984b; Leong, Cheng, & Das, 1985). Bardos (1988) found that learning disabled children, when compared to normal children, had average coding processing (simultaneous and successive) skills but were deficient in planning and attention. In addition, the importance of both planning and attention in the prediction of mathematics achievement was demonstrated (see Warrick, 1989). Naglieri and Das (1987) found that planning increasingly correlated with total achievement across grades 2, 6, and 10 and that these increases in the size of the coefficient were significant. More importantly, planning correlated with reading and math achievement as well as or better than simultaneous and successes processes combined. Thus, the exclusion of measures of planning and attention on tests of intellectual
functioning is an important omission (Naglieri et al., 1990).

RATIONALE AND PURPOSE OF THE STUDY

The purpose of the present study is to explore the validity of the PASS tasks for a sample of referred elementary school children as well as address the relationship of these tasks to academic achievement. Since the majority of research concerning learning problems has been conducted in the area of reading (Kirby & Williams, 1991), there is a need to supplement and enhance this line of research by investigating other areas of academic achievement. Therefore, the present study will not only address how the PASS tasks relate to reading but will also examine the relationship between the PASS cognitive processes and mathematics and written language achievement.

Much of the early work on the relationship between cognitive processes and achievement focused on correlational studies using simultaneous and successive processing tasks only. It was not until the early 1980's that the relationship between planning tasks and academic achievement was investigated. To date, few studies have examined the relationship between all four cognitive processes (Planning, Attention, Simultaneous, Successive) and academic achievement (Bardos, 1988; Reardon & Naglieri, 1992; Prewett, 1991; Warrick, 1989). In two of these studies (Bardos, 1988; Prewett, 1991) however, the attention composite was not clearly defined (i.e., only one task was used to measure this process), and in the third
(Reardon & Naglieri, 1992) and fourth (Warrick, 1989) investigations, only reading and mathematics achievement was addressed, respectively. Since the present study includes an examination of all four PASS processes and 11 specific areas of achievement (i.e., alphabet/word knowledge, reading comprehension, overall reading, math calculation, math reasoning, total math, capitalization, punctuation, written composition, spelling, total writing), it represents one of the most comprehensive investigations of this relationship. Specifically, the contribution of the PASS constructs to the prediction of each area of academic achievement will be investigated. It is hoped that through an exploration of how cognitive processes contribute to achievement in specific academic areas a more complete understanding of the learning difficulties experienced by some students will be achieved.

**Research Questions**

Following from the preceding discussion, several research questions are proposed:

1. Which of the four components of the PASS (Planning, Attention, Simultaneous, Successive) model best predicts DAB-2 Reading achievement (i.e., Reading Composite)?
   a. Which of the four components of the PASS (Planning, Attention, Simultaneous, Successive) model best predicts achievement in the area of Alphabet/Word Knowledge?
b. Which of the four components of the PASS (Planning, Attention, Simultaneous, Successive) model best predicts achievement in the area of Reading Comprehension?

2. Which of the four components of the PASS (Planning, Attention, Simultaneous, Successive) model best predicts DAB-2 Writing achievement (i.e., Writing Composite)?
   a. Which of the four components of the PASS (Planning, Attention, Simultaneous, Successive) model best predicts achievement in the area of Punctuation?
   b. Which of the four components of the PASS (Planning, Attention, Simultaneous, Successive) model best predicts achievement in the area of Capitalization?
   c. Which of the four components of the PASS (Planning, Attention, Simultaneous, Successive) model best predicts achievement in the area of Written Composition?
   d. Which of the four components of the PASS (Planning, Attention, Simultaneous, Successive) model best predicts achievement in the area of Spelling?

3. Which of the four components of the PASS (Planning, Attention, Simultaneous, Successive) model best predicts DAB-2 Mathematics achievement (i.e., Mathematics Composite)?
a. Which of the four components of the PASS (Planning, Attention, Simultaneous, Successive) model best predicts achievement in the area of Math Reasoning?

b. Which of the four components of the PASS (Planning, Attention, Simultaneous, Successive) model best predicts achievement in the area of Math Calculation?

4. Which of the four components of the PASS (Planning, Attention, Simultaneous, Successive) model best predicts overall achievement?

5. How much of an individual's academic achievement in the DAB-2 Reading Composite is explained by a combination of the Planning, Attention, Simultaneous, and Successive composites?

6. How much of an individual's academic achievement in alphabet/word knowledge is explained by a combination of the Planning, Attention, Simultaneous, and Successive composites?

7. How much of an individual's academic achievement in reading comprehension is explained by a combination of the Planning, Attention, Simultaneous, and Successive composites?

8. How much of an individual's academic achievement in DAB-2 Writing is explained by a combination of the Planning, Attention, Simultaneous, and
Successive composites?

9. How much of an individual's academic achievement in punctuation is explained by a combination of the Planning, Attention, Simultaneous, and Successive composites?

10. How much of an individual's academic achievement in capitalization is explained by a combination of the Planning, Attention, Simultaneous, and Successive composites?

11. How much of an individual's academic achievement in written composition is explained by a combination of the Planning, Attention, Simultaneous, and Successive composites?

12. How much of an individual's academic achievement in spelling is explained by a combination of the Planning, Attention, Simultaneous, and Successive composites?

13. How much of an individual's academic achievement in the DAB-2 Mathematics composite is explained by a combination of the Planning, Attention, Simultaneous, and Successive composites?
14. How much of an individual's academic achievement in math reasoning is explained by a combination of the Planning, Attention, Simultaneous, and Successive composites?

15. How much of an individual's academic achievement in math calculation is explained by a combination of the Planning, Attention, Simultaneous, and Successive composites?

16. How much of an individual's DAB-2 Total academic achievement (i.e., Total Achievement Composite) is explained by a combination of the Planning, Attention, Simultaneous, and Successive composites?

**Null Hypotheses**

1. None of the four components of the PASS (Planning, Attention, Simultaneous, Successive) model account for significant variance in DAB-2 Reading achievement (i.e., Reading Composite).
   a. None of the four components of the PASS (Planning, Attention, Simultaneous, Successive) model account for significant variance in Alphabet/Word Knowledge achievement.
   b. None of the four components of the PASS (Planning, Attention, Simultaneous, Successive) model account for significant variance in Reading Comprehension achievement.
2. None of the four components of the PASS (Planning, Attention, Simultaneous, Successive) model account for significant variance in DAB-2 Writing achievement (i.e., Writing Composite).
   a. None of the four components of the PASS (Planning, Attention, Simultaneous, Successive) model account for significant variance in Punctuation achievement.
   b. None of the four components of the PASS (Planning, Attention, Simultaneous, Successive) model account for significant variance in Capitalization achievement.
   c. None of the four components of the PASS (Planning, Attention, Simultaneous, Successive) model account for significant variance in Written Composition achievement.
   d. None of the four components of the PASS (Planning, Attention, Simultaneous, Successive) model account for significant variance in Spelling achievement.

3. None of the four components of the PASS (Planning, Attention, Simultaneous, Successive) model account for significant variance in DAB-2 Mathematics achievement (i.e., Mathematics Composite).
   a. None of the four components of the PASS (Planning, Attention, Simultaneous, Successive) model account for significant variance in Math Reasoning achievement?
   b. None of the four components of the PASS (Planning, Attention, Simultaneous, Successive) model account for significant variance in
4. None of the four components of the PASS (Planning, Attention, Simultaneous, Successive) model account for significant variance in overall achievement.

5. A combination of the Planning, Attention, Simultaneous, and Successive composites does not explain a significant proportion of variance in the DAB-2 Reading Composite.

6. A combination of the Planning, Attention, Simultaneous, and Successive composites does not explain a significant proportion of the variance in alphabet/word knowledge achievement.

7. A combination of the Planning, Attention, Simultaneous, and Successive composites does not explain a significant proportion of the variance in reading comprehension achievement.

8. A combination of the Planning, Attention, Simultaneous, and Successive composites does not explain a significant proportion of variance in the DAB-2 Writing composite.
9. A combination of the Planning, Attention, Simultaneous, and Successive composites does not explain a significant proportion of the variance in punctuation achievement.

10. A combination of the Planning, Attention, Simultaneous, and Successive composites does not explain a significant proportion of the variance in capitalization achievement.

11. A combination of the Planning, Attention, Simultaneous, and Successive composites does not explain a significant proportion of the variance in written composition achievement.

12. A combination of the Planning, Attention, Simultaneous, and Successive composites does not explain a significant proportion of the variance in spelling achievement.

13. A combination of the Planning, Attention, Simultaneous, and Successive composites does not explain a significant proportion of variance in the DAB-2 Mathematics composite.

14. A combination of the Planning, Attention, Simultaneous, and Successive composites does not explain a significant proportion of the variance in math reasoning achievement.
15. A combination of the Planning, Attention, Simultaneous, and Successive composites does not explain a significant proportion of the variance in math calculation achievement.

16. A combination of the Planning, Attention, Simultaneous, and Successive composites does not explain a significant proportion of the variance in the DAB-2 Total Achievement Composite.
CHAPTER II

REVIEW OF RELATED LITERATURE

An overview of the PASS model of cognitive processing based on Luria's concept of the three functional units of the brain as well as a review of the literature regarding the PASS tasks and their relation to academic achievement is presented in this chapter.

THE THREE FUNCTIONAL UNITS OF THE BRAIN

According to Luria (1966, 1973, 1980, 1984), human processes can be divided according to three principal functional units. They can be described as a unit for regulating tone or waking (first functional unit), a unit for obtaining, processing and storing information as it arrives from the outside world (second functional unit), and a unit for programming, regulating and verifying mental activity (third functional unit). Although each unit has a distinctive role to play in mental processing, the collective participation of these structures necessitates any type of mental activity. The role of each functional unit will be described briefly.
ATTENTIONAL PROCESSES: THE FIRST FUNCTIONAL UNIT

According to Luria (1973), the first functional unit of the brain maintains an optimal level of cortical tone or arousal which allows the individual to receive and analyze information so that the individual can respond to a variety of stimuli and a general state of readiness or focus of attention is maintained. The maintenance of an optimal level of cortical arousal is necessary for effective responding to the environment, discriminating among stimuli, and activating the second and third functional units. The principal structures responsible for maintaining and regulating cortical tone are located in the subcortex and brain stem. These structures both influence the tone of the cortex and experience its regulatory influence. The reticular formation in particular, with its ascending and descending systems, constitutes a single vertically arranged functional system capable of changing the tone of the cortex. During the studies of the reticular formation the concept of the first functional unit of the brain was formulated. Luria (1973) conceptualized this unit as "an apparatus maintaining cortical tone and the waking state and regulating these states in accordance with the actual demands confronting the organism" (p. 47). The first functional unit, therefore, is critical for organized mental activity because it regulates the state of cortical activity and the level of alertness. It does not, however, have any direct relationship to the reception and processing of external information (second functional unit) or to the formation of complex goal-directed intentions, plans, and programs of behavior (third functional unit).
SIMULTANEOUS AND SUCCESSIVE PROCESSES: THE SECOND FUNCTIONAL UNIT

The second functional unit of the brain has a primary function of receiving, analyzing and storing information. It is located in the lateral regions of the neocortex, which occupies the posterior regions, including the visual (occipital), auditory (temporal) and general sensory (parietal) regions. This unit utilizes simultaneous and successive processes to analyze and encode incoming information. When information is encoded simultaneously, each individual element of an informational unit is related to every other element of the unit. When information is encoded successively, each element of an informational unit is related to the elements immediately preceding and following it (Luria, 1973).

A hierarchical organization characterizes the second functional unit whereby three zones (primary, secondary, tertiary) have varying degrees of modal specificity. The primary zones are essentially modality specific (e.g., auditory information is processed by the temporal lobe, visual by the occipital lobe). The secondary zones, superposed above the primary zones, have a lower degree of modal specificity because their function is primarily synthetic rather than receptive in nature. The tertiary zones integrate information from a number of sense modalities into a single, polymodal conception of the environment. This zone is therefore, multimodal and is responsible for the more integrated conceptions of the individual (Luria, 1973).
PLANNING PROCESSES: THE THIRD FUNCTIONAL UNIT

The third functional unit, according to Luria (1973), is responsible for the programming, regulation, and verification of information. The complex cognitive processes that occur in this unit distinguishes humans and primates. The structures of the third functional unit are located in the anterior regions of the hemispheres, anteriorly to the precentral gyrus. Specifically, this unit creates plans for action (e.g., conscious activity), regulates their performance, determines the effectiveness of the activity, and corrects mistakes accordingly. Thus, planning processes allow individuals to act effectively on the environment and to execute complex mental activity that involves the first (attentional) and second (simultaneous and successive) functional units (Luria, 1973).

Like the second functional unit, the third functional unit is described in terms of primary, secondary, and tertiary zones. Rather than being associated with differing levels of modal specificity, however, these zones are described in regard to degree of muscle specificity. The primary zone is associated with the motor cortex and is characterized by specific groups of neurons which are associated with specific muscles. The secondary zone is characterized by an increased level of integration whereby groups of neurons are associated with systems of muscles involved in a single coordinated movement. The tertiary zone is integrated further and is associated with the execution of several coordinated movements to reach a desired goal. This zone is quite complex as is evidenced by its connection with virtually every area of the cortex, the motor systems, and the lower brain
structures (i.e., reticular formation). Thus, the third functional unit utilizes information from other areas of the brain in its creation of programs, including the first and second units' processes, while at the same time directly influences their functioning (Luria, 1973).

THE OPERATIONALIZATION OF LURIA'S THREE FUNCTIONAL UNITS

Tasks designed to measure cognitive processes following Luria's conceptualization of the three functional brain systems will be described in Chapter III. Following is a brief overview of the structural architecture of these Planning, Attention, Simultaneous, and Successive processing tasks.

Attentional tasks, following from Luria's description of the first functional unit of the brain, require the individual to selectively attend to one aspect of a two dimensional stimulus while ignoring the other. Thus, these tasks involve competing stimuli that are as salient or more salient than the target stimulus. Expressive Attention and Number Finding are examples of Attentional measures.

Simultaneous processing tasks are associated with the second functional unit of the brain and require the individual to interrelate the component parts of a task to arrive at a gestalt (i.e., the correct solution). The individual must appreciate the relationships among all elements of a stimulus array in order to successfully complete a pattern. The difficulty of a simultaneous task is a function of its complexity and number of interrelationships. Figure Memory, Matrices, and Simultaneous Verbal are
examples of Simultaneous measures.

Successive processing tasks also require second functional unit activity and require the individual to appreciate the serial nature of stimuli. In order to solve a successive task, the individual is required to reproduce a sequence of events or answer questions that require an interpretation of the linearity of events. Examples of Successive measures include Sentence Repetition, Sentence Questions, Successive Speech Rate and Word Recall.

Finally, tasks associated with Luria's third functional unit involve planning and require the individual to develop an effective means of solving a relatively simple problem. Visual Search, Planned Connections, and Planned Codes are examples of planning measures.

Luria's conceptualization of the three functional units of the brain provides a theoretical framework for assessing cognitive functioning. Current intellectual instruments measure ability using tasks associated with the processes of the second functional unit (simultaneous and successive), while essentially ignoring the processes of the first (attentional) and third (planning) functional units (see Naglieri, Das, & Jarman, 1990). Because attention is at the base of all cognitive functioning and planning represents a uniquely human cognitive process according to Luria (1973), the omission of tasks designed to systematically measure attention and planning may be regarded as a limitation to current intellectual measures (Das, & Naglieri, 1990). An understanding of Luria's model may enhance our knowledge of the nature of cognitive strategies so that innovative methods for measuring
these aspects of human processing may be designed. In addition, through the utilization of this theoretical perspective and an analysis of its relationship to academic achievement effective remediation strategies can be developed.

THE PASS TASKS AND ACHIEVEMENT

A specific goal of the Planning, Attention, Simultaneous, and Successive cognitive processing approach to understanding human functioning is to provide an alternative to standardized IQ testing of normal and exceptional children (e.g., learning disabled, reading disabled). Current measures of intellectual ability provide minimal insight into how children learn and, therefore, have been virtually ineffective in providing information that is useful for the remediation of learning problems. Research has recently demonstrated that the PASS tasks differentiate between normal and reading disabled populations (Bardos, 1988) and significantly correlate with academic achievement (Prewett, 1991; Warrick, 1989). For example, Warrick (1989) found that the PASS Composite correlated .67 (p<.001) with mathematics achievement and Prewett (1991) found that the Planning, Simultaneous, and Successive Composites correlated .53, .64, and .59 (p<.01) with the K-TEA Battery Composite, respectively. Therefore, it would appear that the PASS model of cognitive processing is a viable alternative to existing intellectual instruments when used for the identification and remediation of learning disabilities.
PASS AND READING ACHIEVEMENT

The majority of research concerning learning problems has been done in the area of reading (Kirby & Williams, 1991). Much early work on the relationship between cognitive processes and reading achievement focused on correlational studies using simultaneous and successive processing tasks. Later, Das, Kirby, and Jarman's (1979) Information-Integration model, which included planning tasks, supplemented and enhanced this line of research. Recently, investigations aimed at understanding the relationship between all four cognitive processes (Planning, Attention, Simultaneous, Successive) and academic achievement have been conducted and will be discussed.

READING ACHIEVEMENT AND SIMULTANEOUS AND SUCCESSIVE PROCESSES

In the early 1970's researchers reported that both simultaneous and successive processes were utilized in reading. Leong (1974) was perhaps one of the first researchers to compare average and below average readers on simultaneous and successive tasks. He found below average readers to be inferior to average readers on both processing tasks. Several subsequent attempts to replicate the work of Leong have been successful. For example, Das, Snart, and Mulcahy (1982) found that disabled readers were inferior to average readers in simultaneous and successive processing tasks as well as planning tasks. Das and his colleagues have conducted
several studies since the early work of Leong comparing reading achievement to simultaneous, successive, and planning processes.

In an early study relating reading achievement to simultaneous and successive processing, Kirby and Das (1977) hypothesized that high levels of achievement could only be attained by those individuals possessing high levels of both modes of coding (i.e., simultaneous and successive) because complex achievement tasks depend on both forms of processing. Moreover, they hypothesized that moderate levels of achievement would be attained by those individuals possessing moderate levels of both processing modes or by those high in either simultaneous or successive processing. This latter hypothesis, if supported, would lend credence to the notion that simultaneous and successive processes are non-hierarchically related and thus provide further support for the information processing model (Das, 1973; Das, Kirby, & Jarman, 1975).

The subjects in Kirby and Das' (1977) study were 104 fourth-grade boys from regular, urban classrooms in Canada. The subjects were given tasks previously demonstrated to load independently on simultaneous and successive processing factors. Subsequently, these subjects were divided into four quadrants on the basis of median splits of simultaneous and successive factor scores resulting in the following groups: a) high-simultaneous, high-successive; b) high-simultaneous, low-successive; c) low-simultaneous, high-successive; and d) low-simultaneous, low-successive. The performance of the four groups on the vocabulary and
comprehension parts of the Gates McGinitie Reading Test was then analyzed. Results clearly indicated that children high in both simultaneous and successive processing had the highest reading achievement scores, those low in both modes the lowest, and those high in one mode of processing and low in the other had intermediate scores. Both hypotheses were supported, suggesting that high reading achievement necessitates adequate skill development in both simultaneous and successive processing and neither by itself is sufficient (Kirby & Das, 1977).

Although Kirby and Das (1977) demonstrated that reading achievement is related to both coding processes, reading difficulties have frequently been related to deficits in sequential (successive) processing. Several researchers have reported that reading disabilities are related to low performance on sequential processing tasks (Doehring, 1968; Kinsbourne & Warrington, 1966). Others have reported that sequential memory processes correlated with the acquisition of word recognition skills in EMR children (Blackman, Bilsky, Burger & Mar, 1976; Blackman & Burger, 1972). In an attempt to understand the fine discriminations between simultaneous-sequential processing and reading achievement, Cummins and Das (1978) looked at the relationship between simultaneous and successive processing and performance on a variety of linguistic tasks using a sample of 60 third grade children. They found that successive processing was significantly related to children's ability to analyze propositions that involved ambiguities in surface structure and deep structure. In addition, simultaneous
processing was significantly related to children's ability to interpret sentences involving lexical surface structure. These findings support Luria's contention that simultaneous and successive processes differ in their importance regarding various aspects of linguistic functioning (Cummins & Das, 1978).

Cummins and Das (1978) point out, however, that at different developmental levels, and between different groups, the role of simultaneous and successive processing in linguistic functioning may vary. "It is possible...that successive processing of the linguistic input may be a prerequisite for deeper levels of semantic analysis involving simultaneous processes" (p. 247). Thus, successive processing may be particularly important for mastering initial reading decoding skills while simultaneous processing may be more highly related to fluent reading or advanced levels of reading. Based on this rationale, Das and Cummins (1978), in a second study, hypothesized that the relationship of simultaneous and successive processing on reading performance would be different for low-achieving and normal reading groups.

Using the same median split procedure as described in Kirby and Das (1977), Das and Cummins (1978) used a sample of 52 EMR children between the ages of 10 and 14 to investigate the relationship between cognitive processing (i.e., simultaneous and successive) marker tests, WISC IQ, a Syllogistic Reasoning Task, and the Wide Range Achievement Test (WRAT). It was shown that successive processing tasks significantly correlated with the oral reading and spelling subtests of the WRAT as well as
the Syllogistic Reasoning Task. Simultaneous tasks significantly correlated with the WISC Performance IQ and the arithmetic subtest of the WRAT. These findings demonstrate the importance of successive processing strategies for the development of decoding skills in retarded children. Das and Cummins concluded that low levels of successive processing ability may be one of the factors which limits the reading achievement of low achieving children (Das & Cummins, 1978).

The involvement of successive processing in linguistic performance among EMR children is consistent with the results of Blackman and his colleagues as well as Walker, Roodin and Lamb (1975) who found that retarded children’s deficits in auditory sequential memory significantly correlated with receptive and expressive language comprehension as measured by the Northwestern Syntax Screening Test. Successive processing, however, is not only related to the development of reading skills in EMR children but to a variety of groups who are likely to experience difficulty in reading. For example, Das, Manos, and Kanungo (1975) found that success in reading among low SES children was related to successive processing and to both simultaneous and successive processing among high SES children.

This relationship between successive processing and reading achievement changes notably when the performance of high achieving children are investigated. For example, McLeod (1978; cf. Das, Cummins, Kirby, & Jarman, 1979) found that simultaneous processing (but not
successive processing) was highly related to reading performance among grade 4 advanced readers.

In another study, Cummins and Das (1977) employed a median split procedure with a sample of grade 3 children in order to investigate the relationship between simultaneous/successive processing and reading decoding and comprehension. Results of the analyses of variance showed significant main effects for simultaneous processing in both reading decoding and comprehension and are consistent with those reported by Kirby and Das (1977). The main effect for successive processing was not significant for reading decoding or comprehension.

In order to investigate further the hypothesis that simultaneous processing is important at more advanced stages of reading whereas successive processing is important at less-proficient stages, the correlations between simultaneous and successive processes and comprehension scores for subjects at the top and bottom half of the comprehension distribution were analyzed. Results indicated that simultaneous processing correlated significantly with comprehension in the top, but not the bottom, half of the distribution, despite the reduced variance in comprehension scores. The decoding distribution was similarly divided into top and bottom halves; a relationship between decoding and simultaneous processing was not evident. This apparent inconsistency with the findings of Kirby and Das (1977) may be attributed to the different criterion measures of reading that were employed in each study as well as the different mean IQ scores
obtained for the two samples (Cummins & Das, 1977).

From the aforementioned studies it may be concluded that competence in successive processing is crucial for reading achievement among children who are likely to experience reading difficulty. Specifically, successive processing appears to be important for the development of initial reading decoding skills. Conversely, for children at more advanced levels of reading and comprehension skills simultaneous processing is as important or more important than successive processing in the reading process (Das, 1988).

MORE RECENT EVIDENCE OF THE RELATIONSHIP BETWEEN READING ACHIEVEMENT AND SIMULTANEOUS/SUCCESSION PROCESSING

Several investigations regarding the involvement of simultaneous and successive processing in reading performance continued into the 1980's and have supported, extended, and replicated previously mentioned findings. For example, Ryckman (1981) replicated the work of Kirby and Das (1977) finding that simultaneous and successive factors were both highly correlated with reading vocabulary and reading comprehension for a group of learning-disabled children. Similarly, Das, Bisanz, and Mancini (1985) found that successive processing (i.e., Digit Span) had a strong correlation with the Schonell Reading test followed by simultaneous processing (i.e., Memory for Designs). McRae (1986) also looked at the relationship between word recognition and comprehension and simultaneous and successive processes. Her results support the body of literature that has found a relationship between simultaneous processing and reading
comprehension. Das and Siu (1989), on the other hand, provided further support for the literature linking successive processing to the performance of children likely to experience academic difficulties. They concluded that poor readers had significantly more difficulty encoding and ordering information successively when compared to good readers.

Cummins and Das (1980) supported their previous research (Das & Cummins, 1978) by investigating the relationship between cognitive processes, WISC-R performance, and academic achievement among a group of EMR adolescents. As predicted, successive processing was significantly related to the reading and spelling subtests of the WRAT as well as WISC-R Verbal Comprehension. Simultaneous processing was related to WISC-R Perceptual Organization and, to a lesser extent, WISC-R third factor (Arithmetic, Digit Span, Coding) and WRAT arithmetic. They concluded that the poor reading skills of EMR children and adolescents may not be due solely to low intellectual ability but rather may be attributed to an inability or failure to effectively apply their cognitive abilities to literacy-related academic tasks (Cummins & Das, 1980).

With regard to cognitive processes and language awareness, Leong (1984) investigated the relationship between simultaneous and successive syntheses, language awareness, and reading. Under the assumption that "cognitive processing is antecedent to conscious awareness of language, which in turn precedes or develops with reading" (p. 371), Leong hypothesized that there should be a stronger direct effect of language
awareness on reading than that of simultaneous and successive synthesizes on reading. He concluded that simultaneous and successive synthesizes are necessary but not sufficient for reading; these processes underpin reading development via the mediating or facilitating effects of differing language awareness levels (Leong, 1984).

Similarly, Kirby and Robinson (1987) extended the work of Cummins and Das (1978) regarding the relationship between cognitive processes, linguistic ambiguities, and reading. They concluded that simultaneous processing was involved in direct lexical access and semantic processing while successive processing was involved in graphophonic decoding and syntactic analysis. Perhaps the most striking finding of Kirby and Robinson's investigation was that the reading disabled children in their study utilized simultaneous processing in the early stages of reading (i.e., word recognition and syntactic analysis) which involve tasks that are more effectively handled with successive processing (Leong, 1976-1977).

Finally, Das and Mensink (1989) investigated the relationship between K-ABC simultaneous and sequential scores and achievement in reading. Their results indicated that both processes contribute to reading achievement and therefore supported the findings obtained by Kirby and Das (1977) and Cummins and Das (1977). Specifically, they found that a group of fifth grade subjects high in simultaneous processing were better at decoding than those low in simultaneous processing, regardless of their sequential performance. In addition, no significant difference was found
between high and low sequential subjects on reading decoding tasks. Although sequential processing has been found to relate to beginning stages of learning to decode, especially among EMR children (Cummins & Das, 1977), when considering a fifth grade sample, simultaneous processing plays an important role in children's decoding strategies (Das & Mensink, 1989). Naglieri and Das (1987) showed similar findings among a group of sixth grade children. That is, simultaneous factor scores correlated significantly with decoding whereas successive factor scores did not. Das and Mensink concluded that different processing demands are required for different achievement tasks and that these demands vary as a function of age or grade level. Therefore, it is important to consider the content and type of processing demands of achievement tests when comparing results across studies (Das & Mensink, 1989).

READING ACHIEVEMENT AND PLANNING PROCESSES Investigations of planning processes and reading achievement were more evident in the 1980's then they were in the 1970's. Through the utilization of the planning tasks incorporated in Das, Kirby, and Jarman's (1979) model of Information-Integration and later, those planning tasks used to operationalize the DN: CAS (1989), researchers have gained additional insight regarding the intricate relationship between reading achievement and cognitive processes.
Research conducted by Molloy and Das (1980) examined the relationship between simultaneous and successive processing, and planning for those with mental retardation. They concluded that although both simultaneous and successive processing were available to all the children they tested, those with cognitive problems differed from normals in the "spontaneous utilization of the most efficacious process or combination of processes" (p. 116), which is directly related to planning. This study points to the importance of planning processes for the execution of academic tasks. The following investigations will expound on the relationship between planning, simultaneous and successive processes, and reading achievement.

Das, Snart, and Mulcahy (1982) investigated the relationship between reading and cognitive processes by comparing normal and disabled readers in grades 2, 4, and 6 on simultaneous, successive, and planning tasks. All the tasks were shown to discriminate between normal 4th and 6th grade readers with the older children being superior to the younger ones. The normal readers, as a whole, were superior to the reading disabled children on all processing tasks. Thus, the reading disabled children were not only poor in coding tasks when compared to normal readers but in planning tasks as well. In addition, the results of this study showed that at the lower grades decoding may require successive processing whereas simultaneous processing is required for comprehension at any grade and therefore are consistent with earlier findings (Cummins & Das, 1977, 1978). Similarly, Das, Bisanz, and Mancini (1985) found a significant relationship between
both coding (i.e., simultaneous and successive) and planning processes and performance on a simple word recognition task (e.g., Schonell).

To further investigate the involvement of cognitive processes in reading achievement, Ramey (1985; cf. Das, 1988) administered marker planning tests (e.g., Visual Search and Trail Making) in addition to measures of simultaneous (e.g., Progressive Matrices, Memory for Designs, and Figure Copying) and successive (e.g., Digit Span and Serial Recall) processing to junior high school males and females. These students were also administered a reading test in which vocabulary as well as level and speed of comprehension scores were obtained. Factor analyses indicated that Progressive Matrices and Digit Span had substantial loadings on the reading factor (i.e., the three reading scores). A median split procedure, as described previously, was carried out, only this time planning was included. This resulted in eight groups which were then compared on vocabulary and comprehension scores. Results indicated significant main effects of simultaneous and successive processing for all three reading scores. Specifically, a significant main effect of successive processing for speed of comprehension and significant main effects of simultaneous processing and planning for level of comprehension were found. Although the implications for speed of comprehension are not clear, it appears that good successive processing is important for speed of comprehension but is relatively unimportant for level of comprehension for this sample of junior high school students (Das, 1988).
In yet another investigation that shed light on the relationship between cognitive processing and reading performance, Naglieri and Das (1987) examined the criterion-related validity (correlations with achievement) of nine experimental tasks they designated as measures of planning and coding (i.e., simultaneous and successive processing). Subjects from grades 2, 6, and 10 were administered planning ( Trails, Visual Search, Matching Numbers), simultaneous (Tokens, Matrices, Figure Recognition), and successive (Word Recall, Successive Ordering, Hand Movements) tasks as well as the Multilevel Academic Survey Test (MAST). Examination of the relationship between cognitive processes and achievement indicated that reading was related to coding at the lower grades and both coding and planning at the tenth grade level. Additionally, planning had as high a correlation with achievement as simultaneous and successive processes, evidenced larger correlations with achievement from grade 2 to grade 10, and was related increasingly to the total reading MAST score.

Prewett and Naglieri (1992) examined the relationship between planning, simultaneous, and successive processes and academic achievement (KTEA) with 4th and 5th grade students from both regular and special education (e.g., reading disabled) classrooms. Results showed that the successive and simultaneous composites correlated significantly with the KTEA reading, math, and battery composite scores for the normal group. For the reading disabled group, simultaneous, successive, and planning composites correlated significantly with all KTEA subtests and composites.
except spelling. The authors concluded that although planning, simultaneous, and successive composites contributed significantly to the prediction of academic achievement, the individual processing composites varied between normal and reading disabled groups. The finding that only the simultaneous and successive composites correlated significantly with achievement among normals is inconsistent with previous research that has found planning to be significantly related to academic achievement among reading disabled children (Naglieri & Das, 1987). This inconsistency may have been related to: 1) a restriction in the range of scores for the normal sample in the present study which served to decrease the Pearson correlations, or 2) group administered achievement tests (Das & Naglieri, 1987) versus the individually administered KTEA in the present study.

Prewett and Naglieri (1992) also found that the planning, simultaneous, and successive composites accounted for 64% ($R^2 = .80$) of the variance in the KTEA reading composite score in the reading disabled group. In contrast, the WISC-R accounted for only 46% ($R^2 = .68$) of the variance in the KTEA reading composite score with a similar sample of reading disabled children (Prewet, Bardos, & Fowler, 1990). This additional variance explained by these cognitive processing tasks is evidence of the important role that planning plays in the academic achievement of students with reading disabilities (Prewett & Naglieri, 1992).

The above mentioned studies have broadened our understanding of the relationship between reading achievement and cognitive processes by including processing tasks that measure planning as well as simultaneous
and successive processes. It may be concluded from these investigations that planning not only relates to reading achievement but is necessary for the spontaneous utilization of simultaneous and successive processes to ensure optimal performance. To conclude this section on the relationship between reading achievement and cognitive processes, studies that involved an examination of the PASS model of cognitive processing will be discusses in relation to reading achievement.

READING ACHIEVEMENT AND PASS PROCESSES

In one of the first attempts to represent all four areas of the PASS model, Bardos (1988) investigated and extended the validity of this cognitive processing model, operationalized by Naglieri and Das (1987, 1988). Bardos examined the differences between exceptional (i.e., reading disabled) and normal individuals matched on age, sex, race, socioeconomic status, and area of residence. Results showed that the LD children, when compared to normal children, had average simultaneous and successive cognitive processing skills but were deficient in planning and attention. The finding that normal and learning disabled children's performance does not differ on simultaneous and successive processing tasks provides further support for the research conducted with the simultaneous and sequential (successive) scales of the K-ABC (Naglieri, 1985; Naglieri & Haddad, 1984). These results are also consistent with previous investigations (Das et al., 1982; Das, 1984; Kirby & Robinson, 1987) that have found a relationship
between reading disability and planning deficiency. In addition, Bardos' results further strengthen the utility of remedial approaches that emphasize planning strategies.

In another investigation using PASS tasks, Snart, Das, and Mensink (1988) examined the role of information processing in intellectual and academic functioning. This study focused on severely reading disabled children who were above-average in intelligence. These children were compared to reading disabled and normal children of average intelligence on measures of planning (e.g., Planned Connections, Visual Search), attention (e.g., Selective Attention-Receptive, Sustained Attention), simultaneous (e.g., K-ABC Triangles, Gestalt Closure, Matrix Analogies and Spatial Memory), and successive (e.g., K-ABC Number Recall and Word Order) processing tasks. It was found that high IQ learning disabled students had an advantage over their average IQ peers in simultaneous processing (i.e., they received higher than average scores). However, this advantage seemed to disappear in regard to sequential processing (i.e., the groups did not differ significantly). Furthermore, the non-learning disabled students were superior to LD students on selective attention tasks (i.e., those involving Physical and Name matching) only when lexical access as opposed to direct visual matching was a requirement. Planning tasks also distinguished between learning disabled and non-learning disabled students. Based on the results of their investigation, the authors concluded that remedial programming for learning disabled students should include an
emphasis on attention and planning in addition to simultaneous and sequential processing.

Another attempt to separate reading disability from intelligence was made by Das, Mensink and Mishra (1992). Their investigation focused on identifying those cognitive processes which discriminated between good and poor readers when IQ was covaried. Their subjects were 45 children with and 95 children without reading problems. All children attended 5th and 6th grade classes in Catholic schools in Canada. Subjects were administered twelve experimental tasks (representing the PASS functions) from the Das-Naglieri Cognitive Assessment System (DN:CAS). Results showed that Sequence Repetition, Naming Time, and Speech Rate (successive tasks), as well as the Stroop Color-Word test (selective attention task) discriminated between good and poor readers when IQ was covaried. The four tests were then administered to high and low IQ reading disabled children. As predicted, both groups performed poorly on the four tasks. Since all four tasks involve the use of articulatory representation, the importance of speech-related processes in reading (decoding) is evident. In fact, the major problem inherent in reading disabled children may be a deficiency in speech-related processes (Das et al., in press).

Finally, Reardon and Naglieri (1992) examined the relationship between Planning, Attention, Simultaneous, and Successive cognitive processes and phonological coding. In this investigation, normal (N=30) and reading disabled (N=30) samples were administered PASS cognitive processing tasks as well as the Woodcock-Johnson Revised pseudoword reading
subtest and the WRAT-R reading subtest. Results indicated that successive processing was the best predictor of pseudoword reading scores ($R=.52$) and successive and planning processes best predicted scores on the WRAT-R reading subtest ($R=.54$) in the reading disabled sample. In the normal sample, simultaneous processing was the best predictor of pseudoword reading scores ($R=.58$) but none of the PASS composites accounted for significant variance in WRAT-R reading scores. This latter finding may have been influenced by the restriction in range on the achievement variable (Reardon & Naglieri, 1992). This study points to the important relationship between successive processing and reading deficiency, defined as phonological coding, and is consistent with previous research investigations (e.g., Kirby & Das, 1990). Furthermore, the significant portion of variance in WRAT-R reading scores accounted for by planning processes is consistent with studies conducted by Bisanz, Das and Mancini (1984), Das (1985), Das and Siu (1989), Snart, Das and Mensink (1988), Varnhagen, Das, and Varnhagen (1986), and Prewett and Naglieri (1992).

Based on this review of the literature on cognitive processes and reading achievement it is evident that an assessment of only simultaneous and successive processes provides limited information concerning the relationship between information processing and academic achievement. Both planning and attentional strategies are significantly related to reading achievement and have been shown to differentiate reading disabled from
non-reading disabled children. Thus, an assessment of all four PASS processes provides an opportunity for a better understanding of the cognitive characteristics of individuals with and without learning disabilities. Only through this deeper knowledge will the nature of reading disabilities become more apparent and effective remedial training (Brailsford, Snart, & Das, 1984) more widespread. Another area in which there is a relationship between cognitive processes and achievement is in mathematics. Following is a review of the literature on PASS processes and their relationship to mathematics achievement.

THE PASS MODEL AND MATHEMATICS ACHIEVEMENT

The literature reviewing the relationship between the PASS model and mathematics achievement is limited in comparison to the previously reviewed studies relating cognitive processes to reading achievement. However, mathematics achievement has been linked to planning, attention, simultaneous, and successive processes and will be reviewed here.

Sprecht (1979; cf. Das et al., 1979) investigated the relationship between mathematics and simultaneous and successive processes with a sample of low-achieving high-school students. Results indicated that mathematics achievement test scores demonstrated a moderate loading on the simultaneous processing factor. This finding supported both Luria (1966) and Das et al.'s (1979) contention that mathematics achievement is more closely related to simultaneous processing rather than successive
processing due to the highly spatial nature of mathematics. Several research projects have supported this firm relationship between mathematics tasks and simultaneous processing (e.g., Das & Cummins, 1978; Das & Mohanty, 1989; Leong, Cheng, & Das, 1984; Mwamwenda, Dash, & Das, 1985).

Wachs and Harris (1986) also demonstrated the importance of simultaneous processing strategies for mathematics proficiency. They individually administered a battery of simultaneous and successive processing tasks to a sample of 70 undergraduate college students and correlated these scores with those obtained on the Mathematics portion of the Scholastic Aptitude Test (SAT). Their findings showed that simultaneous processing correlated significantly with Math SAT scores whereas successive processing correlated significantly with the subjects’ grade in English.

In another study, Das, Manos, and Knaungo (1975; cf. Das et al., 1979) investigated the relationship between simultaneous and successive processing and mathematics achievement. Their subjects were fourth grade students of high and low socioeconomic status. The results indicated that mathematics achievement was predicted by a simultaneous processing task (i.e., Figure Copying) for students in the high SES group whereas the strongest predictor of math achievement in the low SES group was a successive processing task (i.e., Serial Recall). It should be noted, however, that Figure Copying was also a strong predictor of math achievement in the
low SES group. The authors concluded that although simultaneous processing appears to be the most efficacious method of processing for mathematics, it was used less frequently than successive processing by students in the low SES group.

Garafalo (1986) investigated two related domains of arithmetic (i.e., computation and problem solving) in order to determine whether they are differentially related to coding processes. The subjects in this study were 95 students from 5th grade classes in an Indiana school system. All subjects were administered tasks that measured simultaneous (e.g., Raven's Coloured Progressive Matrices, Memory for Designs), successive (e.g., Digit Span, Auditory Serial Recall), and planning (e.g., Trail Making Test for Children, Wisconsin Card Sorting Task) processes as well as mathematics achievement (Cognitive Abilities Test, Iowa Test of Basic Skills). The relationship of these cognitive processes to mathematics computation, problem solving, and quantitative ability was subsequently investigated. Results indicated that quantitative ability and problem solving loaded significantly on the simultaneous factor whereas computation had its highest loading on the planning factor. Garafalo concluded that these results are consistent with the expectation that problem solving and quantitative ability require an understanding of mathematical and logico-grammatical relationships (i.e., simultaneous processing) while Computation is more related to the regulation and monitoring of behavior (i.e., planning). This latter relationship was subsequently confirmed by Kirby and Ashman (1984).
Naglieri and Das (1987) examined the simultaneous, successive, and planning processes of 434 children in grades 2, 6, and 10. These cognitive processing scores were subsequently correlated with the Multilevel Academic Survey Test (MAST). Results showed differential effects of cognitive processes on mathematics achievement indicating developmental changes across grades. Specifically, mathematics achievement was most strongly associated with simultaneous processing and planning at the second grade level. Although simultaneous processing continued to show a strong association with mathematics achievement at the sixth grade level, successive and planning processes were also significantly correlated with math achievement scores. At the tenth grade level, the relationship of successive processing to math achievement increased to a level nearly commensurate with that of simultaneous processing. Similarly, Prewett and Naglieri (in press) examined the relationship between planning, simultaneous, and successive cognitive processes and academic achievement (KTEA) with a sample of 4th and 5th grade students from regular and special education classes. They found that planning accounted for a significant portion of the variance in a reading disabled group's KTEA math ($r = .37$) and total achievement ($r = .59$) scores. These findings illustrate the need to include measures of planning in tests of intelligence in order to better understand academic performance.

Finally, Warrick (1989) investigated the cognitive processes that underlie mathematics achievement following Naglieri and Das' (1988)
operationalization of Planning, Attention, Simultaneous, and Successive processes. Her subjects were 208 students from grades 3, 6, and 9. All students were administered a battery of 12 experimental tasks developed by Das and Naglieri (1989) and a standardized group mathematics achievement test. Differences among high and low math achievers on the four cognitive processing components were subsequently analyzed. The findings indicated that high math achievers performed significantly better than low math achievers on all four components of the PASS model. Of the four individual PASS components, simultaneous processing generally provided the greatest discrimination among high and low math achievers in all four areas of math (i.e., math concepts, math problem solving, math computation, and total math achievement), for all grade levels. The author concluded that although simultaneous processing appeared to be the strongest predictor of math achievement in general, all four cognitive processing components are important in math achievement.

Warrick (1989) also examined the utility of the PASS model in the prediction of math achievement. At the third grade level, total math achievement was best predicted by attention, followed by simultaneous and successive processing. In addition, math concepts was best predicted by successive processing (followed by attention and simultaneous), problem solving was best predicted by attention (followed by simultaneous), and computation was best predicted by simultaneous processing (followed by attention). Warrick concluded that the strong predictability of the attention
Component at the third grade level may indicate the importance of attention in the early stages of mathematics learning. The importance of the simultaneous processing component for mathematics proficiency is consistent with previous findings (Naglieri, 1985; Naglieri & Das, 1987).

For the sixth grade sample, simultaneous processing was the best predictor of achievement in all four areas of math achievement. For the ninth grade sample, total math was best predicted by attention and simultaneous processing (followed by successive and planning), problem solving was best predicted by simultaneous processing and attention, and computation was best predicted by attention and planning (followed by simultaneous and successive processes). Warrick concluded that these findings demonstrate the increasing importance of all four cognitive processing components with age; the planning component was particularly evident across grade levels (Warrick, 1989).

**CONCLUSION**

This chapter reviewed the literature on the relationship between planning, attention, simultaneous, and successive cognitive processes and academic achievement. Numerous investigations have been conducted on the relationship between simultaneous and successive processes and academic performance. In general, these findings indicate that successive processing is important for initial reading decoding skills whereas simultaneous processing is important for more advanced stages of reading comprehension. In regard to mathematics achievement, many studies have
reported strong correlations between simultaneous processing and math proficiency.

However, with the development of tasks that measure planning (Das et al., 1979) and attention (Das & Naglieri, 1987, 1988) a more complete understanding of the intricate relationship between cognitive processes and academic achievement has begun to emerge. For example, learning disabled children, when compared to normal children, had average simultaneous and successive processing skills but were deficient in planning and attention (Bardos, 1988). In addition, although the literature regarding the relationship between cognitive processing and writing achievement is sparse, a strong positive correlation was shown to exist between written composition and planning. Finally, the importance of both planning and attention in the prediction of mathematics achievement was demonstrated.

Including measures of all four PASS processes may provide an opportunity for a more comprehensive understanding of the relationship between cognitive characteristics and academic achievement. Thus, as the range of processes extends beyond that which current intelligence tests measure, a more complete understanding of the relationship between intelligence and academic performance may be achieved.
CHAPTER III

METHODOLOGY

Subject Selection

Subjects comprising the sample for the present study are 78 elementary school students from the Southwestern City School District located in central Ohio. These students were referred for psychoeducational assessment by a classroom teacher because of suspected learning problems. Parental permission was obtained from the parents of the subjects included in this study. All students who were referred and whose parents agreed to participate were involved in the present investigation. More than 95% of those referred received parental permission and therefore were included in the study.

Procedure

All subjects were administered twelve experimental tasks and a standardized measure of academic achievement by one of three examiners. The examiners were advanced graduate students in school psychology who received extensive training in psychological test administration. In addition, the examiners were trained in the administration of the experimental tasks.
by the test author. Scoring procedures were closely supervised by the test author in order to ensure accuracy. Standard testing procedures, as outlined by Sattler (1988), were employed by the examiners.

The 12 experimental tasks were administered to all students within the context of a larger psychoeducational assessment battery. The administration of these experimental tasks was conducted in one testing session of approximately 75 minutes duration. The Diagnostic Achievement Battery - Second Edition (DAB-2) (Newcomer, 1990) was also administered and took approximately one hour to administer.

Assessment Measures

The following measures of planning, attention, simultaneous, and successive processing are the experimental tasks that currently comprise the Das-Naglieri: Cognitive Assessment System (DN: CAS) (Das & Naglieri, 1990). The operationalization of this model of cognitive processing (PASS) currently includes three measures of planning, two measures of attention, three measures of simultaneous processing, and four measures of successive processing. A presentation of these twelve experimental tasks will be followed by a description of the academic achievement tasks of the Diagnostic Achievement Battery - Second Edition.
Experimental Tasks

The description of the experimental tasks that follow will occur in the order in which the tasks were administered. Thus, the three planning tasks will be presented first followed by the tasks designed to measure simultaneous, successive, and attentional processes. In addition, the academic achievement tasks will also be presented in the order in which they were administered.

Planning Tasks
1. Visual Search

This task requires the subject to point to a picture, number, or letter located in a field around a target, which appears in a stimulus box, and is similar to that developed by Teuber, Battersby, and Bender (1949). Two targets appear on each 8 1/2" X 11" page, one on the top half and the other on the bottom half. Each item is timed from initial exposure of the page to location of the second target. Looking left to right, top to bottom is an example of one strategy that might be employed to solve this task. This task has been found to load on a planning factor (Ashman & Das, 1980; Naglieri, Braden & Warrick, 1990; Naglieri & Das, 1988; Naglieri, Das, Stevens, & Ledbetter, 1991; Naglieri, Prewett, & Bardos, 1989). The test score is the total amount of time required to complete all items.
2. **Planned Connections**

This task requires the subject to connect sequential stimuli (e.g., the numbers 1-2-3-4-5-6). These stimuli appear in a scattered order on an 8 1/2" X 11" page. A more difficult task of this nature requires the subject to alternately connect numbers and letters in their proper sequence (e.g., 1 to A, A to 2, 2 to B, B to 3). Strategies for solving these particular tasks include scanning the page for the next number or letter and/or repeating the number or alphabet sequence to oneself or aloud while engaged in the task. Investigations by Ashman and Das (1980), Naglieri, Braden, and Warrick (1990), Naglieri and Das (1987), Naglieri et al. (1991), and Naglieri, Prewett, and Bardos (1989) have found this task to load on a planning factor. The test score is the total amount of time required to complete all items.

3. **Planned Codes**

In this task, a sequence of codes (e.g., XO, OO, OX, or XX) is paired with the letters A, B, C, or D. This task consists of two items. On each item, the subject is presented with a page of boxes. The top part of each box contains a letter and the bottom part of each box is empty. The subject is instructed to fill in the codes that correspond with the letters using a standard of correct code/letter pairings that appear at the top of each page. An effective way of completing this task is to fill in the boxes by letter (i.e., all the A's first, then the B's, etc.). This task was found by Naglieri and Das (1988), and Naglieri, Braden, and Warrick (1990) to load on a planning factor. The subject's score is the number of seconds required to complete each item divided by
the number of correct code/letter pairings.

**Simultaneous Tasks**

4. **Figure Memory**

   In this task, the subject is presented with a geometric figure or design (e.g., square, triangle, three dimensional cube) for five seconds. Then the design is removed and the subject is instructed to locate and trace the figure within a more complex design (that includes the original figure) from memory. Successful completion of this task involves interrelating the lines and angles of the figure. This task is similar to a simultaneous marker task previously used by Das et al. (1979) and Naglieri and Das (1987). In addition, support for this task is also provided by recent exploratory (Naglieri, Prewett, & Bardos, 1989) and confirmatory (Naglieri, Das, Stevens, & Ledbetter, 1991; Naglieri, Braden, & Warrick, 1990) factor analytic studies. The score for this test is the total number of designs correctly reproduced (i.e., no partial credit is given).

5. **Matrices**

   This task utilizes abstract designs of the standard progressive matrices type and requires the completion of figural analogies following a multiple choice format. The subject is instructed to select one of six options that best completes an abstract analogy. Like the Figure Memory task, the subject must understand the interrelationships of the item components in order to
arrive at a correct solution. The score for this test is the total number of correct items.

6. **Simultaneous Verbal**

   This task requires the subject to answer questions involving logical grammatical relationships. For example, the subject is shown six illustrations and is asked to point to "the balloon above the tree to the right of the house" or "the diamond in a square on top of a triangle." Support for this task as a simultaneous measure is provided by recent confirmatory (Naglieri, Das, Stevens, & Ledbetter, 1991; Naglieri, Braden, & Warrick, 1990) factor analytic studies. The score on this test is based on the total number of items answered correctly.

**Successive Tasks**

7. **Sentence Repetition**

   This task requires the subject to repeat sentences that have little meaning (i.e., sentences in which nouns and verbs have been replaced with color words). Thus, the subject is asked to repeat a sentence such as "The black purpled the orange" exactly as presented. An item is completed successfully only if the subject retains the correct order and the correct syntax of the sentence. Support for this task as a successive measure is provided by recent exploratory (Naglieri, Prewett & Bardos, 1989) and confirmatory (Naglieri, Braden, & Warrick, 1990; Naglieri, Das, Stevens, &
Ledbetter, 1991) factor analytic studies. The subject's score is the total number of sentences repeated correctly.

8. **Sentence Questions**

This task utilizes the sentences from the Sentence Repetition task and requires the subject to answer a question about each sentence. For example, rather than repeating "The black is yellowing," the subject is asked the question "Who is yellowing?" A response such as "The black" or "black" is scored as correct. The subject must comprehend the syntax of the sentences in order to successfully complete these items. This task has been found to load on a successive factor (Naglieri, Braden, & Warrick, 1990; Naglieri, Das, Stevens, & Ledbetter, 1991; Naglieri, Prewett, & Bardos, 1989). The subject's score is the number of questions answered correctly.

9. **Word Series**

This task consists of nine single syllable words. These words have a high degree of familiarity (e.g., car, key, shoe, bird, dog, man) and are presented in serial order ranging in length from two to nine words. This task has been used as a marker test for successive processing and has been found to load on a successive factor (Das et al., 1979; Naglieri, Braden, & Warrick, 1990; Naglieri & Das, 1987, 1988; Naglieri, Prewett & Bardos, 1989). The subject's score is the total number of items in which all words were recalled correctly.
10. **Successive Speech Rate**

On this test the subject is required to repeat a series of three familiar words (e.g., key, dog, book or blue, red, green) ten times, without making any mistakes. This test consists of six sets, three words per set. The examiner begins timing when the subject says the first word in the series for the first time and stops timing when the subject says the last word in the series for the tenth time. The subject's score is the amount of time it takes to say each sequence of words ten times.

**Attention Tasks**

11. **Expressive Attention**

This task is a modified version of the Stroop test (Golden, 1978) and contains three pages of which the last is used as a measure of selective attention. The first page contains the words red, blue, green, and yellow. The subject is required to read these words as quickly as possible, in the order presented. The second page contains colored rectangles printed in these colors arranged in eight rows, five to a row. The subject is instructed to name these colors as quickly as possible, in the order presented. The third page uses an interference paradigm; the words red, blue, green, and yellow are printed in colors different from the word. The subject must name the color the word is printed in as quickly as possible, in the order presented. This task has consistently loaded on an attention factor (Gottling, 1990; Hurt, 1988; Naglieri, Braden, & Warrick, 1990; Naglieri, Das, Stevens, &
Ledbetter, 1991; Naglieri, Prewett, & Bardos, 1989). The subject's score is the time needed to complete the third page of this task.

12. **Number Finding**

This task requires the subject to identify a number when it appears in one form rather than another. For example, the subject is instructed to underline the numbers 1, 2, and 3 when they appear in bold faced (1, 2, 3) rather than regular (1,2,3) print. This task involves two pages of items; each page contains 180 numbers and 45 targets. Support for this task as a measure of attention is provided by recent confirmatory (Naglieri, Braden, & Warrick, 1990; Naglieri, Das, Stevens, & Ledbetter, 1991) factor analytic studies. The subject's score was obtained by dividing the total number of seconds required to complete the last item by the total number of targets identified on that page. Each subject was allotted 90 seconds to complete each page.

A description of the reading, mathematics, and written language tasks of the Diagnostic Achievement Battery - Second Edition will follow.

**The Diagnostic Achievement Battery - Second Edition (DAB-2)**

The Diagnostic Achievement Battery - Second Edition (DAB-2) (Newcomer, 1990) is a nationally standardized individual achievement test used to assess academic knowledge in the areas of reading, mathematics, and written language for children aged 6 years to 14 years, 11 months. Reading, as measured by the DAB-2, involves literal and interpretive
meaning from the written/printed word (Newcomer, 1990). Mathematics is divided into two components: Theoretical Mathematics and Applied Mathematics. Theoretical Mathematics "involves the abstract logical study of quantity, form arrangement, and magnitude" whereas Applied Mathematics "pertains to the practical applications of the abstractions involved in Theoretical Mathematics" (Newcomer, 1990, p. 4). Only the Applied Mathematics component is assessed using the DAB-2, as is the case with most achievement tests. The writing subtests of the DAB-2 are designed to measure both linguistic and conventional achievement that "permit the expression of ideas and thought through the graphic mode" (Newcomer, 1990, p. 4).

The standardization sample of the DAB-2 consists of 2,623 students from 40 states. The procedures followed during the standardization of the DAB-2 was designed to obtain a representative group similar to the United States population. The characteristics of the normative sample with regard to sex, residence, race, ethnicity, and geographic area were compared to the percentages reported in the Statistical Abstracts of the United States (1985). Based on a comparison of these percentages with those of the norm group, it was determined that the sample is nationally representative (Newcomer, 1990).

The DAB-2 test manual reports estimates of the test's reliability using three procedures: internal consistency, test-retest, and standard error of measurement. In evaluating the reliability of this instrument, the author used
a reliability coefficient of .80 as a minimally acceptable criteria for sufficient reliability (Salvia & Ysseldyke, 1988; cited in Newcomer, 1990).

Internal consistency reliability coefficients are an estimate of the degree of homogeneity among a group of items and may be computed using the coefficient alpha technique (Newcomer, 1990). Coefficients alpha were computed for all DAB-2 subtests at each age interval. Reliability coefficients for DAB-2 composites were computed using Guilford's formula (1954; cited in Newcomer, 1990). All mean internal consistency coefficients for each age level fall at or exceed the .80 criterion indicating a high degree of homogeneity among the test items. Similarly, all test-retest reliability coefficients for the subtests and composite scores exceed the .80 criterion, indicating that the DAB-2 is stable over time (Newcomer, 1990).

The third procedure that was used to estimate the tests' reliability involved the standard error of measurement (SEm). The SEm was calculated using the reliability coefficients from the internal consistency data and "provides information about the certainty or confidence with which a test score can be interpreted" (Salvia & Ysseldyke, 1988, p. 119; cited in Newcomer, 1990). The SEm for the DAB-2 standard scores are provided in the test manual, Table 5.6 (Newcomer, 1990). In addition to reliability, the author of the DAB-2 also provides evidence of the test's content validity, criterion-related validity, and construct validity.

To ensure adequate content validity of the DAB-2 subtests, care was taken to select items that were representative of the subject matter within each academic area (Newcomer, 1990). This was achieved by reviewing
commonly used curricula and teaching programs. Following this review, the DAB-2 subtest were designed to measure achievement in the academic areas delineated in P.L. 94-142 and, therefore, represent the skills that make up reading, mathematics, listening, speaking, and writing achievement. A multiplicity of items were generated that pertained to each academic achievement area. Item analyses were subsequently conducted in order to determine which items were retained for inclusion in the DAB-2 subtests (Newcomer, 1990). Because listening and speaking subtests were not included in the present investigation, they will not be discussed further.

The criterion validity of the DAB-2 was examined by correlating DAB-2 subtests and composites to those of similar achievement tests. Because eight of the 12 subtests from the 1983 version of the DAB have remained unchanged, criterion validity evidence for the DAB will also be reported. Evidence of the criterion validity of the DAB was found by comparing its scores with those of the following selected achievement instruments: Durrell Analysis of Reading Difficulty, Keymath Diagnostic Arithmetic Test, Test of Language Development-Intermediate, Test of Language Development-Primary, Test of Written Language, Wide Rang Achievement Test, Woodcock Reading Mastery Test. Results indicate that the DAB subtests are significantly correlated with the aforementioned criterion measures and therefore supports the DAB criterion-related validity (Newcomer, 1990).

A second study was conducted to examine the criterion validity of the DAB-2. In this investigation, 45 students from grades 1-6 were administered
the DAB-2, the Wide Range Achievement Test-Revised (WRAT-R) (Fastak & Wilkinson, 1985), and the Detroit Tests of Learning Aptitude-School Edition (DTLA-SE) (Hammill, 1991). The validity data for this study are reported in the DAB-2 manual (Table 5.7) and provide evidence of the criterion validity of the DAB-2 subtest and composite scores (Newcomer, 1990).

Finally, Newcomer (1990) examined the validity of several basic constructs that appeared to underlie the DAB-2. The following five hypotheses, based on the constructs presumed to account for test performance, were generated: a) performance on the DAB-2 should be related to chronological age and school experience because it is an achievement test; b) the subtests that pertain to each of the five major content areas should be highly intercorrelated; c) performance on the DAB-2 should relate to performance on scholastic aptitude since it is assumed that performance on the DAB-2 is affected by cognitive processes; d) the DAB-2 subtests should differentiate between normal and atypical children (e.g., learning disabled) because it purports to measure the level of information that has been acquired or learned; and e) specific items within each subtest should correlate highly with the tests' total score since the items within each subtest measure similar traits. Support for each of the aforementioned hypotheses was found through a variety of empirical investigations (Newcomer, 1990).

Following is a description of the subtests and composites of the DAB-2 that were included in the present investigation.
Reading

1. *Alphabet/Word Knowledge*

   On the beginning section of this subtest subjects are required to identify letters and words, point to a series of letters presented by the examiner, name letters, and recognize words beginning and ending with specific speech sounds presented by the examiner. On the latter half of the subtest, the subject is required to pronounce written words that increase in level of difficulty. The internal consistency reliability coefficient alpha for the alphabet/word knowledge subtest was .91 when averaged across 9 age levels (6 years - 14 years).

2. *Reading Comprehension*

   On this 35 item subtest, the subject is required to read several short stories silently. Following each story several questions are asked by the examiner in order to assess the subject's level of comprehension. These stories vary in complexity ranging from three-sentence stories to lengthier paragraphs. The internal consistency reliability coefficient alpha for the reading comprehension subtest was .90 when averaged across 9 age levels (6 years - 14 years).

Writing

3-4. *Capitalization and Punctuation*

   On these subtests, the subject is presented with 30 sentences containing no capital letters nor punctuation marks. The subject is instructed to rewrite
each sentences inserting the correct capital letters and punctuation marks. The internal consistency reliability coefficient alphas for the capitalization and punctuation subtests were .95 and .92, respectively, when averaged across 9 age levels (6 years - 14 years).

5. **Writing Composition**

   This subtest contains three pictures that represent a modified version of the fable "The Tortoise and the Hare." The subject is instructed to view each picture carefully, take approximately five minutes to think about a story, and write a story based on the three pictures. The subject is also instructed to write a story with a beginning, middle, and end. Two methods are implemented in evaluating the maturity of the subject's written story. First, the examiner adds together all words containing at least seven letters used in the story. Second, a list of nine criteria are used in order to assess thematic content. The Writing Composition score is then derived from these two totals using the scoring criteria located on the test protocol. The internal consistency reliability coefficient alpha for the written composition subtest was not provided in the DAB-2 manual because the data were not appropriate for coefficient alpha analysis (Newcomer, 1990).

6. **Spelling**

   This subtest contains 20 items that range in order of increasing difficulty. The student is required to write words that are dictated by the examiner. The
internal consistency reliability coefficient alpha for the spelling subtest was 
.86 when averaged across 9 age levels (6 years - 14 years).

Mathematics

7. Mathematics Reasoning

This subtest has 30 items and utilizes pictures at the lower levels. Problems are presented orally to the subjects. Each subject must retain the information and solve the problem without paper or pencil. The internal consistency reliability coefficient alpha for the mathematics reasoning subtest was .81 when averaged across 9 age levels (6 years - 14 years).

8. Mathematics Calculation

On this 36 item subtest, the student is presented with a worksheet on which he/she solves problems directly. The problems on the worksheet are arranged in order of increasing difficulty and involve an understanding of basic calculations (i.e., addition, subtraction, multiplication, division) as well as decimal usage, fractions, and, at the higher levels, beginning algebraic concepts. The internal consistency reliability coefficient alpha for the mathematics calculation subtest was .87 when averaged across 9 age levels (6 years - 14 years).

9. Reading Composite

The Alphabet/Word Knowledge and Reading Comprehension subtests
combine to yield the Reading Composite score. The internal consistency reliability coefficient alpha for the reading composite was .96 when averaged across 9 age levels (6 years - 14 years).

10. **Writing Composite**

   The Punctuation, Capitalization, Written Composition, and Spelling subtests combine to yield the Writing Composite score. The internal consistency reliability coefficient alpha for the writing composite was .96 when averaged across 9 age levels (6 years - 14 years).

11. **Mathematics Composite**

   The Math Reasoning and Math Calculation subtests combine to yield the Mathematics Composite score. The internal consistency reliability coefficient alpha for the mathematics composite was .87 when averaged across 9 age levels (6 years - 14 years).

12. **Total Achievement Composite**

   The Alphabet/Word Knowledge, Reading Comprehension, Punctuation, Capitalization, Written Composition, Spelling, Math Reasoning and Math Calculation subtests combine to yield the Total Achievement Composite score. This composite is based on a subset of subtests (i.e., only those subtests used in the present investigation), therefore a reliability coefficient will not be reported.
Data Analysis

The data were analyzed in accordance with the research questions presented in Chapter I. The methods of analysis utilized to answer these questions will follow.

1. Which of the four components of the PASS (Planning, Attention, Simultaneous, Successive) model best predicts DAB-2 Reading achievement (i.e., Reading Composite)?
   a. Which of the four components of the PASS (Planning, Attention, Simultaneous, Successive) model best predicts achievement in the area of Alphabet/Word Knowledge?
   b. Which of the four components of the PASS (Planning, Attention, Simultaneous, Successive) model best predicts achievement in the area of Reading Comprehension?

   This question was analyzed using a stepwise multiple regression procedure. The Planning, Attention, Simultaneous, and Successive composites represented the independent variables while the three areas of reading achievement (Reading Composite, Alphabet/Word Knowledge, Reading Comprehension) represent the dependent variables.

2. Which of the four components of the PASS (Planning, Attention, Simultaneous, Successive) model best predicts DAB-2 Writing achievement (i.e., Writing Composite)?
a. Which of the four components of the PASS (Planning, Attention, Simultaneous, Successive) model best predicts achievement in the area of Punctuation?
b. Which of the four components of the PASS (Planning, Attention, Simultaneous, Successive) model best predicts achievement in the area of Capitalization?
c. Which of the four components of the PASS (Planning, Attention, Simultaneous, Successive) model best predicts achievement in the area of Written Composition?
d. Which of the four components of the PASS (Planning, Attention, Simultaneous, Successive) model best predicts achievement in the area of Spelling?

This question was analyzed using a stepwise multiple regression procedure. The Planning, Attention, Simultaneous, and Successive composites represented the independent variables while the five areas of Writing achievement (Writing Composite, Punctuation, Capitalization, Written Composition, Spelling) represent the dependent variables.

3. Which of the four components of the PASS (Planning, Attention, Simultaneous, Successive) model best predicts DAB-2 Mathematics achievement (i.e., Mathematics Composite)?
   a. Which of the four components of the PASS (Planning, Attention, Simultaneous, Successive) model best predicts achievement in the
area of Math Reasoning?

b. Which of the four components of the PASS (Planning, Attention, Simultaneous, Successive) model best predicts achievement in the area of Math Calculation?

This question was analyzed using a stepwise multiple regression procedure. The Planning, Attention, Simultaneous, and Successive composites represented the independent variables while the three areas of Mathematics achievement (Mathematics Composite, Math Reasoning, Math Calculation) represent the dependent variables.

4. Which of the four components of the PASS (Planning, Attention, Simultaneous, Successive) model best predicts overall achievement?

This question was analyzed using a stepwise multiple regression procedure. The Planning, Attention, Simultaneous, and Successive composites represented the independent variables while the Total Achievement Composite represents the dependent variable.

5. How much of an individual's academic achievement in the DAB-2 Reading Composite is explained by a combination of the Planning, Attention, Simultaneous, and Successive composites?

This question will be analyzed using a stepwise multiple regression procedure.
6. How much of an individual's academic achievement in alphabet/word knowledge is explained by a combination of the Planning, Attention, Simultaneous, and Successive composites?

This question will be analyzed using a stepwise multiple regression procedure.

7. How much of an individual's academic achievement in reading comprehension is explained by a combination of the Planning, Attention, Simultaneous, and Successive composites?

This question will be analyzed using a stepwise multiple regression procedure.

8. How much of an individual's academic achievement in DAB-2 Writing is explained by a combination of the Planning, Attention, Simultaneous, and Successive composites?

This question will be analyzed using a stepwise multiple regression procedure.

9. How much of an individual's academic achievement in punctuation is explained by a combination of the Planning, Attention, Simultaneous, and Successive composites?

This question will be analyzed using a stepwise multiple regression procedure.
10. How much of an individual's academic achievement in capitalization is explained by a combination of the Planning, Attention, Simultaneous, and Successive composites?

   This question will be analyzed using a stepwise multiple regression procedure.

11. How much of an individual's academic achievement in written composition is explained by a combination of the Planning, Attention, Simultaneous, and Successive composites?

   This question will be analyzed using a stepwise multiple regression procedure.

12. How much of an individual's academic achievement in spelling is explained by a combination of the Planning, Attention, Simultaneous, and Successive composites?

   This question will be analyzed using a stepwise multiple regression procedure.

13. How much of an individual's academic achievement in the DAB-2 Mathematics composite is explained by a combination of the Planning, Attention, Simultaneous, and Successive composites?

   This question will be analyzed using a stepwise multiple regression procedure.
14. How much of an individual's academic achievement in math reasoning is explained by a combination of the Planning, Attention, Simultaneous, and Successive composites?

This question will be analyzed using a stepwise multiple regression procedure.

15. How much of an individual's academic achievement in math calculation is explained by a combination of the Planning, Attention, Simultaneous, and Successive composites?

This question will be analyzed using a stepwise multiple regression procedure.

16. How much of an individual's DAB-2 Total academic achievement (i.e., Total Achievement Composite) is explained by a combination of the Planning, Attention, Simultaneous, and Successive composites?

This question will be analyzed using a stepwise multiple regression procedure.
CHAPTER IV

RESULTS

The present chapter is organized into the following sections: (1) summary of descriptive statistics; (2) procedures followed for the statistical transformation of PASS raw scores into standard score values; (3) summary of achievement data; (4) intercorrelations of experimental PASS tasks; (5) intercorrelations of PASS composites and achievement; (6) factor analysis; (7) stepwise regression analysis; (8) summary of results.

Summary of Descriptive Statistics

Data describing the distribution of the sample by age, grade, sex, and race are presented in Table 1. The sample consisted of 42 males and 36 females from grades 1, 2, 4, and 5. Subjects ranged in age from 7 years, 3 months to 11 years, 9 months (mean = 9.00, sd = 1.21). Approximately 50% of the sample were between the ages of 7 years, 3 months and 8 years, 8 months. As shown in Table 1, the sample was 96% White and 4% Black which closely approximates the racial composition of the Southwestern City School District.
Table 1
Description of Total Sample (N = 78)

<table>
<thead>
<tr>
<th>Descriptor Variable</th>
<th>Number</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Age (years, months)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7-3 to 7-8</td>
<td>14</td>
<td>18.0</td>
</tr>
<tr>
<td>7-9 to 8-2</td>
<td>10</td>
<td>12.8</td>
</tr>
<tr>
<td>8-3 to 8-8</td>
<td>18</td>
<td>23.1</td>
</tr>
<tr>
<td>8-9 to 9-2</td>
<td>7</td>
<td>9.0</td>
</tr>
<tr>
<td>9-3 to 9-8</td>
<td>7</td>
<td>9.0</td>
</tr>
<tr>
<td>9-9 to 10-2</td>
<td>8</td>
<td>10.2</td>
</tr>
<tr>
<td>10-3 to 10-8</td>
<td>5</td>
<td>6.4</td>
</tr>
<tr>
<td>10-9 to 11-2</td>
<td>5</td>
<td>6.4</td>
</tr>
<tr>
<td>11-3 to 12-8</td>
<td>4</td>
<td>5.1</td>
</tr>
<tr>
<td><strong>Grade</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>first</td>
<td>27</td>
<td>34.6</td>
</tr>
<tr>
<td>second</td>
<td>7</td>
<td>9.0</td>
</tr>
<tr>
<td>fourth</td>
<td>27</td>
<td>34.6</td>
</tr>
<tr>
<td>fifth</td>
<td>17</td>
<td>21.8</td>
</tr>
<tr>
<td><strong>Sex</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>male</td>
<td>42</td>
<td>53.8</td>
</tr>
<tr>
<td>female</td>
<td>36</td>
<td>46.2</td>
</tr>
<tr>
<td><strong>Race</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>White</td>
<td>75</td>
<td>96.2</td>
</tr>
<tr>
<td>Black</td>
<td>3</td>
<td>3.8</td>
</tr>
</tbody>
</table>
The ability and achievement levels of the present sample are provided in Table 2. Scores on the Slosson Intelligence Test (Slosson, 1983) demonstrate that the sample is average in ability (mean = 94.17, $sd = 19.99$), while scores on the Wide Range Achievement Test - Revised indicate low average achievement in the areas of reading (mean = 75.82, $sd = 15.71$), arithmetic (mean = 80.83, $sd = 12.75$), and spelling (mean = 77.81, $sd = 14.04$).

Table 2
Ability and Achievement Levels of Total Sample (N = 78)

<table>
<thead>
<tr>
<th>Instrument</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ability</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Slosson</td>
<td>94.17</td>
<td>19.99</td>
<td>54 - 143</td>
</tr>
<tr>
<td>Achievement</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WRAT-R</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reading</td>
<td>75.82</td>
<td>15.71</td>
<td>47 - 122</td>
</tr>
<tr>
<td>Arithmetic</td>
<td>80.83</td>
<td>12.75</td>
<td>52 - 126</td>
</tr>
<tr>
<td>Spelling</td>
<td>77.81</td>
<td>14.04</td>
<td>52 - 119</td>
</tr>
</tbody>
</table>

Note: All scores are reported in standard score units (mean = 100; $sd = 15$)
Statistical Transformations of Raw Scores to Standard Scores

The raw score means, standard deviations, and ranges for the total sample on all PASS tasks are presented in Table 3. An examination of these raw score values shows that the majority of PASS tasks (i.e., Planned Connections, Simultaneous Verbal, Expressive Attention, Figure Memory, Speech Rate, Word Series) have sufficient variability of item difficulty indicating that neither ceiling nor floor effects influenced the obtained scores. For example, Figure Memory has a mean of 8.55 and a standard deviation of 2.75 which means that 3.11 standard deviations are possible in either direction. Two PASS tasks, however, Number Finding and Sentence Questions, show floor effects. On these tasks, the maximum the scores could vary below the mean is approximately 1.6 standard deviations. The remaining tasks (i.e., Visual Search, Matrices, Planned Codes, Sentence Repetition) show minor floor effects. For example, on the Visual Search task, the maximum the scores could vary below the mean is approximately 2.0 standard deviations. None of the PASS tasks showed a ceiling effect.
Table 3
Raw Score Means, Standard Deviations, and Ranges for the Total Sample (N = 78) on all PASS tasks

<table>
<thead>
<tr>
<th>Task</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Planning</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Visual Search</td>
<td>145.24</td>
<td>72.93</td>
<td>58 - 462</td>
</tr>
<tr>
<td>Planned Codes</td>
<td>3.15</td>
<td>1.24</td>
<td>2 - 9</td>
</tr>
<tr>
<td>Planned Connections</td>
<td>321.26</td>
<td>109.91</td>
<td>141 - 595</td>
</tr>
<tr>
<td><strong>Attention</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number Finding</td>
<td>10.73</td>
<td>6.80</td>
<td>3 - 46</td>
</tr>
<tr>
<td>Expressive Attention</td>
<td>82.08</td>
<td>23.26</td>
<td>45 - 181</td>
</tr>
<tr>
<td><strong>Simultaneous</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Simultaneous Verbal</td>
<td>13.60</td>
<td>2.85</td>
<td>0 - 19</td>
</tr>
<tr>
<td>Figure Memory</td>
<td>8.55</td>
<td>2.75</td>
<td>3 - 18</td>
</tr>
<tr>
<td>Matrices</td>
<td>9.38</td>
<td>3.98</td>
<td>2 - 20</td>
</tr>
<tr>
<td><strong>Successive</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sentence Repetition</td>
<td>5.13</td>
<td>2.23</td>
<td>0 - 10</td>
</tr>
<tr>
<td>Sentence Questions</td>
<td>4.13</td>
<td>2.55</td>
<td>1 - 14</td>
</tr>
<tr>
<td>Speech Rate</td>
<td>86.00</td>
<td>20.94</td>
<td>53 - 204</td>
</tr>
<tr>
<td>Word Series</td>
<td>8.31</td>
<td>2.94</td>
<td>3 - 16</td>
</tr>
</tbody>
</table>

Note: On the following tasks higher raw score values are associated with poorer performance:
Visual Search, Planned Codes, Planned Connections, Expressive Attention, Number Finding
The raw scores obtained on each of the 12 PASS tasks were transformed into standard scores with a mean of 100 and a standard deviation of 15 so that composite scores could be derived (using equal weighting of the tests) and for statistical analyses. Standard scores for the Figure Memory, Simultaneous Verbal, Matrices, Word Series, Sentence Repetition, and Sentence Questions tasks were calculated using the total number of correct responses provided by the subject. The following formula was used to convert raw scores to standard scores for these tasks:

\[
\text{Formula A: } SS = \left( \frac{\text{RS} - \text{RS mean}}{\text{RS sd}} \right) \times 15 + 100
\]

where RS is the total number of correct responses, RS mean is the mean of the sample, and RS sd is the standard deviation of the sample.

Standard scores for the Visual Search, Planned Connections, Expressive Attention, and Speech Rate tasks were obtained from the total number of seconds required to complete a given number of items. For example, Visual Search, Planned Connections, and Speech Rate raw scores were computed based on the number of seconds required for the subject to complete all items on the task, while the Expressive Attention raw score values were based on the number of seconds required for the subject to complete the last item of the task. Since high raw score values are indicative of poor performance and low raw score values are indicative of high performance on these tasks, the distributions of raw scores were
inverted. Thus, subjects who completed the task(s) swiftly earned a high standard score while subjects who completed the task slowly earned a low standard score. The following formula was used to compute the standard scores for the above mentioned tasks:

Formula B: \( SS = \left( \frac{(RS - RS \text{ mean})}{RS \text{ sd}} \right) \cdot -1 \cdot 15 + 100 \)

where \( RS \) is the number of seconds required to complete the item(s), and \( RS \text{ mean} \) and \( RS \text{ sd} \) are the mean and standard deviation of the sample, respectively. The z values (i.e., \( RS - RS \text{ mean} / RS \text{ sd} \)) were multiplied by -1 in order to invert the distribution before transforming these values into standard scores based on a mean of 100 and standard deviation of 15.

Formula B was also used to compute standard scores for the Number Finding and Planned Codes tasks. However, the raw score values obtained for these tasks are based on the number of seconds required to complete the task as well as the number of correctly answered items. Thus, the highest scores were earned by subjects who completed these tasks swiftly and made few errors while the lowest scores were earned by subjects who completed these tasks slowly and made many errors. The following transformation was used to compute the raw score values for the Number Finding task:
RS_{nf} = \frac{T_4}{NC_4}

where \( T_4 \) is the number of seconds required by each subject to complete item number 4 and \( NC_4 \) is the total number of correct responses provided by the subject on item number 4. Similarly, the following transformation was used to compute the raw score values for the Planned Codes task:

\[
RS_{pcd} = \frac{(T_1 + T_2)}{(NC_1 + NC_2)}
\]

where \( T_1 \) and \( T_2 \) are the number of seconds required for the subject to complete items 1 and 2 and \( NC_1 \) and \( NC_2 \) are the total number of correct responses provided by the subject on each item.

Following the transformation of raw scores to standard scores, these 12 tasks were grouped into Planning, Attention, Simultaneous, and Successive processing composites based on the results of previous factor analytic studies (see Naglieri, Prewett, & Bardos, 1989). The Planning composite was derived by averaging the standard scores of the Visual Search, Planned Connections, and Planned Codes tasks. The Attention composite was derived by averaging the standard scores of the Number Finding and Expressive Attention tasks, and the Simultaneous and Successive composites were derived by averaging the standard scores of Figure Memory, Simultaneous Verbal and Matrices, and Word Series, Sentence Repetition, Sentence Questions, and Speech Rate tasks, respectively. The
means, standard deviations, and ranges of the Planning, Attention, Simultaneous, and Successive processing composites are presented in Table 4.

Table 4
Standard Score Means, Standard Deviations, and Ranges for the Total Sample (N = 78) on the Four Processing Composites

<table>
<thead>
<tr>
<th>Composite</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Planning</td>
<td>100.00</td>
<td>12.75</td>
<td>52 to 118</td>
</tr>
<tr>
<td>Attention</td>
<td>100.03</td>
<td>12.64</td>
<td>30 to 118</td>
</tr>
<tr>
<td>Simultaneous</td>
<td>100.00</td>
<td>11.78</td>
<td>68 to 138</td>
</tr>
<tr>
<td>Successive</td>
<td>99.97</td>
<td>11.39</td>
<td>65 to 133</td>
</tr>
</tbody>
</table>

Summary of Achievement Data

Means, standard deviations, and ranges for the Diagnostic Achievement Battery - 2nd Edition nationally standardized composites and subtests are reported in Table 5. The Reading, Mathematics, and Writing Composite standard scores are based on a mean of 100 and standard deviation of 15 while the individual subtest standard scores are based on a mean of 10 and standard deviation of 3. An examination of the means and standard deviations of the achievement composites indicates that the present sample
performed in the Borderline range of functioning in the areas of Reading (mean = 79.28, sd = 16.18) and Writing (mean = 75.50, sd = 11.59), and in the Low Average range of functioning in the area of Mathematics (mean = 82.69, sd = 12.12). A Total Achievement composite was calculated by averaging the Reading, Writing, and Mathematics composite scores. The present samples' overall level of achievement as measured by the Total Achievement composite is considered Borderline (mean = 79.13, sd = 11.91).
Table 5
Standard Score Means, Standard Deviations, and Ranges for the Total Sample (N = 78) on all DAB-2 Composites and Subtests

<table>
<thead>
<tr>
<th>Composite/Subtest</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reading Composite</td>
<td>79.28</td>
<td>16.18</td>
<td>53 to 124</td>
</tr>
<tr>
<td>alphabet/word knowledge</td>
<td>6.59</td>
<td>3.13</td>
<td>1 to 16</td>
</tr>
<tr>
<td>reading comprehension</td>
<td>6.51</td>
<td>2.51</td>
<td>2 to 14</td>
</tr>
<tr>
<td>Mathematics Composite</td>
<td>82.69</td>
<td>12.12</td>
<td>58 to 124</td>
</tr>
<tr>
<td>mathematics reasoning</td>
<td>7.18</td>
<td>2.21</td>
<td>4 to 16</td>
</tr>
<tr>
<td>mathematics calculation</td>
<td>7.05</td>
<td>2.30</td>
<td>2 to 11</td>
</tr>
<tr>
<td>Writing Composite</td>
<td>75.50</td>
<td>11.59</td>
<td>52 to 113</td>
</tr>
<tr>
<td>written composition</td>
<td>5.45</td>
<td>2.06</td>
<td>2 to 11</td>
</tr>
<tr>
<td>capitalization</td>
<td>6.37</td>
<td>2.36</td>
<td>3 to 16</td>
</tr>
<tr>
<td>punctuation</td>
<td>7.23</td>
<td>1.91</td>
<td>4 to 11</td>
</tr>
<tr>
<td>spelling</td>
<td>6.32</td>
<td>2.45</td>
<td>2 to 14</td>
</tr>
<tr>
<td>Total Achievement</td>
<td>79.13</td>
<td>11.91</td>
<td>57 to 120</td>
</tr>
</tbody>
</table>

Note: Composites are based on a mean = 100 and sd = 15; subtests are based on a mean = 10 and sd = 3
Intercorrelations of Experimental PASS Tasks

The Pearson product-moment correlational coefficients of the 12 experimental PASS tasks for the total sample are presented in Table 6. Since many of these tasks show a significant correlation with chronological age, partial correlations with age held constant were computed (Guilford & Fruchter, 1978). These correlations are presented in Table 7. An examination of this intercorrelational matrix indicates significant correlations ($p < .01$) between the Planning tasks (Visual Search, Planned Connections, Planned Codes), the Attention tasks (Number Finding, Expressive Attention), Simultaneous processing tasks (Figure Memory, Simultaneous Verbal, Matrices), and Successive processing tasks (Word Series, Sentence Repetition, Sentence Questions, Successive Speech Rate).

Intercorrelations after removing age effects among the four PASS processing composites are presented in Table 8. Correlations between Planning and Attention, Planning and Simultaneous processing, and Simultaneous and Successive processing are significant at the $p < .01$ level, while the correlations between Attention and Simultaneous processing and Planning and Successive processing are significant at the $p < .05$ level. The high correlations between all PASS composites, with the exception of Attention and Successive processing which do not correlate significantly, is expected and consistent with the interactive nature of the three functional units of the brain inherent in the PASS theory.
Table 6
Obtained Pearson Product-Moment Standard Score Correlations Between PASS tasks and Age for the Total Sample (N = 78)

<table>
<thead>
<tr>
<th>Task</th>
<th>Age</th>
<th>VS</th>
<th>PC</th>
<th>PCD</th>
<th>FM</th>
<th>SV</th>
<th>M</th>
<th>EA</th>
<th>NF</th>
<th>WS</th>
<th>SR</th>
<th>SQ</th>
</tr>
</thead>
<tbody>
<tr>
<td>VS</td>
<td>.29**</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PC</td>
<td>.37**</td>
<td>.58**</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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Note: ** p < .01; * p < .05
VS = Visual Search; PC = Planned Connections; PCD = Planned Codes; FM = Figure Memory; SV = Simultaneous Verbal; M = Matrices; EA = Expressive Attention; NF = Number Finding; WS = Word Series; SR = Sentence Repetition; SQ = Sentence Questions; SPR = Successive Speech Rate
Table 7
Pearson Product-Moment Standard Score Correlations Between PASS tasks for the Total Sample (N = 78) After Removing the Effects of Age

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Note: **p < .01; *p < .05
VS = Visual Search; PC = Planned Connections; PCD = Planned Codes; FM = Figure Memory; SV = Simultaneous Verbal; M = Matrices; EA = Expressive Attention; NF = Number Finding; WS = Word Series; SR = Sentence Repetition; SQ = Sentence Questions; SPR = Successive Speech Rate
Table 8
Pearson Product-Moment Standard Score Correlations Between PASS Composites and Achievement for the Total Sample (N = 78)

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Note: ** p < .01; * p < .05

Plan = Planning Composite; Atten = Attention Composite; Sim = Simultaneous Composite; Succ = Successive Composite; awk = alphabet/word knowledge; rc = reading comprehension; rd = Reading Composite; mr = math reasoning; mc = math computation; mth = Mathematics Composite; cap = capitalization; pu = punctuation; wc = written composition; wr = Writing Composite; ta = Total Achievement
Intercorrelations of PASS Composites and Achievement

The Pearson product-moment intercorrelations among the four PASS processing composites and achievement are also presented in Table 8. Of particular significance is the consistently high correlations (ρ < .01) between Planning and virtually all areas of academic achievement. Planning correlates significantly (ρ < .01) with the Reading composite, alphabet/word knowledge subtest, and reading comprehension subtest, as well as the Mathematics composite, math reasoning subtest, and math computation subtest. High correlations (ρ < .01) were also demonstrated between Planning and the Writing composite and punctuation subtest. It should be noted that restriction of range on the achievement variables, particularly in the area of Writing, served to reduce the magnitude of the correlations. When restriction of range is corrected, the correlations between Planning and spelling, capitalization, and written composition are significant at the ρ < .05 level. In order to gain a more accurate estimate of the relationship between the PASS composites and achievement, the following correction formula was used:

\[
\text{Corrected } r_{xy} = \frac{r_{xy} \left( \frac{sd_x}{sd_{xc}} \right)}{\sqrt{1 + r_{xc}^2 \left( \frac{sd_x^2}{sd_{xc}^2} - 1 \right)}}
\]

where x is the achievement variable, y is the PASS composite, xc is the variable that is curtailed or strained, sd_x is the standard deviation of x if the range was not restricted and, therefore, is an estimated value, sd_{xc} is the
standard deviation of the curtailed variable, and $r_{xy}$ is the correlation between $x$ and $y$ (R. McCallum, personal communication, April 4, 1991).

Table 9 shows the correlations between the PASS composites and achievement after correcting for restriction of range on the achievement variable.
Table 9
Pearson Product-Moment Standard Score Correlations Between PASS Composites and Achievement for the Total Sample (N = 78) After Correcting for Restriction of Range

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Note: ** p < .01; * p < .05

Plan = Planning Composite; Atten = Attention Composite; Sim = Simultaneous Composite; Succ = Successive Composite; awk = alphabet/word knowledge; rc = reading comprehension; rd = Reading Composite; mr = math reasoning; mc = math computation; mth = Mathematics Composite; cap = capitalization; pu = punctuation; wc = written composition; wr = Writing Composite; ta = Total Achievement
Factor Analysis

An examination of the intercorrelational data among the 12 PASS tasks provides preliminary support for the grouping of these tasks into separate Planning, Attention, Simultaneous, and Successive composites. In order to provide further support for the assignment of PASS tasks into composites, principal components factor analysis was employed.

Principal components factor analyses (orthogonal and oblique) were obtained for the total sample (N=78) and are presented in Tables 10 and 11, respectively. The orthogonal factor solution is provided because it allows for comparisons with previous research (Ashman & Das, 1980; Das & Heemsbergen, 1983; Leong, Cheng & Das, 1985; Naglieri, Prewett, & Bardos, 1989; Snart, O'Grady & Das, 1985); the oblique factor solution is provided because it allows for correlations among the factors and, therefore, is consistent with the interactive nature of the PASS theoretical model (Naglieri et al., 1989).

The principle components factor analyses were performed using the Statview 512+ program (1988). In accordance with the PASS theoretical model, a four factor solution was selected and has previously been shown to be most appropriate with similar tasks designed to measure these processes (Naglieri et al, 1989; Warrick, 1989). Eigen values associated with the first four factors were 3.6, 1.9, 1.3, and 1.2, and accounted for 30, 16, 11, and 10 percent of the variance respectively.
The significance of factor loadings was determined by implementing the method recommended by Stevens (1986, p. 343-344). In this approach, the doubled critical value for an ordinary correlation ($p<.01$) based on the sample size is used as the criterion for significance of factor loadings. This approach has been used in previous factor analytic research investigations of the PASS model (Gottling, 1990; Naglieri et al., 1989, Warrick, 1989). In the present study, .513 was the criterion used to determine the significance of factor loadings.

An examination of Tables 10 and 11 demonstrate that the four factors obtained using both the orthogonal and oblique solutions may be defined as Planning (Visual Search, Planned Connections, Planned Codes), Successive (Word Series, Sentence Repetition, Sentence Questions, Successive Speech Rate), Simultaneous (Figure Memory Simultaneous Verbal Matrices), and Attention (Expressive Attention, Number Finding). The orthogonal solution indicated an additional significant loading ($p>.35$) for Planned Connections on the Simultaneous factor; the oblique solution indicated an additional significant loading ($p>.35$) for Number Finding on the Planning factor.
Table 10
Principal Components Factor Analysis (Orthogonal Solution) of PASS tasks for the Total Sample (N = 78)

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Note: **2t (p<.01); *Loadings ≥ .35
VisSrch = Visual Search; PIcon = Planned Connections; PICds = Planned Codes; FigMem = Figure Memory; SimVerb = Simultaneous Verbal; Mat = Matrices; ExpAtt = Expressive Attention; NumFind = Number Finding; WordSer = Word Series; SentRep = Sentence Repetition; SentQues = Sentence Questions; SpchRate = Successive Speech Rate.
Table 11
Principal Components Factor Analysis (Oblique Solution) of PASS tasks for the Total Sample (N = 78)

<table>
<thead>
<tr>
<th>Task</th>
<th>Factor I</th>
<th>Factor II</th>
<th>Factor III</th>
<th>Factor IV</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Planning</td>
<td>Successive</td>
<td>Simultaneous</td>
<td>Attention</td>
</tr>
<tr>
<td>VisSrch</td>
<td>.898**</td>
<td>-.001</td>
<td>.047</td>
<td>-.215</td>
</tr>
<tr>
<td>PIcon</td>
<td>.603**</td>
<td>-.007</td>
<td>.275</td>
<td>.057</td>
</tr>
<tr>
<td>PICds</td>
<td>.787**</td>
<td>.158</td>
<td>-.110</td>
<td>.213</td>
</tr>
<tr>
<td>FigMem</td>
<td>.041</td>
<td>-.002</td>
<td>.828**</td>
<td>.056</td>
</tr>
<tr>
<td>SimVerb</td>
<td>-.012</td>
<td>.256</td>
<td>.570**</td>
<td>-.067</td>
</tr>
<tr>
<td>Mat</td>
<td>.019</td>
<td>-.098</td>
<td>.865**</td>
<td>.032</td>
</tr>
<tr>
<td>ExpAtt</td>
<td>-.208</td>
<td>.141</td>
<td>.059</td>
<td>.905**</td>
</tr>
<tr>
<td>NumFind</td>
<td>.354*</td>
<td>-.165</td>
<td>-.014</td>
<td>.693**</td>
</tr>
<tr>
<td>WordSer</td>
<td>.253</td>
<td>.683**</td>
<td>.083</td>
<td>-.116</td>
</tr>
<tr>
<td>SentRep</td>
<td>.197</td>
<td>.765**</td>
<td>-.021</td>
<td>.004</td>
</tr>
<tr>
<td>SentQues</td>
<td>-.276</td>
<td>.822**</td>
<td>.052</td>
<td>-.069</td>
</tr>
<tr>
<td>SpchRate</td>
<td>.006</td>
<td>.666**</td>
<td>-.016</td>
<td>.207</td>
</tr>
</tbody>
</table>

Note: **2£ (p<.01); *Loadings ≥ .35

VisSrch = Visual Search; PIcon = Planned Connections; PICds = Planned Codes; FigMem = Figure Memory; SimVerb = Simultaneous Verbal; Mat = Matrices; ExpAtt = Expressive Attention; NumFind = Number Finding; WordSer = Word Series; SentRep = Sentence Repetition; SentQues = Sentence Questions; SpchRate = Successive Speech Rate.
Stepwise Regression Analysis

A series of stepwise regression analyses were conducted in order to determine which PASS composite best predicts achievement as well as which combination of PASS composites best predict achievement. A total of 12 regression analyses were conducted. In each analysis, the four PASS composites (i.e., Planning, Attention, Simultaneous, Successive) and age served as the independent or predictor variables and one of the twelve areas of achievement served as the dependent variable. Since age was previously shown to correlate highly with several of the variables, it was included as an independent variable in all the regression analyses. Specifically, age was forced into each regression equation first in order to prevent its influence on subsequent reductions in the residual sums of squares. This procedure, therefore, prevents the misinterpretation of a variable significantly correlated with age.

The computer program Statview 512+ (Feldman & Gagnon, 1986) was used to conduct the stepwise regression analyses. This program conducts stepwise multiple regression using a step-forward analysis. In the first step of this analysis, the independent variable having the largest squared correlation ($r^2$) with the dependent variable enters the equation. At each additional step, the independent variable that produces the largest increase in the squared multiple correlation ($R^2$) enters the model. This process continues until all independent variables that explain a significant proportion of the variance in the dependent variable have entered the equation. At
each step of this analysis, it is necessary to test the significance of the contribution of the variables that entered at an earlier step. This is necessary since the contribution of earlier variables may be reduced as additional variables enter the equation. This reduction in variance accounted for is a function of multicollinearity or the degree of intercorrelation among the independent variables. Thus, the rationale for the stepwise procedure is to arrive at a subset of variables such that all make a significant contribution and none of the remaining variables explain a significant proportion of the variance in the dependent variable.

Central to the Statview 512+ program is the selection of an $F$ to enter value. This value represents the significance required for insertion of an independent variable into the regression equation and, therefore, provides a guideline for acceptable reduction in the residual sums of squares or an acceptable level of variance accounted for. According to Draper and Smith (1981), a 5% significance level is too stringent and may result in lost information. Therefore, they recommend an alpha level of .10 as a guideline for entry of predictor variables into the regression equation. In the present study, an $F$ to enter value of 2 was chosen.

Results of the stepwise regressions are reported in Tables 12-23. The Adjusted $R^2$ value will be interpreted rather than the squared multiple correlation ($R^2$) to demonstrate the amount a variance in achievement accounted for by each independent variable. The squared multiple correlations are not interpreted because they are likely biased and,
therefore, tend to overestimate the $R^2$ values in the population. Since the regression model capitalizes on the chance characteristics or idiosyncrasies inherent within a given sample, the Adjusted $R^2$ values are assumed to be a more accurate representation of actual variance accounted for because they represent the squared multiple correlations that would result if these regressions were repeated on an infinite number of samples drawn from the same population. The magnitude of the difference (i.e., shrinkage) between $R^2$ and Adjusted $R^2$ is a function of both the size of the sample and the number of independent variables; that is, as the size of the sample increases, the amount of shrinkage is lower and as the number of independent variables increases, the amount of shrinkage is greater. The following formula is used to compute the Adjusted $R^2$:

$$\text{Adjusted } R^2 = 1 - (1 - R^2) \left( \frac{n - 1}{n - k - 1} \right)$$

where $R^2$ is the squared multiple correlation, $n$ is the sample size, and $k$ is the number of independent variables (R. McCallum, personal communication, April 30, 1991).

**Reading Achievement**

The results of the stepwise regressions on Reading achievement are reported in Tables 12, 13, and 14. As shown in Table 12, Planning was the best predictor of alphabet/word knowledge ($F = 10.271; \ p < .01$) accounting
for approximately 7% of the variance, followed by Attention ($F = 4.440; p < .05$) which accounted for 4% of the variance. Together, chronological age, Planning and Attention accounted for 18% of the variance in alphabet/word knowledge (Cumulative Adj $R^2 = .178; F (3,77 df) = 6.562; p < .01$). Similarly, as shown in Table 13, Planning was the best predictor of reading comprehension ($F = 13.243; p < .01$) accounting for 13% of the variance, followed by Attention which accounted for approximately 4% of the variance. Together, chronological age, Planning and Attention accounted for 17% of the variance in reading comprehension (Cumulative Adj $R^2 = .170; F (3,77 df) = 6.262; p < .01$). As seen in Table 14, Planning and Attention were also the best predictors of overall Reading achievement (i.e., Reading composite) accounting for 9% ($F = 12.719; p < .01$) and 4% ($F = 5.003; p < .01$) of the variance, respectively. Together, chronological age, Planning, and Attention accounted for 19% of the variance in overall Reading achievement (Cumulative Adj $R^2 = .189; F (3,77 df) = 6.985; p < .01$).
Table 12
Stepwise Regression on Alphabet/Word Knowledge Achievement Scores for the Total Sample (N = 78)

<table>
<thead>
<tr>
<th></th>
<th>B</th>
<th>R²</th>
<th>Adj R²</th>
<th>F to Enter</th>
<th>F to Remove</th>
<th>F</th>
<th>df</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>.292</td>
<td>.085</td>
<td>.073</td>
<td></td>
<td></td>
<td>7.078***</td>
<td>1.77</td>
</tr>
<tr>
<td>Planning</td>
<td>.403</td>
<td>.163</td>
<td>.140</td>
<td>6.946**</td>
<td>10.271***</td>
<td>7.289***</td>
<td>2.77</td>
</tr>
</tbody>
</table>

* P < .10, ** P < .05, *** P < .01

Table 13
Stepwise Regression on Reading Comprehension Achievement Scores for the Total Sample (N = 78)

<table>
<thead>
<tr>
<th></th>
<th>B</th>
<th>R²</th>
<th>Adj R²</th>
<th>F to Enter</th>
<th>F to Remove</th>
<th>F</th>
<th>df</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>.214</td>
<td>.046</td>
<td>.033</td>
<td></td>
<td></td>
<td>3.662</td>
<td>1.77</td>
</tr>
<tr>
<td>Planning</td>
<td>.389</td>
<td>.152</td>
<td>.129</td>
<td>9.331***</td>
<td>13.243***</td>
<td>6.697***</td>
<td>2.77</td>
</tr>
<tr>
<td>Attention</td>
<td>.450</td>
<td>.202</td>
<td>.170</td>
<td>4.726**</td>
<td>4.726**</td>
<td>6.262***</td>
<td>3.77</td>
</tr>
</tbody>
</table>

* P < .10, ** P < .05, *** P < .01
Table 14
Stepwise Regression on the Reading Composite Achievement Scores for the Total Sample (N = 78)

<table>
<thead>
<tr>
<th></th>
<th>R</th>
<th>R²</th>
<th>Adj R²</th>
<th>F to Enter</th>
<th>F to Remove</th>
<th>F</th>
<th>df</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>.267</td>
<td>.071</td>
<td>.059</td>
<td></td>
<td></td>
<td>5.817**</td>
<td>1.77</td>
</tr>
<tr>
<td>Planning</td>
<td>.410</td>
<td>.168</td>
<td>.146</td>
<td>8.736***</td>
<td>12.719***</td>
<td>7.572***</td>
<td>2.77</td>
</tr>
<tr>
<td>Attention</td>
<td>.470</td>
<td>.221</td>
<td>.189</td>
<td>5.003***</td>
<td>5.003***</td>
<td>6.985***</td>
<td>3.77</td>
</tr>
</tbody>
</table>

* p < .10, ** p < .05, *** p < .01

Mathematics Achievement

The results of the stepwise regressions on Mathematics achievement are presented in Tables 15, 16, and 17. As shown in Table 15, mathematics reasoning achievement was best predicted by Planning (F = 17.031; p < .01) which accounted for 13% of the variance, followed by the Attention and Successive composites. Based upon the cumulative Adjusted R² value (.214) (F (4,77 df) = 6.234; p < .01), these three PASS composites accounted for 21% of the variance in mathematics reasoning achievement. Similarly, as shown in Table 16, Planning was the best predictor of mathematics computation (F = 12.377; p < .01) accounting for approximately 9% of the variance, followed by Attention which accounted for an additional 2% of the
variance \( (F = 3.076; \ p < .05) \). Together, chronological age, Planning, and Attention accounted for 24% of the variance in mathematics computation (Cumulative Adj \( R^2 = .239; \ F (3, 77 \ df) = 9.059; \ p < .01 \)). Planning and Attention were also the best predictors of overall Mathematics achievement (i.e., Mathematics composite) accounting for 14% (\( F = 19.948; \ p < .01 \)) and 4% (\( F = 5.06; \ p < .01 \)) of the variance, respectively. As may be seen in Table 17, chronological age, Planning, and Attention accounted for 28% of the variance in overall Mathematics achievement (Cumulative Adj \( R^2 = .282; \ F (3, 77 \ df) = 11.09; \ p < .01 \)).

Table 15
Stepwise Regression on the Mathematics Reasoning Achievement Scores for the Total Sample (\( N = 78 \))

<table>
<thead>
<tr>
<th>Variable</th>
<th>( R )</th>
<th>( R^2 )</th>
<th>Adj ( R^2 )</th>
<th>( F ) to Enter</th>
<th>( F ) to Remove</th>
<th>( F )</th>
<th>df</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>.214</td>
<td>.046</td>
<td>.033</td>
<td>3.636</td>
<td>1.77</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Planning</td>
<td>.427</td>
<td>.182</td>
<td>.16</td>
<td>12.511***</td>
<td>17.031***</td>
<td>8.349***</td>
<td>2.77</td>
</tr>
<tr>
<td>Attention</td>
<td>.483</td>
<td>.233</td>
<td>.202</td>
<td>4.908***</td>
<td>4.680***</td>
<td>7.492***</td>
<td>3.77</td>
</tr>
<tr>
<td>Successive</td>
<td>.505</td>
<td>.255</td>
<td>.214</td>
<td>2.121*</td>
<td>2.121*</td>
<td>6.234***</td>
<td>4.77</td>
</tr>
</tbody>
</table>

\* \( p < .10 \), \** \( p < .05 \), \*** \( p < .01 \)
Table 16
Stepwise Regression on the Mathematics Computation Achievement Scores for the Total Sample (N = 78)

<table>
<thead>
<tr>
<th></th>
<th>B</th>
<th>B²</th>
<th>Adj B²</th>
<th>F to Enter</th>
<th>F to Remove</th>
<th>F</th>
<th>df</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>.376</td>
<td>.141</td>
<td>.130</td>
<td></td>
<td></td>
<td>12.48</td>
<td>1.77</td>
</tr>
<tr>
<td>Planning</td>
<td>.488</td>
<td>.238</td>
<td>.218</td>
<td>9.566**</td>
<td>12.377***</td>
<td>11.726</td>
<td>2.77</td>
</tr>
<tr>
<td>Attention</td>
<td>.518</td>
<td>.269</td>
<td>.239</td>
<td>3.076**</td>
<td>3.076**</td>
<td>9.059</td>
<td>3.77</td>
</tr>
</tbody>
</table>

* p<.10, ** p<.05, *** p<.01

Table 17
Stepwise Regression on the Mathematics Composite Achievement Scores for the Total Sample (N = 78)

<table>
<thead>
<tr>
<th></th>
<th>B</th>
<th>B²</th>
<th>Adj B²</th>
<th>F to Enter</th>
<th>F to Remove</th>
<th>F</th>
<th>df</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>.340</td>
<td>.116</td>
<td>.104</td>
<td></td>
<td></td>
<td>9.955</td>
<td>1.77</td>
</tr>
<tr>
<td>Planning</td>
<td>.513</td>
<td>.263</td>
<td>.243</td>
<td>14.977***</td>
<td>19.948***</td>
<td>13.381</td>
<td>2.77</td>
</tr>
<tr>
<td>Attention</td>
<td>.557</td>
<td>.310</td>
<td>.282</td>
<td>5.06***</td>
<td>5.06***</td>
<td>11.09</td>
<td>3.77</td>
</tr>
</tbody>
</table>

* p<.10, ** p<.05, *** p<.01
Writing Achievement

The results of the stepwise regressions on Writing achievement are presented in Tables 18-22. As shown in Tables 18 and 21, Planning was the best predictor of both capitalization ($F = 3.236; p < .10$) and written composition ($F = 2.747; p < .10$) achievement. As shown in Table 19, Planning was also the best predictor of Punctuation achievement and accounted for approximately 9% of the variance ($F = 11.489; p < .01$), followed by Attention which accounted for additional variance ($F = 2.499; p < .10$). Table 20 shows that spelling achievement was best predicted by Simultaneous processing ($F = 4.552; p < .05$), followed by Attention ($F = 2.898; p < .10$). Based upon the cumulative Adjusted $R^2$ value (.099) ($F (3,77 df) = 3.835; p < .05$), Simultaneous processing, Attention and chronological age accounted for approximately 10% of the variance in spelling achievement. Finally, Planning and Attention were the best predictors of overall Writing achievement (i.e., Writing Composite) and together accounted for approximately 8% of the variance. As reported in Table 22, the combination of chronological age, Planning, and Attention accounted for approximately 24% of the variance in overall Writing achievement (Cumulative Adj $R^2=.236; F (3,77 df) = 8.936; p<.01$).
Table 18
Stepwise Regression on the Capitalization Achievement Scores for the Total Sample (N = 78)

<table>
<thead>
<tr>
<th></th>
<th>R</th>
<th>R²</th>
<th>Adj R²</th>
<th>F to Enter</th>
<th>F to Remove</th>
<th>F</th>
<th>df</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>.419</td>
<td>.176</td>
<td>.165</td>
<td>16.189***</td>
<td>1.77</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* p<.10, ** p<.05, *** p<.01

Table 19
Stepwise Regression on the Punctuation Achievement Scores for the Total Sample (N = 78)

<table>
<thead>
<tr>
<th></th>
<th>R</th>
<th>R²</th>
<th>Adj R²</th>
<th>F to Enter</th>
<th>F to Remove</th>
<th>F</th>
<th>df</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>.296</td>
<td>.088</td>
<td>.076</td>
<td>7.311***</td>
<td>1.77</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Planning</td>
<td>.432</td>
<td>.187</td>
<td>.165</td>
<td>9.152***</td>
<td>11.489***</td>
<td>8.623***</td>
<td>2.77</td>
</tr>
<tr>
<td>Attention</td>
<td>.462</td>
<td>.214</td>
<td>.182</td>
<td>2.499*</td>
<td>2.499*</td>
<td>6.697***</td>
<td>3.77</td>
</tr>
</tbody>
</table>

* p<.10, ** p<.05, *** p<.01
Table 20
Stepwise Regression on the Spelling Achievement Scores for the Total Sample (N = 78)

<table>
<thead>
<tr>
<th>Variable</th>
<th>B</th>
<th>R^2</th>
<th>Adj R^2</th>
<th>F to Enter</th>
<th>F to Remove</th>
<th>F</th>
<th>df</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>.250</td>
<td>.063</td>
<td>.050</td>
<td>5.077**</td>
<td>1.77</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Simultaneous</td>
<td>.317</td>
<td>.101</td>
<td>.077</td>
<td>3.173**</td>
<td>4.552**</td>
<td>4.198**</td>
<td>2.77</td>
</tr>
<tr>
<td>Attention</td>
<td>.367</td>
<td>.135</td>
<td>.099</td>
<td>2.898*</td>
<td>3.77</td>
<td>3.835**</td>
<td>3.77</td>
</tr>
</tbody>
</table>

*p < .10, **p < .05, ***p < .01

Table 21
Stepwise Regression on the Written Composition Achievement Scores for the Total Sample (N = 78)

<table>
<thead>
<tr>
<th>Variable</th>
<th>B</th>
<th>R^2</th>
<th>Adj R^2</th>
<th>F to Enter</th>
<th>F to Remove</th>
<th>F</th>
<th>df</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>.353</td>
<td>.124</td>
<td>.113</td>
<td>10.792***</td>
<td>1.77</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Planning</td>
<td>.394</td>
<td>.155</td>
<td>.133</td>
<td>2.747*</td>
<td>2.747*</td>
<td>6.893***</td>
<td>2.77</td>
</tr>
</tbody>
</table>

*p < .10, **p < .05, ***p < .01
Table 22
Stepwise Regression on the Writing Composite Achievement Scores for the Total Sample (N = 78)

<table>
<thead>
<tr>
<th></th>
<th>R</th>
<th>R²</th>
<th>Adj R²</th>
<th>F to Enter</th>
<th>F to Remove</th>
<th>F</th>
<th>df</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>.412</td>
<td>.169</td>
<td>.158</td>
<td></td>
<td></td>
<td>15.497***</td>
<td>1.77</td>
</tr>
<tr>
<td>Planning</td>
<td>.486</td>
<td>.236</td>
<td>.216</td>
<td>6.594**</td>
<td>8.997***</td>
<td>11.615***</td>
<td>2.77</td>
</tr>
<tr>
<td>Attention</td>
<td>.516</td>
<td>.266</td>
<td>.236</td>
<td>2.969*</td>
<td>2.969*</td>
<td>8.936***</td>
<td>3.77</td>
</tr>
</tbody>
</table>

*p < .10, **p < .05, ***p < .01

**Total Achievement**

The results of the stepwise regressions on overall achievement (i.e., Total Achievement Composite) are reported in Table 23. As shown in Table 23, Planning was the best predictor of Total Achievement accounting for approximately 8% of the variance (F = 18.235; p < .01), followed by Attention which accounted for 5% of the variance (F = 5.911; p < .01). Together, chronological age, Planning and Attention accounted for 29% of the variance in overall achievement (Cumulative Adj R² = .290; F (3, 77 df) = 11.469; p < .01).
Table 23
Stepwise Regression on the Total Achievement Scores for the Total Sample
(N = 78)

<table>
<thead>
<tr>
<th></th>
<th>R</th>
<th>R²</th>
<th>Adj R²</th>
<th>F to Enter</th>
<th>F to Remove</th>
<th>F</th>
<th>df</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>.369</td>
<td>.136</td>
<td>.125</td>
<td></td>
<td></td>
<td>11.951***</td>
<td>1.77</td>
</tr>
<tr>
<td>Planning</td>
<td>.513</td>
<td>.263</td>
<td>.243</td>
<td>12.92***</td>
<td>18.235***</td>
<td>13.373***</td>
<td>2.77</td>
</tr>
<tr>
<td>Attention</td>
<td>.563</td>
<td>.317</td>
<td>.290</td>
<td>5.911***</td>
<td>5.911***</td>
<td>11.469***</td>
<td>3.77</td>
</tr>
</tbody>
</table>

* p < .10, ** p < .05, *** p < .01

Summary of Results

The results presented in this chapter will be summarized according to the null hypotheses presented in Chapter I.

1. PASS composites accounted for significant variance in the DAB-2 Reading Composite as well as the alphabet/word knowledge and reading comprehension subtests. Table 24 presents a rank ordering of the PASS composites that best predicted achievement in these areas. Null hypotheses 1, 1a, and 1b were not confirmed.
Table 24
PASS Composites that Best Predict Reading Achievement for the Total Sample (N = 78)

<table>
<thead>
<tr>
<th>Achievement</th>
<th>PASS Composite</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reading Composite</td>
<td>Planning</td>
</tr>
<tr>
<td></td>
<td>Attention</td>
</tr>
<tr>
<td>alphabet/word knowledge</td>
<td>Planning</td>
</tr>
<tr>
<td></td>
<td>Attention</td>
</tr>
<tr>
<td>reading comprehension</td>
<td>Planning</td>
</tr>
<tr>
<td></td>
<td>Attention</td>
</tr>
</tbody>
</table>

2. PASS composites accounted for significant variance in the DAB-2 Writing Composite as well as the punctuation, capitalization, written composition, and spelling subtests. Table 25 presents a rank ordering of the PASS composites that best predicted achievement in these areas. Null hypotheses 2, 2a, 2b, 2c, and 2d were not confirmed.
Table 25
PASS Composites that Best Predict Writing Achievement for the Total Sample (N = 78)

<table>
<thead>
<tr>
<th>Achievement</th>
<th>PASS Composite</th>
</tr>
</thead>
<tbody>
<tr>
<td>Writing Composite</td>
<td>Planning</td>
</tr>
<tr>
<td></td>
<td>Attention</td>
</tr>
<tr>
<td>capitalization</td>
<td>Planning</td>
</tr>
<tr>
<td>punctuation</td>
<td>Planning</td>
</tr>
<tr>
<td></td>
<td>Attention</td>
</tr>
<tr>
<td>spelling</td>
<td>Simultaneous</td>
</tr>
<tr>
<td></td>
<td>Attention</td>
</tr>
<tr>
<td>written composition</td>
<td>Planning</td>
</tr>
</tbody>
</table>
3. PASS composites accounted for significant variance in the DAB-2 Mathematics Composite as well as the math reasoning, and math calculation subtests. Table 26 presents a rank ordering of the PASS composites that best predicted achievement in these areas. Null hypotheses 3, 3a, and 3b were not confirmed.

Table 26
PASS Composites that Best Predict Mathematics Achievement for the Total Sample (N = 78)

<table>
<thead>
<tr>
<th>Achievement</th>
<th>PASS Composite</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mathematics Composite</td>
<td>Planning</td>
</tr>
<tr>
<td></td>
<td>Attention</td>
</tr>
<tr>
<td>mathematics reasoning</td>
<td>Planning</td>
</tr>
<tr>
<td></td>
<td>Attention</td>
</tr>
<tr>
<td></td>
<td>Successive</td>
</tr>
<tr>
<td>mathematics computation</td>
<td>Planning</td>
</tr>
<tr>
<td></td>
<td>Attention</td>
</tr>
</tbody>
</table>
4. PASS composites accounted for significant variance in overall achievement. Table 27 presents a rank ordering of the PASS composites that best predicted total achievement. Null hypothesis 4 was not confirmed.

Table 27
PASS Composites that Best Predict Overall Achievement for the Total Sample (N = 78)

<table>
<thead>
<tr>
<th>Achievement</th>
<th>PASS Composite</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Achievement Composite</td>
<td>Planning</td>
</tr>
<tr>
<td></td>
<td>Attention</td>
</tr>
</tbody>
</table>

5. Figure 1 presents the relative contribution of the PASS Composites in the prediction of academic achievement. As may be seen in Figure 1, Planning was the best predictor of achievement in all academic areas with the exception of spelling.

6. Differing combinations of PASS tasks accounted for significant variance in all areas of achievement except capitalization and written composition. In these areas, Planning was the only composite that accounted for significant variance.
variance. Therefore, null hypotheses 5-9 and 12-16 were not confirmed whereas 10 and 11 were confirmed. Figure 2 demonstrates the variation of PASS combinations that accounted for significant variance in each area of achievement.

![Table of Areas of Achievement](image)

<table>
<thead>
<tr>
<th>Plan</th>
<th>Attent</th>
<th>Sim</th>
<th>Succ</th>
</tr>
</thead>
</table>

Note: awk=alphabet/word knowledge; rc=reading comprehension; rd=reading composite; mr=math reasoning; mc=math computation; mth=math composite; cap=capitalization; pu=punctuation; sp=spelling; wc=written composition; wr=writing composite; ta=total achievement.

Figure 1
PASS Composites that Best Predict Achievement
Note: awk=alphabet/word knowledge; rc=reading comprehension; rd=reading composite; mr=math reasoning; mc=math computation; mth=math composite; cap=capitalization; pu=punctuation; sp=spelling; wc=written composition; wr=writing composite; ta=total achievement.

Figure 2
PASS Composites that Account for Significant Variance in Achievement
CHAPTER V

DISCUSSION

A summary of the present study will be presented in this chapter. Specifically, the relative contributions of the PASS tasks in the prediction of reading, mathematics, and writing achievement will be addressed in terms of their importance for the present sample as well as relationship to previous research findings. In addition, The PASS model will be discussed in terms of how it relates to current intelligence tests, its diagnostic utility, and its relevance to the remediation of learning problems. Finally, a discussion of the limitations of the present study as well as directions for future research will conclude this chapter.

Summary of the Study

The present study was designed to investigate the validity of the PASS model for a sample of referred elementary school children through the examination of the relationship between the four PASS composites and academic achievement. It is unique in that it represents the first comprehensive investigation of the relationship between all four PASS processes and several specific areas of academic achievement. Thus, this
The study was an attempt to support and enhance the research regarding the relationship between cognitive processes and reading and mathematics achievement as well as explore the relationship between cognitive processes and writing achievement, including punctuation, capitalization, spelling, and writing composition. In addition, this study represents the first investigation to examine the relationship between the four PASS processes and academic achievement in a referred population.

The subjects in the present study were 42 males and 36 females from grades 1, 2, 4, and 5. Subjects ranged in age from 7 years, 3 months to 11 years, 9 months. All participants in this study were referred for psychoeducational assessment by their classroom teachers because they were experiencing learning problems in the regular classroom. All subjects were administered the 12 experimental PASS tasks operationalized by Das and Naglieri (1990) as well as the DAB-2 achievement test (Newcomer, 1990).

The beginning stages of data manipulation involved the transformation of PASS raw scores into standard scores. This was followed by a summary of the intercorrelations of the experimental PASS tasks as well as the intercorrelations of PASS composites and achievement. These intercorrelations revealed significant correlations between all PASS composites with the exception of successive processing and attention and, therefore, supports the interactive nature of the model. In addition, the planning composite correlated significantly with virtually all areas of
academic achievement.

An examination of the factor structure of the PASS model was conducted in order to examine the degree to which these tasks efficiently represent the PASS model. The four factors (i.e., planning, attention, simultaneous, successive) that emerged from the principal components (orthogonal and oblique) factor analyses demonstrated support for the theory underlying the PASS model. Finally, in an effort to clarify the relationship between the PASS processes and learning difficulties, the present study addressed the relative importance of these processes and combination of processes to several specific areas of achievement including reading, mathematics, and written language using stepwise multiple regression procedures. Overall, these analyses revealed that planning and attention were the best combination of cognitive processes in the prediction of virtually all areas of academic achievement.

Support for the Factor Structure of the PASS Model

Several exploratory (Naglieri & Das, 1988; Naglieri, Prewett, & Bardos, 1989) and confirmatory (Naglieri, Braden, & Warrick, 1992; Naglieri, Das, Stevens, & Ledbetter, 1991) research investigations have demonstrated evidence of the construct validity of the tasks used to operationalize the Planning, Attention, Simultaneous, and Successive (PASS) model of cognitive processing (Naglieri, 1989; Naglieri & Das, 1988; Naglieri, Das & Jarman, 1990). Because the aforementioned studies included only samples
of normal children, an Investigation of the factor structure of the PASS tasks in the present study was necessary in order to examine the degree to which these tasks efficiently represent the PASS model for a referred population.

The Principal components factor analyses (orthogonal and oblique) were obtained for the total sample \( (N=78) \). A four factor solution was selected based on the theory underlying the PASS model and has previously been shown to be most appropriate with similar tasks designed to measure these processes (Naglieri et al., 1989; Warrick, 1989). The four factors that emerged in both the orthogonal and oblique factor analyses were identified as Planning (Visual Search, Planned Connections, Planned Codes), Successive (Word Series, Sentence Repetition, Sentence Questions, Successive Speech Rate), Simultaneous (Figure Memory Simultaneous Verbal Matrices), and Attention (Expressive Attention, Number Finding). The orthogonal factor solution is consistent with previous research (Ashman & Das, 1980; Das & Heemsbergen, 1983; Leong, Cheng & Das, 1985; Naglieri, Prewett, & Bardos, 1989; Snart, O'Grady & Das, 1985) and the oblique factor solution is consistent with the interactive nature of the PASS theoretical model (Naglieri et al., 1989). The results of these analyses illustrate the robust nature of the four components of the PASS model for the present sample.

**Utility of the PASS Composites in the Prediction of Reading Achievement**

In the present study, results of the stepwise multiple regressions on reading achievement showed that planning was the best predictor of overall
reading achievement as well as specific areas of reading achievement including alphabet/word knowledge and reading comprehension. In each of these regression analyses attention entered the equation second and accounted for a significant portion of the variance in reading achievement beyond that accounted for by planning. The simultaneous and successive processing composites did not contribute significantly to the prediction of achievement in these areas.

These results are somewhat inconsistent with early investigations regarding the relationship between cognitive processes and reading achievement. For example, much of the early work in this area showed that successive processing is important for the development of initial reading decoding skills among children who are likely to experience reading difficulty (Cummins & Das, 1980; Das, Bisanz, & Mancini, 1984; Das & Cummins, 1978; Das & Siu, 1989; Das et al., 1975; Doehring, 1968; Kinsbourne & Warrington, 1966) and simultaneous processing is as important or more important than successive processing in the reading process among children at more advanced levels of reading (Das et al., 1975; Cummins & Das, 1977; Kirby & Das, 1977; Leong, 1984; McRae, 1986; Ryckman, 1981). While these differences in findings between the current study and previous ones may be influenced by sample and instrumentation differences, these early research investigations focused exclusively on simultaneous and successive processes. Therefore, their sensitivity to the deficits of students with reading difficulties was curtailed by
the narrow range of cognitive processing (only the second functional unit) tasks employed.

The results of the present study are consistent with more recent investigations, that included measures of planning, involving the relationship between cognitive processing and reading achievement. This consistency is related to the inclusion of planning tasks in these investigations following the development of Das, Kirby, and Jarman's (1979) model of Information-Integration, and the operationalization of the Das-Naglieri: Cognitive Assessment System (DN: CAS; 1989) which include planning tasks. For example, several researchers found that planning relates to reading achievement (Bardos, 1988; Das et al., 1982; Das et al., 1984; Das et al., 1988; Naglieri & Das, 1987; Reardon & Naglieri, 1992; Prewett & Naglieri, in press; Ramey, 1985) and is necessary for the spontaneous utilization of simultaneous and successive processes (Molloy & Das, 1980). Thus, by including tasks that measure planning, a broader understanding of the relationship between reading achievement and cognitive processes is achieved.

Although a more complete understanding of the relationship between cognitive processes and reading achievement can be achieved when measures of planning are employed in addition to simultaneous and successive processing tasks, it is evident from the results of the present study that attentional processes play a significant role in understanding this relationship. For example, in the present study attention accounted for a
significant portion of the variance in all areas of reading achievement. This finding supports Bardos' (1988) finding that children with learning disabilities were deficient in attention in addition to planning. Similarly, Das et al. (1988) found that non-learning disabled students were superior to learning disabled students on selective attention tasks, and Das et al. (in press) found that a selective attention task discriminated between good and poor readers.

The present investigation illustrates the importance of measuring planning and attention processes in children referred for learning problems. Based on the results of this investigation, it is evident that an assessment of only simultaneous and successive processes provides limited information regarding the relationship between cognitive processes and reading achievement for this sample. In the present study, the combination of both planning and attention accounted for a significant portion of the variance in alphabet/word knowledge, reading comprehension, and total reading achievement. Thus, these results indicate that planning and attention are significantly related to reading achievement and support those studies that have found these processes to be effective in differentiating reading disabled from non-reading disabled children. Previous findings that have found a significant relationship between reading and simultaneous and successive processing are important and should not be ignored, but planning and attention were the best predictors of reading achievement for this sample (i.e., referred).
By contrast, Naglieri and Reardon (1992) found that children with attention deficit disorders displayed a deficit in attention as well as low planning and successive processing scores. Thus, it appears that all children experiencing learning problems do not necessarily have deficits in the same cognitive processing domains. Broad achievement areas such as reading, mathematics, and writing involve a variety of cognitive processing skills; difficulty in using these skills leads to learning problems in one or more academic achievement areas. According to Kirby and Williams (1991):

...attention or arousal problems can disrupt classroom behaviour generally, usually leading to broad academic problems. Inappropriate attention or arousal would act to disrupt planning, which would in turn disrupt simultaneous and successive processing, and achievement areas. Even if attention or arousal are within tolerable limits, planning problems could disrupt all lower levels, or only specific subsets of them. Similarly, one or both of the general cognitive skills (simultaneous or successive processing) may be weak, producing a particular type of learning problem across achievement areas (p. 71).

Utility of the PASS Composites in the Prediction of Math Achievement

In the present study, results of the stepwise multiple regressions on mathematics achievement showed that planning was the best predictor of overall mathematics achievement as well as specific areas of math achievement including math reasoning and math computation. In each of these regression analyses attention entered the equation second and
accounted for a significant portion of the variance in mathematics achievement beyond that accounted for by planning. In addition, successive processing accounted for a significant portion of the variance in math reasoning achievement beyond that explained by planning and attention. The simultaneous processing composite did not contribute to the prediction of achievement in any of the math areas.

The results of the present study illustrate the importance of planning and attention processes in the prediction of mathematics achievement. These results, however, are inconsistent with much of the early research on the relationship between cognitive processes and mathematics achievement. For example, there exists in the literature evidence of a strong relationship between simultaneous processing and mathematics achievement. Several research investigations have supported both Luria (1966) and Das et al.'s (1979) contention that mathematics achievement is closely related to simultaneous processing due to the highly spatial nature of some mathematics items (e.g., Das & Cummins, 1978; Das, Manos, & Knaungo, 1975; Das & Mohanty, 1989; Leong, Cheng, & Das, 1984; Mwamwenda, Dash, & Das, 1985; Wachs & Harris, 1986). Although there is no doubt that simultaneous processing is related to mathematics achievement, the failure of the aforementioned studies to include measures of planning and attention may have hindered a more complete understanding of the processes underlying performance on math tasks.

In the present study, planning emerged as the best predictor of math reasoning, math computation, and total math achievement. These finding
support those studies that included measures of planning in addition to simultaneous and successive processes in their investigation of the relationship between cognitive processes and math achievement. For example, the present findings are consistent with Garafalo (1986) and Kirby and Ashman's (1984) finding that mathematics computation is highly related to planning, Naglieri and Das' (1987) finding that planning was strongly associated with math achievement in grades 2, 6, and 10, and Prewett and Naglieri's (1992) finding that planning accounted for a significant portion of the variance in a reading disabled sample's K-TEA mathematics achievement score. Thus, the results of the present study support previous findings demonstrating the relationship between planning and performance on math tasks and illustrate the importance of planning in the prediction of math reasoning, math computation, and total math achievement.

The predictive validity evidenced by the attention composite in math reasoning, math computation, and total math achievement is an indication of its importance in mathematics performance. To date, only one research study (Warrick, 1989) has investigated the relationship between all four PASS processes and mathematics achievement. Although Warrick (1989) found that simultaneous processing generally provided the greatest discrimination among high and low mathematics achievers in grades 3, 6, and 9, the importance of attention in the prediction of math achievement was evident across grades. Thus, the present findings support Warrick's findings that attention accounted for a significant portion of the variance in problem
solving, math computation, and total math achievement in the third grade sample, and math computation and total math achievement in the sixth grade sample. The results of the present study in conjunction with previous research suggests that academic difficulties in mathematics may be related to deficits in planning and attention.

The finding that successive processing accounted for a significant portion of the variance above that accounted for by planning and attention in math reasoning achievement was not expected and is not supported by previous research findings. It is likely that the importance of successive processing in figuring mathematics reasoning problems is related to the specific nature of the task. That is, many of these DAB-2 items required the individual to solve mathematical problems in his/her head rather than use a pencil and paper. Therefore, the specific ordering of information must be maintained in short-term memory, which is similar to the demands of the sentence questions task in the present study, until the problem is solved. Thus, the maintainance of a proper sequence of events is necessary for success on many items within the DAB-2 math reasoning subtest.

Utility of the PASS Composites in the Prediction of Writing Achievement

In the present study, results of the stepwise multiple regressions on writing achievement showed that planning was the best predictor of overall writing achievement as well as specific areas of writing including capitalization, punctuation, and written composition. In the areas of
punctuation and total writing achievement, attention entered the regression equation second and accounted for a significant portion of the variance over that accounted for by planning. In addition, simultaneous processing was the best predictor of spelling achievement followed by attention. The successive processing composite did not contribute to the prediction of achievement in any of the writing areas.

The present study represents the first investigation of the relationship between all four PASS processes and writing achievement. To date, few studies have addressed the relationship between cognitive processing and written composition (e.g., Ashman, 1978; Wachs & Harris, 1986). Results of the present investigation support Ashman's (1978) finding that planned composition loaded highly on a factor with other planning tasks (i.e., Visual Search, Trail-Making, Verbal Fluency). Conversely, Wachs and Harris (1986) found a significant relationship between written composition and successive processing in college freshman. This finding is inconsistent with Ashman's findings as well as those of the present study. This inconsistency may be related to the fact that Wachs and Harris (1986) did not use planning tasks in their investigation of the relationship between writing and cognitive processing. From the results of the present investigation, it appears that planning plays an important role in understanding the underlying cognitive processes in written composition achievement.

The literature espousing the relationship between cognitive processing and spelling achievement is equally sparse. In the present study,
simultaneous processing emerged as the best predictor of spelling achievement followed by attention. This finding is inconsistent with previous studies that found a significant positive relationship between the WRAT spelling subtest and successive processing (Das & Cummins, 1978; Cummins & Das, 1980). However, the results of the present study support Prewett and Naglieri's (1992) findings that simultaneous processing is significantly related to spelling achievement in developmentally handicapped and learning disabled children. None of the aforementioned investigations, however, included measures of attention. Therefore, this study not only represents the first investigation to examine the relationship between attention and spelling, but also demonstrates the importance of attention in the prediction of spelling achievement.

The present study marks the first attempt to relate planning, attention, simultaneous, and successive cognitive processes to specific writing skills such as capitalization and punctuation. In the present study, planning was the best predictor of both capitalization and punctuation achievement. In addition, attention accounted for a significant portion of the variance in punctuation achievement beyond that accounted for by planning. The simultaneous and successive processing composites did not account for a significant portion of the variance in capitalization or punctuation achievement. These results demonstrate the important contribution of both planning and attention in understanding the processes that underlie specific writing skills. These findings, in conjunction with previous findings regarding the relationship between cognitive processing and writing achievement, may
be particularly useful in designing strategies to improve written language skills.

Utility of the PASS Composites in the Prediction of Total Achievement

In the present study, results of the stepwise multiple regressions showed that planning, followed by attention, was the best predictor of total achievement. This finding is supported by previous research that has found a significant relationship between planning and total achievement (e.g., Naglieri & Das, 1987). However, the finding that only planning and attention accounted for a significant portion of the variance in total achievement is inconsistent with previous studies that found both simultaneous and successive processes to contribute significantly to the prediction of a students' overall academic achievement (e.g., Prewett, 1991). The results of the present investigation support previous studies that found a relationship between planning and total achievement. In addition, the importance of attention is particularly evident in the present investigation since previous studies did not assess this area when examining the relationship between cognitive processes and total academic achievement.

In conclusion, an examination of simultaneous and successive processing only may be viewed as a limited approach to understanding cognitive processes. For example, this approach does not address that which is controlling these processes (planning) nor that which is responsible for energizing the processing and planning systems (attention) (Kirby &
Williams, 1991). "Because the three information processing systems are interdependent, we cannot say that intelligence is here, and that achievement is there. Instead, we have to admit that the situation is complicated; the entire cognitive system is involved in the production of intelligent actions and school achievement" (Kirby & Williams, 1991, p. 70).

The PASS Model in Perspective

The PASS model provides a theoretical framework from which to study the relationship between cognitive processes and academic achievement. It is evident from the results of the present investigation that both planning and attention play a significant role in understanding this relationship. Current assessment instruments, however, have been shown to be ineffective in measuring many characteristics (e.g., attentional problems, poor planning and strategic behavior) of atypical children (Das et al., 1992; Kavale & Forness, 1984; McDermott, 1990; Mueller, Dennis, & Short, 1986). Furthermore, current intelligence tests only measure simultaneous processing and, to a lesser extent, successive processing and therefore, essentially ignore the planning and attention components of Luria's model (Das, 1984; Naglieri & Das, 1987). Thus, it is unlikely that the relationship between planning and attention and reading, mathematics, and writing achievement would be found through the use of current assessment instruments such as the WISC-III, SB:FE, K-ABC, and McCarthy Scales (Naglieri et al., 1990) because they are not sensitive to the variations in
these cognitive processes (Naglieri & Das, 1987).

Current intelligence tests have also been shown to be ineffective for differential diagnosis (Hale & Lindino, 1981; Hale & Saxe, 1983; Henry & Wittman, 1981; Kavale & Forness, 1984; Mueller et al., 1986; Naglieri, 1985; Naglieri & Haddad, 1984). For example, several studies have shown that the use of WISC-R profile patterns for the identification of learning disabilities is not effective (e.g., Kavale & Forness, 1984). In addition, process-oriented tests such as the K-ABC do not appear to provide an advantage over other intelligence tests in terms of their diagnostic utility (Naglieri, 1985). Studies using PASS tasks, however, have provided discriminant validity evidence which indicates that these processes may be useful to distinguish between exceptional and nonexceptional populations (Bardos, 1988; Snart et al., 1990). Thus, by including both planning and attention tasks in the assessment of children with learning problems, a more efficient system for the identification of learning disabilities may ensue.

PASS and Remediation

Including measures of planning and attention in addition to simultaneous and successive processing in the assessment of children with learning problems provides an opportunity for a more comprehensive understanding of the relationship between cognitive characteristics and academic achievement. In addition, this broader perspective that the PASS model offers of cognitive functioning may allow a more efficacious approach to remediation.
One purpose of assessment is to observe and monitor deficiencies in order to gain an understanding of the cognitive processes that underlie academic achievement. This information may be used for diagnosis of cognitive deficits as well as the development of training programs and remedial strategies for the amelioration of learning problems (Das, 1992). Many studies have found a positive relationship between information processing training and subsequent improvement in academic reading achievement (e.g., Brailsford, 1981; D. Kaufman, 1978; Krywaniuk, 1975). These investigations, however, focused exclusively on training simultaneous and successive processes. Because the results of the present investigation showed that a combination of planning and attention was the best predictor of achievement in virtually all academic areas, it is likely that the development of training tasks which emphasize these processes will be useful in training programs designed to enhance weak skill areas.

In one recent investigation, Cormier, Carlson, and Das (1990) investigated the relationship of an interactive approach involving overt, concurrent verbalization, planning, and cognitive performance. This relationship was investigated under two test administration conditions: the standard administration procedure suggested by Raven (1965) and the interactive procedure involving overt, concurrent verbalization. Cormier et al. (1990) hypothesized that children who are poor in planning would do less well on a standardized nonverbal test of ability (i.e., Raven Coloured Progressive Matrices, 1965) than children who are good planners.
However, poor planners were expected to be able to compensate and regulate their performance to a level commensurate with good planners under the verbalization condition. The findings support these general hypotheses. Specifically, poor planners in the verbalization condition achieved higher scores than poor planners in the standard instruction condition. This difference was not evident for a good planning ability group. These results indicated that overt verbalization improves performance on the Raven's (a test requiring simultaneous information integration) and is particularly efficacious in improving the performance of children with poor planning skills. These findings demonstrate that verbalization is an effective way for children to control their behavior. Furthermore, this study emphasizes the important role that planning plays in intellectual assessment (Cormier et al., 1990).

Strategy training in the planning domain is particularly relevant for the present sample. According to Kirby and Williams (1991), children with learning problems typically approach tasks in a nonstrategic and passive manner. Furthermore, and in support of Cormier et al's (1990) findings mentioned above, "learning problem children have been shown to perform poorly on tasks requiring spontaneous use of strategies (e.g., Torgesen, 1978; Worden, 1983), especially memory tasks. However, when the task is designed to force the subjects to use an appropriate strategy, learning problem children improve greatly" (Kirby & Williams, 1991, p. 215). These findings demonstrate that children can use appropriate strategies; however,
they often do not spontaneously choose to use appropriate strategies in any
given task or situation. This description of children with learning problems
has sparked much research concerning diagnostic and remedial procedures
that address the planning component. It is hoped that through an
understanding of planning it may be realized that performance is not only a
function of an individual's level of skill or ability, but also a function of how
well the individual deploys or uses those skills (Kirby & Williams, 1991).

Limitations of the Present Study and Suggestion for Future Research

One limitation of the present study was the limited number of subjects
included in the sample. A minimum of 100 subjects is considered
appropriate for a correlation matrix containing 16 variables (i.e., Table 10 in
the present study) (Bentler and Lettier, 1976). This ideal sample size was
determined using the following formula: $n = 60 + \text{SQRT}(X)$, where $X$ is the
number of variables in the correlation matrix. Therefore, it is possible that
the lack of significance found between attention, simultaneous, and
successive processing and some areas of academic achievement may, in
part, be a function of sample size. That is, as the sample size increases,
confidence in obtaining a random sample also increases thereby allowing
greater generalizability to the population from which the sample was drawn.
Future research investigations should include larger sample sizes so that
these important relationships can be reexamined.
Another limitation of the present study was the restriction of range on the achievement variable. This restriction may have contributed to the lack of predictive power of simultaneous and successive processes in virtually all areas of academic achievement.

Finally, because the sample did not contain a large number of subjects at each age level, the PASS factor structure as well as the predictive validity of each PASS composite was examined only for the total sample. Future research should examine the relationship between all four PASS processes and academic achievement using larger sample sizes at each age level to permit an examination of the PASS factor structure and the relationship between PASS composites and academic achievement by age.

Future research should also examine more thoroughly the relationship between cognitive processes and specific areas of writing achievement. This may be achieved by using larger sample sizes and including students of varying levels of writing ability so that differences among high and low achievers may be examined. In addition, since this is the first investigation to examine the relationship between all four PASS composites and reading and writing achievement, replication of these results is warranted. Finally, future research should focus on reexamining the relationship between all four PASS composites and reading, mathematics, and writing achievement in different populations (e.g., learning disabled, attention deficit hyperactivity disorder).
References


