PLANNING AND ITS RELATIONSHIP TO CODING, ACHIEVEMENT, AND IQ

By

JULIA BRASSFIELD SHACKELFORD

Bachelor of Science
Indiana University
Bloomington, Indiana
1976

Master of Arts
Northwestern University
Evanston, Illinois
1979

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Thesis Advisor

Dean of the Graduate College

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[1]Scofield, C. I. (Ed.) (1945). The holy bible (King James version). New York: Oxford University Press.

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CHAPTER I

INTRODUCTION

Purpose of the Study

The present dissertation is concerned with planning as a cognitive function. The question posed is whether planning ability is more closely related to achievement than to IQ. It is further questioned whether deficient planning ability is related to discrepancies between coding processes.

Luria (1973, 1980), through his clinical observations of patients with lesions in various parts of the brain, determined that the brain has three major functional divisions. Luria associated one of these divisions, that which is located in the frontal region of the brain, with planful behavior. Thus, planning was determined to be a major cognitive function.

In developing his theory of intelligence, Sternberg (1986) identified processes involving planning as essential ingredients of intelligence. He called these processes "metacomponents" and defined them as "the executive processes people use in planning, monitoring, and evaluating their problem solving and performance" (Sternberg, 1986, p. 42).

In working with culturally disadvantaged children, Feuerstein (1979) observed that the culturally disadvantaged often demonstrate "unplanned and unsystematic exploratory behavior" (p. 61). This planning-related deficiency was considered to be among the specific impairments limiting the cognitive ability of retarded performers.

Hallahan and Reeve (1980), as well as Torgesen (1980), concluded that there was extensive evidence for a task strategy deficit among learning disabled (LD) children. In other words, a planning-related deficiency appeared to be associated with learning disabilities.

Through their research with reading-disabled children, Leong (1974) and Das (1984a) both observed weaknesses in the control processes of these children that were manifested in the "poor utilization of strategies for coding information" (p. 40). In other words, difficulties were noted in the planning ability of this group of LD children. In regard to the LD child's difficulties coding information, Naglieri and Das (1988a) identified the need "to determine if these children have a deficit in coding (that is, are unable to engage in simultaneous or successive processing) or have a relative incompetence for utilizing their coding processes appropriately" (p. 47).

Conclusions of the above researchers implied that planning is a major cognitive function. Several of the above also suspected deficient planning to be a significant aspect of learning disabilities. Thus, it was the aim of the present study to investigate planning, particularly in regard to characteristics typical of LD children.

A basic characteristic of LD children is that achievement falls significantly below what would be expected for a given IQ (Hallahan & Cruickshank, 1973; Johnson & Myklebust, 1967). In order to investigate the possibility that such underachievement is related to deficient planning, the relationship between planning and achievement has been compared to that of planning and IQ in the present study.

Another basic LD characteristic is that of processing discrepancies, perceptual processing that is characterized by a wide range of strengths and weaknesses (Hallahan & Cruickshank, 1973; Johnson & Myklebust, 1967). In terms of the theoretical framework utilized in this study, processing discrepancies would be referred to as coding discrepancies and would imply the presence of coding deficits. Validity studies for the Kaufman Assessment Battery for Children (K-ABC) (Kaufman & Kaufman, 1983b), an instrument based on the present theoretical framework, did in fact verify the tendency for LD children to exhibit greater than normal coding discrepancies.

Naglieri and Das (1988a) specified the need to determine whether apparent coding deficits were related to difficulties with properly allocating coding processes, a planning-related difficulty. In order to address the research need voiced by Naglieri and Das, determining the relationship between planning and coding discrepancies has been among the goals of the present study.

While characteristics under investigation are typical of LD children, these characteristics have been examined in terms of the population as a whole in order to avoid restricting inferences to that of the LD subgroup. Because LD children present extreme examples of learning difficulties, their hallmark characteristics pinpoint obvious areas in need of research. Nevertheless, it seems logical to expect LD characteristics to exist in the population as a whole in terms of a continuum from nonsignificant to extreme. Thus, while research problems for this study were primarily derived from observation of the extreme, that of learning disabilities, the present purpose was to examine relationships of interest using the full spectrum of student abilities from high to low. As a consequence of utilizing the full range of abilities, the scope of possible inferences has been broadened from that of an extreme subgroup to that of the general population. Furthermore, it has become possible to study the normal relationships among the variables of interest and thereby establish a basis for subsequent research of extreme groups.

Overview of the Study

The theoretical framework of the present study is that of the Planning-Arousal-Simultaneous-Successive (PASS) model of information-integration, originally presented by Das, Kirby, and Jarman (1975, 1979), and recently updated by Naglieri and Das (1988a). This model of information-integration is based on Luria's clinical research. As previously stated, Luria (1973, 1980) proposed that the brain has three major functional divisions. Luria classified these three divisions as Block 1, which is involved in arousal; Block 2, which controls coding of information; and Block 3, which is concerned with planning and decision making. Through these three functional divisions of the brain Luria represented both affective and cognitive aspects of functioning including motivation (arousal), coding of information (coding), and conscious and unconscious planning and decision making (planning).

Considering Luria's research and subsequent research of others, Naglieri and Das (1987, 1988a) have asserted that an adequate measure of psychological processes must represent each of the three functional divisions of the brain: arousal, coding, and planning. Furthermore, they claim the omission of measures of both planning and attention represent deficiencies in tests such as the WISC-R (Wechsler, 1974), the Stanford-Binet (Thorndike, Hagen, & Sattler, 1985) and the K-ABC (Kaufman &

Kaufman, 1983a). Researchers (Ashman, 1978; Das et al., 1979; Naglieri & Das, 1987, 1988a) have been developing tasks to measure both coding and planning for a number of years. The need, however, remains for an adequate measure of arousal.

The present study involves two of Luria's (1973, 1980) major functional divisions of the brain, planning and coding. Though focusing on planning, planning and coding are examined one in relationship to the other, and both in relationship to academi achievement and IQ. Thus, the variables of interest for this study are planning, coding, achievement, and IQ. The present study is that of a correlational design and is included in the category of descriptive research.

Planning has been described by Das (1984b) as "a relatively distinct set of operations such as generating, selecting, and executing plans and programs, evaluating one's own and others' activities and judgments" (p. 231).

Planning ability was measured by means of performance on the Trail Making Test (TMT) (Reitan, 1979). TMT has consistently loaded on planning factors in previous factor analytic studies (Ashman, 1978; Das & Dash, 1983; Das & Heemsbergen, 1983). TMT is an individually administered test given in two parts. The first part requires the subject to connect encircled numbers, quasi-randomly distributed on a page, in correct numerical order. The second part is similar to the first, except that letters are involved in addition to numbers. The subject must connect the numbers in numerical order and the letters in alphabetical order by alternating between the two sequences. The score is the time taken to complete either task.

Coding information has been described by Das (1984b) as "... receiving, analyzing, and synthesizing information into simultaneous, quasispatial arrays, or into successively ordered sequences, and retrieving information that has been thus arranged" (p. 231). In other words, coding includes both simultaneous and successive processing. Coding was measured by means of individually administered tasks which have loaded heavily on simultaneous and successive factors in previous factor analytic studies (Das et al., 1979), Memory-for-Designs (MFD) (Graham & Kendall, 1946, 1960) and Digit Span (DS) (Das et al., 1979), respectively. The simultaneous task, MFD, requires the reproduction from memory of simple straight line drawings. The successive task, DS, requires the oral repetition of aurally presented sequences.

While the coding variable is typically represented by scores from simultaneous and successive tasks, for purposes of the present study an additional score has been derived, a coding discrepancy score (CDS). CDS represented the difference between simultaneous and successive processing. It was derived by means of subtracting MFD and DS z scores for each subject. An absolute value score was utilized.

As previously cited, Das (1984a), Leong (1974), Naglieri and Das (1988a) and Torgesen (1980) suggested that what has traditionally been considered a coding deficit (inability to engage in simultaneous or successive processing) may actually be a problem of planning how to effectively allocate coding processes, a planning-related difficulty. CDS was derived in order to represent the case in which simultaneous processing is higher than successive processing or vice versa. Such profiles would have been traditionally considered indicative of a relative coding deficit. Thus, in terms of the traditional viewpoint, CDS may be considered a measure of coding deficits. On the other hand, the viewpoint presented by the above researchers (Das, 1984a; Leong, 1974; Naglieri & Das, 1988a; Torgeson, 1980) would suggest that CDS may actually measure the extent that individual subjects effectively plan how to allocate their coding processes. To obtain evidence contributing to resolution of the above quandary regarding CDS, has been a major goal of this study.

The variables of achievement and IQ were represented by scores from group testing mandated by the school district of the present sample. The Total Complete Battery score from the Metropolitan Achievement Test, 6th Edition (MAT6) (The Psychological Corporation, 1986) was used to indicate achievement. The School Achievement Index of the Otis-Lennon School Ability Test (O-LSAT) (Otis & Lennon, 1979) was used to indicate IQ.

Although research questions for the present study were derived from characteristics of the LD population, the sample was drawn such that a relatively complete population of fourth-grade students was represented. A sample representing a complete population, rather than one comprised of an LD group and a normal group was desired, as mentioned previously, in order to examine the relationships of interest in terms of the full range of abilities. The sample was drawn from a fourth-grade population attending a suburban public elementary school near a large metropolitan area. The present sample was comprised of all fourth graders who returned signed parental consent forms and who also had participated in the district-mandated group testing of achievement and IQ.

The method of gathering data included individual administration of the following tasks: MFD, DS, and TMT. MAT6 and O-LSAT scores were obtained from subjects' cumulative school records. Raw scores from the above measures were used as indicators of the variables of interest: coding (simultaneous and successive processing), planning, achievement, and IQ. CDS was derived by subtracting the z scores of DS from the z scores of MFD. Obtained scores underwent various statistical analyses to address the hypotheses formulated for this study.

Research Hypotheses

The following research hypotheses were formulated in accordance with expectations based upon findings in the literature. Findings upon which these hypotheses were based will be presented in the subsequent literature review.

Hypothesis One: There is a negative correlation between planning and absolute value coding discrepancy scores (i.e., the higher the subject's planning ability, the lower will be his discrepancy between simultaneous and successive processing).

Hypothesis Two: There is a negative correlation between achievement and absolute value coding discrepancy scores.

Hypothesis Three: The correlation between IQ and absolute value coding discrepancy scores is not significant.

Hypothesis Four: Planning correlates more closely with achievement than with IQ.

Hypothesis Five: The correlation between planning and simultaneous processing does not differ from that of planning and successive processing.

Importance of the Study

A possible contribution of the present study is that of yielding additional support for the PASS model (Naglieri & Das, 1988a). If relationships between planning, coding, IQ, and achievement were to be found consistent with that of the PASS model, further validation would be contributed to this theoretical framework. Since the PASS model considers planning basic to one of the major functional divisions of the brain (Das et al., 1975, 1979; Luria, 1973, 1980; Naglieri & Das, 1988a), this study would thereby also help justify the proposition that planning is a major cognitive function.

To find that planning is substantially related to achievement or to other variables impacting the learning process would also help establish planning as a major cognitive function. Such findings would reinforce the assertion of Naglieri and Das (1987, 1988a) that the measurement of planning should be included in assessing cognitive functioning. Furthermore, the determination that planning is a vital cognitive function could potentially change the direction of efforts related to promoting cognitive development in children.

Other possible contributions of this study have to do with improving the understanding of learning difficulties. Several researchers have associated poor planning with significant underachievement as seen in LD children (Das, 1984a; Leong, 1974; Naglieri & Das, 1988a; Torgesen, 1980). Furthermore, it has been proposed that coding discrepancies, also typical of LD children, may be due to planning deficiencies (Naglieri & Das, 1988a). In regard to the present study, it has been concluded that investigating the relationships between variables linked with hallmark characteristics of those with significant learning problems, LD children, would yield important implications for the population as a whole. Thus, this study has examined relationships among variables observed to be deficient in LD children: planning, coding, and achievement, using the full spectrum of student abilities. Possible results yield the potential of better understanding variables and relationships contributing to learning problems for both the LD and the normal child. Such findings would provide a basis for subsequent experimental research to determine cause-and-effect relationships among variables of significance to the learning process. Eventual findings could lead to both enhancement of the normal learning process and improvement of remedial techniques for the LD child.

CHAPTER II

REVIEW OF LITERATURE

Structure of the Chapter

As indicated in the previous chapter, the main purpose of the present study was to investigate planning as a cognitive function. Futhermore, planning was to be studied within the theoretical framework of the Planning-Arousal-Simultaneous-Successive (PASS) model of information-integration (Naglieri & Das, 1988a). Thus, the present chapter has provided an overview of the various domains of planning-related research and the state of the field for assessment of planning. This has been followed by a description and validation of the PASS model.

It was further intended that the present study clarify the cognitive role of planning by means of investigating the relationships between planning and the following variables: coding, IQ, and achievement. Therefore, the review of literature has included findings from previous research regarding the relationships between planning, coding, IQ, and achievement. It has also been shown that there is the need for further research regarding the relationships of planning to both IQ and achievement.

While this study has used the full range of student abilities to investigate its research problems, these problems were formulated on the basis of LD characteristics. LD characteristics under investigation included that of achievement falling significantly below the IQ level and also that of processing discrepancies. As stated previously, the present study has questioned whether planning ability is more closely related to achievement than to IQ and also whether deficient planning ability is related to discrepancies between coding processes. To justify the investigation of these problems, findings from the literature have been included that, by means of focusing on the LD child, have indicated the importance of planning. The importance of planning has been evidenced by previous findings that deficient planning and learning disabilities are strongly associated. Also, by focusing on the LD child, a rationale for utilizing a coding discrepancy score has been presented. The indication of a common association of both deficient planning and coding discrepancies with learning disabilities has been given as justification for pursuing the above research problems.

Overview of Planning

In reviewing literature relevant to planning, several different domains of planning-related research emerged. Descriptions of the various domains as well as a section regarding the measurement of planning have been included in the following.

Neuropsychological Research

The neuropsychological domain of research on planning has primarily focused on the functioning of the frontal lobes of the brain. As early as 1895, Bianchi (1895) had enough evidence to suggest that planning was localized in the frontal lobes. In his research, Teuber (1964) attributed an executive function to the frontal lobes concluding, "It is not in the reaction to incoming stimuli, but in the prediction of them, the presetting of a mechanism, that the significance of the frontal structure lies" (p. 440). In his theory of the brain, Luria (1966, 1973, 1980) placed particular emphasis upon the regulatory functions of planning associated with the frontal lobes. Shallice and Evans (1978), in researching the cognitive functions of patients with frontal lobe lesions, similarly concluded that the major function of the frontal lobes was the selection and regulation of cognitive plans. Many others have contributed to research of the psychophysiology of the frontal lobes (Warren & Akert, 1964; Stuss & Benson, 1986). The PASS model, theoretical framework for the present study, would also be included within the domain of neuropsychological theories of planning (Das et al., 1975, 1979; Naglieri & Das, 1988a).

Memory and Cognition Research

Within the domain of memory and cognition, planning-related research has frequently involved the study of strategies (Kirby, 1984). An example would be the investigation of chunking and rehearsal strategies utilized in the performance of short-term memory tasks (Torgesen, 1980). Memory and cognition research has tended to draw inferences about the use of strategies from patterns of performance.

Metacognition Research

Although similar to that of memory and cognition, metacognitive research has been characterized by a reliance upon interviews and self-report instruments. The metacognitive domain has been concerned with the individual subject's awareness of how task, subject and strategy factors can influence performance (Kirby, 1984). As mentioned in Chapter I, Robert Sternberg (1986) included metacomponents in his theory of intelligence. Metacomponents were defined by Sternberg as, "the executive processes people use in planning, monitoring, and evaluating their problem solving and performance" (p. 42). He attempted to increase individual awareness of intellectual skills and produced practice problems for improving one's ability in each area of intelligence. In general, the area of thinking and learning skills has received considerable attention recently. Chipman, Segal, and Glaser (1985) have done an extensive presentation of research in this area.

Artificial Intelligence and Problem Solving Research

Within the category of artificial intelligence and problem-solving research, B. Hayes-Roth and F. Hayes-Roth (1979), and Goldin and B. Hayes-Roth (1980) developed a cognitive model of planning. This model of planning was called the Opportunistic Planning Model (OPM). The OPM definition of planning was similar to that of the PASS model although in the OPM, planning was considered to be a two-stage problem-solving process, that of planning and control. Planning was defined as "the predetermination of a course of action aimed at achieving some goal" (B. Hayes-Roth & F. Hayes-Roth, 1979, p. 275). Control was defined as, "monitoring and guiding the execution of the plan to a successful conclusion" (B. Hayes-Roth & F. Hayes-Roth, 1979, p. 276). The OPM was a detailed model of planning in which planning was described as follows:

> The OPM views planning as the cooperative effort of many independent 'plan specialists' . . . . Different specialists possess different types of planning knowledge and influence different aspects of the plan . . . . Specialists record their decisions in a common data structure, the 'blackboard' . . . . The blackboard

> is partitioned into several 'planes'corresponding to different conceptual categories of decisions. Each plane is further partitioned into several "levels of abstraction" (Goldin & B. Hayes-Roth, 1980, p. 6).

The research of B. Hayes-Roth and F. Hayes-Roth (1979) and also that of Goldin and B. Hayes-Roth (1980) was primarily accomplished by means of having subjects perform errand-planning tasks which were evaluated by means of complicated and somewhat subjective criteria.

Other Research

The investigation of planning has been conducted by yet others. The research of planning by Kirby and Ashman (1982, 1984) evolved from the neuropsychological domain and then expanded to incorporate aspects of both the memory and cognitive domain and the metacognition domain. Kirby and Ashman have described planning in a multidimensional manner characterized by four basic factors: Selective Attention, Rehearsal, Clustering, and Metacognition. The Selective Attention factor was the factor which coincided most closely with the PASS model concept of planning. In fact, the Selective Attention factor was measured by some of the same tasks (e.g., Trails) used for the measurement of planning according to the PASS model. Kirby and Ashman (1984) felt that selective attention has a general role in cognition, and is crucial to the selection of information for processing. This factor was found to be an important discriminator between levels of achievement. The Rehearsal and Clustering factors were considered to be function-specific strategies. The Metacognition factor was said to be an abstract factor having to do with the ability to imagine problems and alternate solutions.

Additional areas involved in planning-related research have included that of psychometrics. Although psychometric research has not examined planning abilities in isolation, various traditional multifactor ability measures have been examined for their planning components. The business world represents another arena for which the study of planning has been of interest.

Measures of Planning

In searching for planning instruments for the present study, a serious incongruity was discovered. In spite of an abundance of research related to planning, a void was found in regard to the measurement of planning ability. The Ninth Mental Measurements Yearbook (Mitchell, 1985) had several measures listed under planning. A review of the different measures, however, revealed that the majority were either rating scales or self-report inventories. Listed measures did not appear to assess planning as an ability, but rather, as an observable personality characteristic. Furthermore, it was felt that the appearance of planful or organized behavior may be quite a different thing from that of planning ability. Consider, for example, the Planful-organized Versus Casual-unregulated Scale of the Orientation and Motivation Inventory by Lorr, Youniss, & Stefic (1981). It would seem possible that the person who appears planful and organized may, in fact, be one who must organize his external environment in order to compensate for difficulties organizing his thoughts or developing cognitive strategies. On the other hand, the individual who quite automatically organizes his thoughts and easily develops strategies may not feel the need for external order or structure, and thus appears more casual and unregulated.

The above example was presented in order to distinguish between planning as measured by rating scales or self-report inventories, and planning as measured by a performance or ability test. The desired planning measure for the present study was of the latter type. However, a very small number of performance measures of planning ability were found. These measures included the planning subtests of both the Flanagan Aptitude Classification Tests (FACT) (Flanagan, 1959) and the Flanagan Industrial Tests (FIT) (Flanagan, 1962), the errand-planning tasks of B. Hayes-Roth and F. Hayes-Roth (1979) and Goldin and B. Hayes-Roth (1980), and the neurologically-based experimental tasks used by Das and his colleagues (Das et al., 1979; Naglieri & Das, 1987, 1988a). Of the above measures, the Flanagan's (1959, 1962) planning tests were the only ones that had undergone publication procedures. During revision, the FACT Planning subtest was excluded from the currently published FACT battery. It should be noted, however, that Naglieri and Das (1988b) have recently submitted for publication a battery of simultaneous processing, successive processing, and planning tasks based on the battery of experimental tasks previously used by Das and his colleagues (J. P. Das, personal communication, January 12, 1989) (The Psychological Corporation, personal communication, April 13, 1989 & March 14, 1990).

In the search for planning measures, one more finding was that very few of the rating scales , self-report inventories, or ability tests had indicators of reliability. Even fewer of the measures had indicators of validity. In fact, only one validity study was found for planning as a separate entity. That study was of the Visual Search task used by Das and his colleagues (Das & Heemsbergen, 1983).

<u>Summary</u>

As was evident from the preceding overview, a great deal of research related to planning has been done. Furthermore, planning-related research has evolved from a variety of domains such as the following: neuropsychological, memory and cognition, metacognition, artificial intelligence and problem solving, psychometric, and the business world. In spite of the abundance of planning-related research, however, an incongruity was revealed in regard to the lack of adequate measures of planning ability. Most measures of planning were rating scales or self-report inventories rather than performance instruments. Very few of the planning measures had indicators of reliability, and only one of the measures had an indicator of validity.

The Planning-Arousal-Simultaneous-Successive Model: Presented and Validated

The following section has included a presentation of the Planning Arousal-Simultaneous-Successive (PASS) model. In order to validate the PASS model, several factor analytic studies of typical coding and planning tasks were also presented. Given studies had a broad range of samples differing in age and ability. Support of the PASS model was made showing factor groupings for simultaneous processing, successive processing, and planning. Furthermore, general factors distinguishing coding from planning were shown in order to confirm the PASS model categorization of coding and planning as separate entities.

Presentation of the PASS Model

As discussed in the Introduction, the present study was derived from the PASS model of information-integration. This information-integration model was originally proposed as the Simultaneous-Successive-Planning model by Das et al. (1975, 1979). It was recently updated by Naglieri and Das (1988a). The PASS model of information-integration has been based on Luria's (1973, 1980) proposal that the brain has three major functional divisions: Block 1, which involves arousal; Block 2, which controls coding of information; and Block 3, which is concerned with planning and decision making.

Block 1, the first functional unit, is a prerequisite for human mental processes. This functional unit maintains a proper state of arousal, maintains cortical tone, and provides the opportunity for other cortical activity (Naglieri & Das, 1988a). Maintaining an appropriate level of arousal is important because too much or too little interferes with proper information processing and effective planning (Das, 1984a).

Block 2, the second functional unit, is involved in the reception, analysis, and storage of information. There are considered to be two basic forms of information-integration accomplishing Block 2 functions: simultaneous processing and successive processing. Both simultaneous and successive processing operate at each of the following levels: perception, memory, and conceptualization. According to Naglieri and Das (1988a), simultaneous processing involves the integration of stimuli into groups in which each element is interrelated to every other element. All components of a simultaneous task are immediately accessible to inspection either through examination of the actual stimuli during the activity or through memory of the stimuli. Naglieri and Das (1988a) described successive processing as follows:

> the integration of stimuli into specific sequential series, where each element is related only to the next . . . . forming a specific chain-like progression. Relationships among elements of a successive task are depicted by order, whereas elements of a simultaneous task are all interrelated. (p. 37)

Block 3, the third functional unit, is responsible for planning and decision making. Luria (1973) has described this functional unit as the center for programming, regulation, and verification of activity. Naglieri and Das (1988a) have claimed that the third functional unit entails the aptitude for asking new questions, solving problems, and self-monitoring. They (Naglieri & Das, 1988a) also proposed that "the application of coding processes is an important function of planning processes that may be efficient and typical and thus result in good performance, or inefficient and unusual, thus resulting in poor scores" (p. 38).

As can be inferred from the above quote, the PASS model presents the three functional units as interrelated. Naglieri and Das (1988a) described the relationship among the units as follows:

> . . . the three units are interactive and influence one another, yet at the same time they maintain independence by having distinct functions. These units also rely on and influence a base of knowledge. That is, plans operate on information (knowledge) that has been coded or properly analyzed . . . . Coding and planning interact to facilitate acquisition of knowledge, but at the same time these higher functions depend on a proper state of arousal to provide the opportunity for learning. (pp. 39-40)

<u>Validation of the PASS Model</u>

The following validation of the PASS model has dealt primarily with the coding and planning components due to a lack of research regarding the attention/arousal unit. Well established tasks have been found for measuring simultaneous processing, successive processing, and planning (Das et al., 1979; Naglieri & Das, 1987, 1988a). However, a means of efficiently measuring the attention/arousal unit has yet to be developed. (Descriptions of tasks used in a typical assessment battery of simultaneous processing, successive processing, and planning have been presented in Appendix A.)

In support of the PASS model, it has been found that simultaneous processing, successive processing, and planning have consistently emerged as factors in numerous factor analytic studies. One such study was that of Das and Heemsbergen (1983) using a sample of sixty adult students from a community college. Variables used in the factor analysis included group performance on the following tasks: Auditory Serial Recall, Digit Span, Memory-for-Designs, and Figure Copying. Statistical results confirmed the two coding factors, simultaneous and successive processing. Auditory Serial Recall and Digit Span loaded heavily (.83 and .85, respectively) on a successive component. Figure Copying and Memory-for-Designs loaded heavily on a simultaneous component (.85 and .79, respectively). These two components accounted for 70.40% of variance.

Das and Heemsbergen (1983) also investigated whether a planning factor would be obtained in adding tasks thought to be measures of planning to the previous battery of simultaneous and successive tasks. Using the same sample as cited above, factor analysis clearly yielded the following three factors: planning, simultaneous processing, and successive processing. Tasks loading on the planning factor included Syllogistic Reasoning Time, Trail Making, Planned Composition, and Visual Search with respective loadings of .88, .72, .70, and .63. Based on these results, Das and Heemsbergen concluded that the planning component can be distinguished from that of simultaneous and successive processing.

Ashman (1978) was another researcher to investigate whether a single planning dimension exists independently of simultaneous and successive processing. In contrast to the adult sample used by Das and Heemsbergen (1983), Ashman's sample was comprised of 104 eighth graders (52 males and 52 females). All subjects were administered each of the following tasks: Porteus Maze Test, Trail Making Test, Visual Search, Verbal Fluency, Planned Composition, Figure Copying, Memory-for-Designs, Auditory Serial Recall, Visual Short-term Memory, and Digit Span. A factor analysis of the data yielded four factors which were labeled simultaneous, successive, planning, and spatial visualization. The simultaneous factor was defined by Figure Copying and Memory-for-Designs with respective loadings of .67 and -.81 (the negative loading is due to directionality of scoring). The successive factor was defined by Auditory Serial Recall and Digit Span with respective loadings of .89 and .84. The planning factor was defined by Trail Making and Visual Search with respective loadings of .61 and .80. The spatial visualization factor was defined by Porteus Mazes and Visual Short-term Memory with respective loadings of .71 and .68. Ashman concluded that a single planning dimension does exist independently of simultaneous and successive processing. Furthermore, the above results reaffirmed the independence of both simultaneous and successive processing.

Using several different samples and numerous factor analyses, Das and Dash (1983) attempted to answer a cluster of research questions. Of relevance in confirming the PASS model was whether the two types of coding, simultaneous and successive, were represented by one general factor. Also relevant was whether planning would stand out as a separate general factor.

In answering the question of whether the two types of coding were represented by one general factor, Das and Dash (1983) reanalyzed data from a previous study (Kirby & Das, 1978). This study used a sample of 104 fourth-grade students. Common factor orthogonal varimax rotation and Schmid-Leiman hierarchical orthogonalization were used to analyze the data. The variables of interest were collective scores on the following battery of tests: Raven's Progressive Matrices, Figure Copying, Memory-for-Designs, Serial Recall, Visual Short-term Memory, Digit Span, Word Reading, and Color Naming. Whereas the former six tasks were generally considered measures of coding, the latter two tasks, Word Reading and Color Naming were considered speed tasks. It was explained that the inclusion of speed tasks along with that of simultaneous and successive tasks served the purpose of isolating speed of reception. It has been found that in samples of small children, speed of reception may be confounded with the two coding processes.

Varimax rotation showed three factors that were labeled as follows: successive, simultaneous, and speed. Serial Recall, Visual Short-term Memory, and Digit Span loaded on the successive factor (.54, .82, and .55, respectively). Word Reading and Color Naming loaded on the speed factor (.68 and .70, respectively).

First-order analysis using the Schmid-Leiman hierarchical procedure also resulted in successive, simultaneous, and speed factors. The second- order analysis, however, clearly yielded a general factor, "g".

The highest loadings on "g" were Visual Short-term Memory, Serial Recall, and Word Reading with respective loadings of .66, .57, and .44.

Das and Dash (1983) carried out two more factor analytic studies investigating the "g" factor in relationship to the coding factors using the Schmid-Leiman hierarchical procedure to analyze the data from both studies. One study was comprised of 76 sixth-graders, while the other was comprised of 52 educable mentally retarded (EMR) children. The variables of interest for both studies included collective scores on the following measures: Raven's Progressive Matrices, Figure Copying, Memory-for-Designs, Serial Recall, Digit Span, Sentence Repetition, and Schonell Silent Reading. For the sixth-grade sample, first-order factors which emerged were those of successive and simultaneous. Highest loadings on the successive factor were Serial Recall (.62), Sentence Repetition (.57), and Digit Span (.48). Highest loadings on the simultaneous factor were Memory-for-Designs (.61), Figure Copying (.53), and Raven's Progressive Matrices (.53). Second-order factoring again yielded the general factor, "g", which included both simultaneous and successive tasks. The "g" factor had its highest loading on the following: Sentence Repetition (.55), Raven's Progressive Matrices (.51), Memory-for-Designs (.50), and Serial Recall (.46).

The sample of EMR children (Das & Dash, 1983) showed very similar results to that of the sixth-graders. As before, successive and simultaneous factors emerged from first-order factoring. An additional reading factor emerged as well. Highest loadings on the successive factor were those of Serial Recall (.67), Sentence Repetition (.63), and Digit Span (.55). Highest loadings on the simultaneous factor were those of Memory-for-Designs (.78), Figure Copying (.64), and Raven's Progressive Matrices (.47).

Highest loadings on the reading factor were, as would be expected, those of Schonell Silent Reading (.70) and Schonell Oral Reading (.68). Second-order factoring once more produced the "g" factor containing both simultaneous and successive tasks. Serial Recall (.60), Sentence Repetition (.53), and Raven's Progressive Matrices (.47) ranked highest on this factor.

In summary, results of the above factor analyses were similar in that distinct factors for both simultaneous and successive processing emerged across the different samples. Furthermore, all three analyses indicated that simultaneous and successive tasks share a general factor, "g". The finding of a shared general factor has helped justify the unification of simultaneous and successive processing into the singular category of coding.

After establishing a general factor for simultaneous and successive processing, Das and Dash (1983) proceeded to investigate whether planning would be distinguished as a separate general factor. Using a sample of 70 third-grade children, Schmid-Leiman hierarchical factoring was applied to collective scores from the following measures: Figure Copying, Memory-for-Designs, Serial Recall, Digit Span, Word Reading, Color Naming, Trail Making, and Visual Search. First-order factoring produced the factors of successive, simultaneous, speed, and planning. Tests loading highest on successive were Serial Recall (.74) and Digit Span (.69). Tests loading highest on simultaneous were Figure Copying (.68) and Memory-for-Designs (.64). Word Reading and Color Naming had the highest loadings (.56 and .35, respectively) on speed. Although somewhat low, the loadings on Trail Making and Visual Search (.18 and .19, respectively) were the highest of the planning factor.

As expected, second-order factoring produced two general factors, those of coding and planning. Furthermore, the second-order planning factor was much clearer than that of first-order factoring with substantial loadings for both Trail Making (.54) and Visual Search (.52). The emergence of two, rather than merely one, general factor with the inclusion of planning tasks was significant in that it demonstrated the relative independence of coding tasks from planning tasks. This distinction between coding and planning tasks helped justify the PASS model categorization of coding and planning as separate entities.

Recently, Naglieri and Das (1988a) completed an extensive effort to operationalize and organize the planning and coding components of the PASS model into workable tasks. The sample for this study included 149 subjects from grade two, 160 subjects from grade six, and 125 subjects from grade ten. All subjects were administered each of the following tasks: Tokens, Figure Recognition, Matrices, Hand Movements, Successive Ordering, Word Recall, Matching Numbers, Visual Search, and Trails. Using raw scores for each task, factor analysis yielded three factors for each grade which were labeled simultaneous, successive, and planning. Using the total sample, factor loadings for Tokens, Figure Recognition, and Matrices were .42, .40, and .51, respectively. These tasks defined the simultaneous factor. Likewise Hand Movements, Successive Ordering, and Word Recall had respective loadings of .44, .44, and .43 on the successive factor. Matching Numbers, Visual Search, and Trails had respective loadings of .55, .54, and .53 on the planning factor. Results for each grade individually were similar to that of the total group. Thus, the above findings demonstrated congruity with previous research by indicating distinct factors for simultaneous, successive, and planning tasks.

Summary

The previous section has presented an overview of the PASS model. The overview was followed by a listing of research that validated the PASS model. It was found that across samples differing in age and ability, factor analytic studies consistently verified the distinction between simultaneous processing, successive processing, and planning. Furthermore, two separate general factors for coding and planning were found, justifying the PASS model categorization of coding and planning as separate entities.

The Relationships Between Planning, Coding, IQ, and Achievement

In the following section, evidence regarding the relationships between planning, coding, IQ, and achievement have been presented. Relationships between these variables have been examined according to various combinations, as follows: planning and coding; planning, coding, and IQ; and planning, coding, and achievement. The relationships of planning to both IQ and achievement have been identified as areas in need of further research.

Planning and Coding

The relationship of planning and coding has been shown to be that of distinct entities. This was demonstrated in the preceding section by several different factor analyses (Ashman, 1978; Das & Heemsbergen, 1983; Das &

Dash, 1983; and Naglieri & Das, 1988a). Correlations, as well, have confirmed the separate nature of coding and planning. For instance, Schofield and Ashman (1986) found a correlation of .00 for planning and simultaneous processing and also for planning and successive processing in working with 323 fifth and sixth grade children.

Ashman (1978) further investigated the distinction between planning and coding. In spite of finding separate factors for simultaneous processing, successive processing, and planning, he questioned whether one's proficiency in simultaneous processing affected one's scores on planning measures. Two common planning tasks, Visual Search and Trail Making, involve a visual-spatial format and would appear to require a degree of simultaneous processing. As cited previously, this sample was comprised of 104 eighth graders who had been administered a battery of simultaneous, successive, and planning tasks. To answer the above question, Ashman (1978) divided the sample into four groups based on a double median split of the simultaneous and successive factor scores. An analysis of variance was performed using planning test scores derived from the following: the planning factor score, Trail Making, Visual Search, Verbal Fluency, and Planned Composition. A significant main effect was found for Visual Search, indicating high simultaneous processors performed significantly better than low simultaneous processors on Visual Search ($p < .005$). No other significant main effects or interactions were found. Thus, performance on the other planning measures, Trail Making, Verbal Fluency, and Planned Composition, would not be expected to be affected by one's proficiency in either simultaneous or successive processing. Of significance to the present study was the finding that Trail Making, the measure of planning for present purposes, measures an ability that is unconfounded by coding proficiency. However, of more general significance was the indication that it is possible for planning measures to be affected by one's coding proficiency, as was demonstrated in the case of Visual Search. This finding should function as a caveat in the search for valid planning measures.

Though viewing planning and coding as distinct entities, the developers of the PASS model have also theorized a type of interaction between the two functions. Naglieri and Das (1988a) described the interaction between planning and coding as follows: "The application of coding processes is an important function of planning processes that may be efficient and typical and thus result in good performance, or inefficient and unusual, thus resulting in poor scores" (p. 38). A similar description of the planning/coding interaction was offered by Das et al. (1979) in writing about strategies, a specific aspect of planning:

> Because they are information-processing plans or programs, strategies are composed of a series of actions and/or processes. Thus processes (e.g., simultaneous or successive processing) are components of strategies; the strategy involves a decision about which form of processing to employ at a certain point in the problem situation. (p. 100)

Thus, the above researchers agreed that effective planning is necessary for the effective application of the coding processes.

Similarly, research of severely retarded adults has demonstrated that a certain level of proficiency in coding is necessary in order to utilize planning. Ashman (1984) wanted to determine whether severely retarded persons had the same factor structure for coding and planning tasks as did the nonretarded and less severely retarded. Previous research (Ashman, 1978; Das, 1980) had shown that factor structures for coding and planning tasks were the same for both nonretarded and less retarded (IQ's of 50 and above) individuals. To answer his research question, Ashman (1984) administered a simplified simultaneous, successive, and planning battery to 100 severely retarded adults (mean IQ of 36.5, S.D. of 11.9). Results of factor analysis revealed only two factors: simultaneous and successive. The simultaneous factor was defined not only by the expected simultaneous tasks but by the planning measures as well. The successive factor was defined by the expected successive tasks. The emergence of planning measures on the simultaneous factor was thought to infer that the severely retarded are deficient in the most basic areas of information gathering such as the scanning of stimuli and the organization of incoming information. In other words, "the severely mentally retarded expended their cognitive energies in coding to the detriment of their organizational ability" (Kirby & Ashman, 1982, p. 13). Although most of the general population (those with IQ's greater than 50) has appeared to have sufficient coding ability to perform planning tasks in a manner that measures planning, Ashman's extreme sample provided an example of dependence of planning on coding and further demonstrated the interactive aspects of planning and coding.

In summary, it has been shown that planning and coding are discrete functions. Nevertheless, it has also been posited that good performance requires effective interaction between planning and coding. Similarly, a certain basic level of proficiency in coding is necessary for the utilization of planning. In regard to the measurement of planning, certain tasks, while loading heavily on the planning factor, can also be affected by the level of proficiency in coding. Consequently, the possible affects of coding on planning tasks should be considered in choosing appropriate measurement tools. Thus, the relationship between planning and coding is that of discrete, though interdependent functions.

Planning, Coding, and IQ

The Normal Population. Kirby and Das (1977) examined the relationships between coding and IQ using a sample of 104 fourth grade boys. A battery of simultaneous and successive tasks as well as the Lorge-Thorndike intelligence test were administered. The simultaneous-successive battery was submitted to factor analysis. The following three factors emerged: simultaneous processing, successive processing, and speed. Correlations between coding factors and IQ were derived and found to be moderate. Specifically, the correlations between simultaneous processing and both verbal IQ and nonverbal IQ were, respectively, .41 and .45. The correlations between successive processing and both verbal IQ and nonverbal IQ were, respectively, .41 and .36.

Analysis of variance was also performed on the above data. The 104 subjects were divided into four groups on the basis of a double median split of the simultaneous and successive factor scores. This yielded the following groups: high simultaneous-high successive, high simultaneous-low successive, low simultaneous-high successive, and low simultaneous-low successive. Two 2 x 2 analyses of variance were performed with simultaneous and successive processing abilities as independent variables and both verbal IQ and nonverbal IQ as dependent variables. Verbal and nonverbal IQ were significantly related to both simultaneous and successive processing, and no interactions were found. In general, those subjects scoring high in both modes of processing, scored highest on both verbal and nonverbal IQ (mean scores were 112 and 119, respectively).

Likewise, subjects scoring low in both modes of processing scored lowest on both verbal and nonverbal IQ (mean scores were 94 and 99, respectively). Those scoring high in one mode of processing and low in the other scored between the two extreme groups on both verbal and nonverbal IQ (mean scores for Hi Sim-Lo Succ were 101 and 109, respectively; mean scores for Lo Sim-Hi Succ were 102 and 109, respectively). Thus, Kirby and Das (1977) have revealed a significant relationship between coding and IQ.

Both Das and Dash (1983), and Schofield and Ashman (1986) have determined correlations for planning, coding, and IQ. Das and Dash (1983) administered a battery of simultaneous, successive, and planning tasks to 70 third-grade children. Also given was the Canadian Cognitive Abilities Test (CCAT) which has the following scales: Verbal, Quantitative , and Nonverbal. Again, moderate correlations were found between coding and IQ. Although correlations between the simultaneous factor and CCAT scales (ranging from .44 to .59) were stronger than correlations between the successive factor and CCAT scales (ranging from .27 to .30), all correlations between coding and IQ variables were at a significant level. In contrast, all correlations between the planning factor and CCAT scales were near zero (ranging from -.12 to .09) and did not approach the level of significance.

Schofield and Ashman (1986) administered a battery of simultaneous, successive, and planning tasks to 323 fifth and sixth-grade children. An estimated IQ was also derived for each subject by means of a shortened form of the Wechsler Intelligence Scale for Children-Revised which included the following subtests: Vocabulary, Object Assembly, and Similarities. Correlations were determined between estimated IQ and each of the following factor scores: simultaneous, successive, and planning. All correlations with IQ were significant at the .005 level. As in the Das and

Dash (1983) study, simultaneous processing had a stronger correlation with IQ than did successive processing with respective correlations of .41 and .30. The correlation between planning and IQ, however, was inconsistent with the findings of Das and Dash (1983). Schofield and Ashman (1986) found a correlation of .31 between planning and IQ as contrasted to the near zero correlations between planning and IQ found by Das and Dash (1983). Several possibilities could account for the two different findings including the following: the two to three year age difference between samples, the use of different IQ tests, or the use of different planning tasks to measure planning [Das and Dash (1983) used Trail Making and Visual Search while Schofield and Ashman (1986) used Trail Making, Clustering, and Verbal Fluency].

In summary, the above studies indicated there is a moderate relationship between coding and IQ with simultaneous processing correlating more closely with IQ than successive processing. Findings regarding the relationship between planning and IQ, however, appeared contradictory, indicating the need for further study.

The Mentally Handicapped Population. Ashman (1978, 1984) did two different studies to determine whether the mentally retarded have the same factor structure for coding and planning as the normal population. In the first study, Ashman (1978) compared 66 normal adults to 46 educable mentally retarded adults (mean IQ of 78.6, S.D. of 7.26) on a typical simultaneous-successive-planning battery. Submitting test results to factor analysis for the two groups separately yielded a simultaneous factor, a successive factor, and a planning factor for both groups. In 1984, Ashman extended his research to include the more severely retarded. As cited earlier, Ashman administered a typical simultaneous-successive-planning battery to 100 adults from a hospital for the mentally retarded with a mean IQ for the group of 36.5 (S.D. of 11.9). In contrast to his findings for normal and EMR groups, the severely retarded yielded only simultaneous and successive factors when test results were submitted to factor analysis.

Thus, the above studies suggested that the relationship between coding and planning remains consistent for levels of intelligence above that of the severely retarded.

Comparison of the Information Integration Model of Cognitive Abilities to the More Traditional Models of Cognitive Abilities. Kirby and Das (1978) compared the information-integration model of cognitive abilities to a traditional primary mental abilities model based on Jensen's (1970) breakdown of cognitive abilities into memory and reasoning. The information-integration model was represented by means of a typical battery of simultaneous and successive tasks plus two speed tasks (Word Reading and Color Naming). The traditional primary mental abilities (PMA) model was represented by means of tests of spatial, memory, and reasoning abilities. Tests for the PMA battery were drawn from the Science Research Associates Primary Abilities Kit (Thurstone & Thurstone, 1962) and also from the French Kit of Reference Tests for Cognitive Factors (French, Ekstrom, & Price, 1963). A group of 104 fourth-grade males was administered both the simultaneous-successive-speed battery and the PMA battery. Test results were submitted to factor analysis and the derivation of correlations. Factor analysis combining all scores yielded four factors defined as follows: (1) complex mixture of simultaneous processing, PMA reasoning, and PMA spatial tasks; (2) successive processing; (3) two PMA memory (paired-associates tasks) and two simultaneous processing tasks; and (4) speed. It was felt that this analysis supported the distinctiveness of successive processing, PMA memory, and speed. In contrast, the complex first factor indicated important relationships among inductive reasoning, spatial ability, and certain aspects of simultaneous processing. It was suggested that this factor could be representative of Level II ability as outlined by Jensen (1970). Jensen (1970) hypothesized two levels of ability in developing his traditional model of cognitive abilities representing memory as Level I and reasoning as Level II. While the complex first factor may have been analogous to Jensen's Level II ability, correlations indicated that the simultaneous processing component, as a single entity, could not be equated with Level II. Correlations confirmed that simultaneous processing was primarily related to PMA spatial ability and, to a lesser extent, to both PMA reasoning and PMA memory. It was also shown that successive processing could not be equated to Level I ability, or memory, in that successive processing and PMA memory appeared on separate factors. Kirby and Das (1978) concluded that the information-integration model of cognitive abilities did not equate with the traditional primary mental abilities model in that simultaneous and successive processing were not analogous to reasoning and memory, respectively. In other words, it was determined that coding was not equivalent to IQ as defined by a traditional model of cognitive abilities.

Since the study of Kirby and Das (1978), planning progressively assumed a more prominent role in research involving the information-integration model. Kirby and Lawson (1983) examined planning aspects involved in a well-accepted measure of general intelligence, that of Raven's Progressive Matrices (RPM) (Raven, 1965). More specifically, Kirby and

Lawson (1983) attempted to determine the effects of strategy training on the solution of RPM problems. RPM was administered to 150 fourth graders, 168 sixth graders, and 252 eighth graders. Four different treatment conditions were established: weak gestalt, weak analytic, strong gestalt, and strong analytic. Half of the items presented were judged to be correctly solved by use of a gestalt method and the other half, by use of an analytic method. Weak conditions merely involved manipulation of whether the gestalt items were administered first or whether the analytic items were administered first. It was assumed that the method of problem solution needed for initial items would tend to be continued throughout latter items as well. Strong conditions included a ten-minute training session in which explicit verbal instructions about how to solve the problems were given. Sample problems were also worked during the training session. Mean scores for each treatment condition indicated that strong conditions do better than weak conditions for grades four and six. The difference between strong and weak conditions was negligible, however, by grade eight. It was concluded that strategy training was helpful for grades four and six. However, by grade eight, the children may have already acquired sufficient gestalt and analytic strategies such that training resulted in very little improvement. The above findings suggested that the RPM, a traditional indicator of intelligence, assesses not only how well a particular skill such as reasoning is used, but also how well the subject chooses the appropriate solution strategy. It was concluded that either intelligence should be measured by cleaner measures, uncontaminated by strategies, or that intelligence is closely related to planning, and that planning should be explicitly addressed.

In addressing how planning is related to intelligence and the measurement of intelligence, Kirby (1984) reiterated some of the implications of the Kirby and Lawson (1983) study as follows:

> How is planning related to intelligence? . . . Theoretically, they should be strongly related, in that planning (as described here) controls the functioning of the cognitive system. With regard to measurement, however, planning has not featured prominently in any of the factor theories that have generated tests . . . . If anything, traditional tests of intelligence appear to minimize the impact of planning, in that they do not assess how the subject solves the task, only how well. Such tests probably do assess planning, though, in that the choice of an inappropriate plan results in poorer performance. (pp. 84-85)

Naglieri and Das (1987) have expressed similar concerns to those of Kirby (1984), stating that there is a need to include measures of planning in tests of intelligence. According to Naglieri and Das (1987):

> Current intelligence tests, such as the WISC-R, and a process-oriented test, such as the Kaufman Assessment Battery for Children (Kaufman and Kaufman, 1983a), only measure the coding component of Luria's model . . . The omission of planning in these measures renders them insensitive to the variations in regulatory facility of children by which their actions are monitored and controlled. (p. 360)

The above subsection has examined coding and planning in relationship to the measurement of intelligence. It has been shown that coding does not equate with IQ as defined by certain traditional primary mental abilities models. It has also been shown that planning, or the choice of appropriate strategies does affect performance on intelligence tests. Furthermore, it has been argued that there is a need to include measures of planning in the assessment of intellectual functioning.

In summary, it has been shown that there is a strong relationship between coding and IQ, although coding does not equate with IQ as traditionally defined. The relationship between planning and IQ remains uncertain, although there is evidence that the two variables may be significantly related. It has been argued that the measurement of planning should be included in the assessment of intelligence. In general, there is an apparent need for further research regarding planning and its relationship to both IQ and the measurement of IQ. Finally, relative consistency has been indicated for the relationship between coding and planning across intellectual levels, with the exception of the severely mentally retarded.

Planning, Coding, and Achievement

Correlations from a variety of studies have been compiled in Tables I and II in order to present the relationships between planning, coding, and achievement. The listed correlations have revealed a similar pattern regarding the relationships between planning, coding, and achievement to that of planning, coding, and IQ. A strong relationship beween coding and achievement while a somewhat uncertain relationship between planning and achievement have been indicated.

Presented findings in Tables I and II have shown that either the simultaneous factor, the successive factor, or both have correlated significantly with the various achievement scores for all samples listed. The only exception occurred in dividing the Ryckman (1981) sample into subgroups. Although as a total group this sample had significant correlations between all given reading achievement areas and at least one coding factor, this was not true in dividing the sample into two subgroups, normal and learning disabled. The LD subgroup correlations for reading speed and reading accuracy were insignificant for both coding factors. Perhaps this finding was reflective of the characteristic processing problems of the LD population.

In regard to planning and achievement, the data of Tables I and II have indicated significant correlations for most instances. There were, however, several exceptions. In studying fifth graders, Kirby and Ashman, (1984) found almost no correlation between planning and math operations for their subgroup with above average math scores. In contrast, moderate correlations were found between planning and math operations for the average math subgroup, below average math subgroup, and total group. Das (1984c) found a very low correlation between planning and the Quantitative Scale of the Canadian Cognitive Abilities Test for his third grade sample. A low correlation between planning and reading decoding for a second grade subgroup was found by Naglieri and Das (1987). Another example of an insignificant relationship between planning and achievement (though not included in Tables I or II) was found by Kirby and Ashman (1982) in studying 120 fifth graders. Among the variables studied was a factor labeled "Search", which equated with the present definition of planning. Also included was the Australian Council for Educational Research Space Test , a measure devised to assess competence in spatial aspects of mathematics ability. An analysis of variance indicated an insignificant main effect upon Space for Search [$F(1, 105) = .15$, $p>.05$]. Thus, the above exceptions illustrated the uncertain relationship between planning and achievement.

In summary, significant relationships have been consistently found for coding and achievement. Significant relationships between planning and achievement have frequently been found as well. However, the number of exceptions to the planning/achievement relationship indicated the need for further research.

TABLE I

CORRELATION OF READING ACHIEVEMENT TO CODING AND PLANNING

Authors	Group	Reading Measure	Correlation between reading scores and factor scores: Sim	Succ	Total Coding	Planning
Kirby & Das, 1977 (p.567)	Gr. 4, males, N=104 from regular classrooms	Gates-MacGinitie:				
		Vocabulary	.32	.42		
		Comprehension	.42	.51		
Rykman, 1981 (p.79)	Mean age= 120.3 mo. (SD=19.9 mo.) Total Group N=201	Gates-MacGinitie:				
		Speed	.01	.27		
		Accuracy	.07	.27		
		Vocabulary	.50	.55		
		Comprehension	.47	.48		
	Normal Subgroup N=99	Speed	-.02	.21		
		Accuracy	.05	.23		
		Vocabulary	.48	.54		
		Comprehension	.47	.47		
	LD Subgroup N=102	Speed	-.10	.15		
		Accuracy	-.08	.04		
		Vocabulary	.49	.45		
		Comprehension	.42	.40		
Das, 1984c (p. 43)	Gr. 3 N=70	Schonell:				
		Word Reading (decoding)	.33	.34		-.24
		Silent Reading	.26	.28		-.24
		Multilevel Academic Survey Test:				
Naglieri & Das, 1987 (p. 359)	Gr. 2 N=149	Reading (primarily decoding)	.29	.22	.32	-.18
	Gr. 6 N=160	Reading (primarily comprehension)	.28	.17	.27	-.43
	Gr. 10 N=125	Reading (primarily comprehension)	.46	.30	.46	-.54

Note. Coding and planning factors are defined by measures consistent with the PASS model. Planning was defined by tests representing poor performance, and thus negative correlations with reading measures were not unexpected.

TABLE II

CORRELATION OF MATH ACHIEVEMENT TO CODING AND PLANNING

Author(s)	Group	Math Measure	Correlation between math scores and factor scores			
			Sim	Succ	Total Coding	Planning
Kirby & Ashman 1984 (p.16)	Gr. 5 Total Group N=121	Australian Council for Educational Research: Operations Test				r=.39
	(Subgroups divided according to math score)					
	Disabled: N=38					r=.42
	Average: N=48					r=.35
	Able: N=35					r=.01
Das, 1984c (p. 43)	Gr. 3 N=70	Canadian Cognitive Abilities Test Quantitative Scale	.555	.265		.09
		Multilevel Academic Survey Test:				
Naglieri & Das 1987 (p. 359)	Gr. 2 N=149	Math (Computation and applied math)	.38	.11	.31	.28
	Gr. 6 N=160	Math (Computation)	.40	.21	.38	.29
	Gr. 10 N=125	Math (Computation)	.38	.32	.42	.42

Note. Coding and planning factors are defined by measures consistent with the PASS model.

Summary

The preceding section revealed numerous relationships between planning, coding, IQ, and achievement. The most essential findings, however, included the following:

(l) planning and coding were discrete, though interdependent functions;

(2) the relationship of coding to both IQ and achievement was significant;

(3) the relationship of planning to both IQ and achievement was inconsistent.

Inconsistent and inconclusive findings regarding the relationship of planning to both IQ and achievement were indicative of the need for further research.

Further Evidence of the Importance of Planning

Within the Introduction Chapter, Luria (1973, 1980), Sternberg (1986), Feuerstein (1979), Das (1984a), Naglieri and Das (1988a) were cited as researchers who had become convinced that planning plays a major role in cognitive functioning. In studying disabled learners, other researchers have also determined that planning, or the appropriate use of performance strategies, is of vital importance. Thus, the present section has included research conclusions of several who have studied the planning skills of disabled learners followed by a presentation of research findings substantiating the importance of planning.

Research Conclusions

Das et al. (1979) determined that even basic information processing of the learning disabled or mentally retarded could be improved by teaching appropriate strategies. Das et al. (1979) asserted that "coding can be made more efficient by teaching simultaneous and successive strategies. . . .it is possible to improve performance through teaching both how and when to use simultaneous and successive processes" (p. 158).

After an extensive review of research investigating task strategies of LD children, Torgesen (1980) concluded as follows:

> Children with learning problems have been shown to be deficient in use of such basic information processing strategies as verbal labeling and rehearsal, the use of organizational structure to aid recall, and the active construction of implied parts of sentences. Furthermore, these deficiencies have been found consistently in samples of children of different ages and from several different areas of the United States and Canada. (p. 368)

Similarly, Hallahan and Reeve (1980) determined that there was evidence of a task strategy deficit among LD children. In response to a review of research regarding selective attention, Hallahan and Reeve (1980) concluded as follows:

> At this time, it appears that the most parsimonious explana-tion for the learning disabled child's tendency to have problems in attending to relevent cues and ignoring irrelevent cues is his inabililty to bring to the task a specific learning strategy . . . . Apparently, then, it is not so much the learning disabled child's inability to attend selectively that is his basic problem so much as it is the inability to analyze the task in terms of the best strategies needed for performing it. (p. 156)

Although Kirby and Ashman (1984) defined planning as multi-dimensional, the dimension they called selective attention was measured by means of the same tasks used to measure planning within the PASS model. Thus, selective attention would be equivalent to the present definition of planning. Kirby and Ashman speculated that it is the selective attention aspect of planning that affects LD children. They claimed that "in attempting to employ the strategies required by complex achievement tasks, students with poor selective attention skills would stress their working memory capacity and thus their ability to select working memory contents appropriately" (Kirby & Ashman, 1984, p. 19).

Research Findings

It has been shown by the above statements that several researchers have found planning-related deficiencies to be significantly related to inadequate cognitive performance. A study by Krywaniuk (1974) of 112 third grade high and low achievers yielded evidence substantiating the above conclusions. Factor analysis of scores from a typical simultaneous-successive battery administered to the two groups, indicated that the two groups processed certain tasks differently. In that the high achieving group was generally more successful, it was concluded that this finding suggested the high achievers were able to employ their processes more appropriately than the low achievers. Thus, better planning was attributed to high achievers than to low achievers.

Leong (1974) had similar findings to those of Krywaniuk (1974). Leong (1974) administered a typical simultaneous-successive battery to 116 nine-year-old normal and severely reading disabled males. He discovered, by means of factor analysis, processing differences between the two groups. It was concluded that the reading disabled child had general difficulties selecting appropriate strategies for, or the most efficient means of processing, given tasks.

Ryckman (1981) provided one more example in which children with learning problems evidently failed to employ their processes as effectively as normal children. Ryckman administered a simultaneous-successive battery to a sample of 201 normal and learning disabled children with a mean age of 120.3 months (S.D. = 19.9 mo.). Ryckman's simultaneous-successive battery deviated from the usual and included the Seashore Tonal Memory Test. Results of factor analysis indicated a notable difference between the normal and LD children. For Tonal Memory, the LD group had primary loading on the simultaneous factor (.594) and low negative loading on the successive factor (-.216). In contrast, the normal group had primary loading on the successive factor (.620) and strong secondary loading on the simultaneous factor (.442). Furthermore, the normal group performed significantly better than the LD group on Tonal Memory (t (199)= 3.76, p<.001). The Ryckman study thus provided a clear example of strategy selection significantly affecting performance and the tendency of LD children to be deficient in this regard.

Providing substantiation for the above conclusions, Das, Bisanz, and Mancini (1984) found that learning disabled readers did, in fact, perform at a lower level on planning than did average and above average readers. Trail Making, the present measure of planning, was administered to 52 fourth graders. With higher scores indicating poorer performance, mean scores for learning disabled, average, and above average readers were as follows: 78.67, 59.22, and 62.78, respectively.

Whereas the above studies evolved from the PASS theoretical framework, the following studies have come from various other planning-related domains. Falling within the domain of memory and cognition research, Torgesen and Goldman (1977) questioned whether LD children who perform poorly on memory tasks do so because they do not use proper task strategies as efficiently as children who learn normally. The research question was approached by dividing a sample of 32 second graders into two groups: normal readers and poor readers. Each subject was required to recall the sequences in which a group of pictures had been pointed to by an examiner under two different conditions. The first condition examined the use of memory strategies as spontaneously utilized by individual subjects. The second condition promoted the use of rehearsal as a memory strategy. During the first condition, good readers spontaneously utilized rehearsal significantly more than poor readers [$t(30) = 2.19$, $p<.05$]. Likewise, good readers recalled significantly more than poor readers during the first condition. Differences for the two groups, however, for both use of rehearsal and recall were not significant for the second condition. Although the small sample represented an inadequacy in this study, results did yield further evidence of failure by learning disabled groups to spontaneously use proper task strategies.

Bradley and Bryant (1978) investigated whether there was a difference between normal and backward readers in phonological organization. In order to eliminate differences due to reading experience, 60 ten-year-old backward readers were matched on reading level with 30 six-year-old normal readers. The backward and normal readers were compared on performance of an "Oddity Task". The Oddity Task was comprised of several aurally presented word series. For each series the subject was required to determine which one of four monosyllabic words was different from the others in terms of either initial, middle, or final phonemes. It was found that backward readers performed significantly worse than normal readers on the Oddity Task [$F(1, 88) = 32.50$, $p<.001$]. Thus, another planning-related difficulty was indicated for disabled learners in that backward readers were inferior to normal readers in organizing and categorizing phonemes.

Wong (1980) questioned whether children with learning disabilities were as efficient as children without learning disabilities in utilizing implied relationships within given verbal stimuli as a strategy for encoding. To answer the given research question, Wong utilized four subject groups as follows: 32 normal second graders, 32 LD second graders, 32 normal sixth graders, and 32 LD sixth graders. Half of each group were read Explicit Sentences, sentences which included a clause stating the given consequence. The other half of each group were read Implicit Sentences, sentences in which the consequence clause was omitted, only implied. For either condition, Explicit Sentences or Implicit Sentences, a cued recall test followed a four minute intervening unrelated activity. During recall, each subject was cued by being given both a noun from the given sentence plus the consequence regardless of whether the consequence had originally been stated or merely implied. Simple main effects from analysis of variance indicated that normal and LD subjects did not differ in the recall of explicit sentences [$F(1, 112) < 1$, N.S.]. On the other hand, it was also indicated that normal subjects recalled significantly more implicit sentences than LD subjects [$F(1, 112) = 5.74$, $p < .05$]. Rather than the implication of memory deficits for LD subjects, it was concluded that results suggested a failure on the part of LD subjects to utilize implied relationships within given verbal stimuli as a strategy for encoding. In other words, it was found that LD children failed to use the cognitive mediators or strategies available to them.

One further example of the importance of planning to cognitive performance was provided by the Kirby and Lawson (1983) study cited previously. Kirby and Lawson found that strategy training accounted for superior performance among fourth and sixth-grade groups on Raven's Progressive Matrices (Raven, 1965), a well-accepted measure of general intelligence.

Summary

By primarily focusing on the disabled learner, the above section has presented substantial evidence that planning is of major importance to cognitive performance. Cited were a number of researchers who have concluded that planning-related deficits are significantly related to the inferior processing and performance of disabled learners (Das et al., 1979; Hallahan & Reeve, 1980; Kirby & Ashman, 1984; Torgesen, 1980). Evidence was presented of the disabled learner's tendency to exhibit task strategy deficits or failure to appropriately employ available strategies and resources. The improvement of performance through strategy training was also indicated.

Rationale for Coding Discrepancy Score

Although investigating a full range of student abilities, the major research questions of this study have been derived from some basic characteristics of LD children. One characteristic of interest has been that of achievement falling significantly below ability, in other words, under-achievement. Another has been that of processing discrepancies, perceptual processing that is characterized by a wide range of strengths and weaknesses. Whereas the characteristic of underachievement is inherent to the definition of a learning disability, processing discrepancies of various types have traditionally been viewed as underlying the underachievement (Hallahan & Cruickshank, 1973; Johnson & Myklebust, 1967). Thus, it has been the intention of the present study to examine both underachievement and processing discrepancies. To be consistent with the PASS theoretical framework, the present study has represented processing discrepancies by means of a coding discrepancy score, the difference between simultaneous processing and successive processing scores.

In support of the coding discrepancy concept was research involving the performance of LD children on the Wechsler Intelligence Scale for Children (WISC) (Wechsler, 1949), Wechsler Intelligence Scale for Children-Revised (WISC-R) (Wechsler, 1974), Kaufman Assessment Battery for Children (K-ABC) (Kaufman & Kaufman, 1983a), and Cognitive Laterality Battery (CLB) (Gordon, 1984).

Bannatyne (1971, 1974) and Rugel (1974) both acknowledged a discrepancy between simultaneous processing and successive processing in the performance of LD children on the WISC. In recategorizing the WISC, Bannatyne's (1971) category of "Spatial Ability" basically coincided with simultaneous processing, whereas the category of "Sequential Ability" coincided closely with successive processing. Thus, Bannatyne (1971) described a coding discrepancy among dyslexic children in making the following observation, "Genetic dyslexic children do quite well in all those spatial tests which do not demand sequencing . . . . In fact, arbitrary (that is, nonlogical) sequencing tests are especially difficult" (p. 22).

Rugel (1974) examined WISC scores of 22 populations of disabled readers and 13 populations of normal readers in terms of Bannatyne's (1971) categories. Regarding disabled readers, the Spatial Category received the highest rank for a significant majority of the populations (X^2 = 24.37, p<.005). The Sequential Category received the lowest rank for a significant majority of the populations (X^2 = 24.37, p<.005). Furthermore, even in comparison to the normal readers (using the .05 probability level as criterion for a reliable difference), the disabled readers exhibited a strength in the Spatial Category and a weakness in the Sequential Category. Thus, Rugel's findings indicated there is a tendency for disabled readers to have a discrepancy between simultaneous processing and successive processing.

Anderson, Kaufman, and Kaufman (1976) compared the WISC-R scores of LD children (N = 41, ages 6-1 to 15-7) to those of the normal population. Findings were similar to those of Bannatyne (1971, 1974) and Rugel (1974) in that discrepancies between areas of cognitive functioning were found for LD children. The mean Performance IQ was seven points higher than the mean Verbal IQ for the LD group. Furthermore, the size of the Verbal-Performance IQ discrepancy, regardless of sign, was significantly higher (p<.05) for the LD sample (M = 12.5) than for the normal sample (M = 9.7). If Verbal-Performance discrepancies could be considered indicative of coding discrepancies, then the Anderson et al. study could be said to have verified the prevalence of coding discrepancies among LD children.

Smith, Lyon, Hunter, and Boyd (1988) provided further substantiation of the higher incidence of coding discrepancies among LD children in comparison to those without learning disabilities. Furthermore, in support of the above generalization of Verbal-Performance differences to coding discrepancies, this study yielded evidence that WISC-R Verbal-Performance discrepancies coincide with coding discrepancies. Subjects for this study were 67 students referred for psychological evaluation as a result of serious academic or academic/ behavioral problems. The psychological evaluations indicated that 32 of the students were severely LD, while the remaining 35 had a variety of other problems (non-LD). Smith et al. compared the LD group to the non-LD group on K-ABC Simultaneous Processing-Sequential Processing discrepancies (equivalent to coding discrepancies) and also on WISC-R Verbal-Performance discrepancies. It was found that more than twice as many LD students displayed discrepancies as non-LD students. Forty-five percent of the LD group in comparison to 11% of the non-LD group displayed K-ABC Simultaneous Processing-Sequential Processing discrepancies. Similarly, 41% of the LD group in comparison to 20% of the non-LD group displayed WISC-R Verbal-Performance discrepancies.

Validity studies associated with development of the K-ABC (Kaufman & Kaufman, 1983b) also revealed the tendency for LD children to exhibit coding discrepancies. The discrepancy between K-ABC Simultaneous and Sequential standard scores was less sensitive than had been anticipated due to the number of subtests requiring the integration of simultaneous and sequential processing. In spite of this lack of sensitivity, K-ABC validity studies performed on LD children (combined N = 304), nevertheless, revealed "Simultaneous Processing standard scores that average two to five points higher than Sequential Processing standard scores" p. 139. Furthermore, one of the validity studies (Hooper and Hynd, 1983), using 55 dyslexic children plus 30 normal children, found the K-ABC Sequential Processing Scale especially effective in discriminating between dyslexics and normals. In other words, a deficiency in successive processing was found for LD children and would imply the presence of a coding discrepancy.

Up to this point, it may have appeared that coding discrepancies for LD children consistently indicated higher simultaneous than successive processing. Thus, the hypothetical argument could have been made that coding discrepancies merely represented a tendency for LD children to be deficient in successive processing. The apparent tendency for LD samples to have higher simultaneous than successive processing, however, may have actually been a function of sample selection. For example, there has appeared to be a tendency in research of the learning disabled to utilize subjects with a reading disability, rather than representing the complete spectrum of learning disabilities. As a result, characteristics of the reading disabled may have been overrepresented in the research of learning disabilities.

It should be clarified, however, that the tendency for LD children to favor simultaneous over successive processing has not been substantiated. For example, in discussing results of K-ABC validity studies, Kaufman and Kaufman (1983b) reported, "Some samples of learning-disabled children tested on the K-ABC demonstrated approximately equal proportions of significant Simultaneous-greater-than-Sequential and Sequential-greater-than- Simultaneous discrepancies" (p.139). This finding was true for three of the K-ABC validity studies (combined $\underline{N} = 129$).

A final example of coding discrepancies was an investigation by Harness, Epstein, and Gordon (cited in Gordon, 1984) within the domain of cerebral hemisphere research. The Cognitive Laterality Battery (CLB) (Gordon, 1984), a group administered test of right and left hemisphere functioning, was administered to 108 LD children. Ninety-seven percent of the subjects performed better on tests attributed to right hemisphere functioning than on tests attributed to left hemisphere functioning. The average performance on right hemisphere tests was one standard deviation better than on left hemisphere tests. In that tests attributed to right hemisphere functioning were of a visuo-spatial nature, they could be presumed to involve primarily simultaneous processing. Likewise, tests attributed to left hemisphere functioning were of an analytic-sequential nature and could be presumed to involve primarily sequential processing. Thus, the Harness et al. findings yielded presumptive evidence of a discrepancy between simultaneous and sequential processing in LD children. In fact, further study indicated the discrepancy for LD children to be much greater than that of normal children (Gordon, 1984). In comparison to the CLB standardization sample (N = 751), the LD sample performed one-half standard deviation above average on tests attributed to right hemisphere functioning and one-half standard deviation below average on tests attributed to left hemisphere functioning.

Summary

In summary, it has been shown that processing discrepancies have long been associated with learning disabilities. Studies have been presented that justified the representation of processing discrepancies by means of a coding discrepancy score, the difference between simultaneous processing and successive processing scores. Evidence indicating coding discrepancies to be more prevalent among LD children than normal children has been supplied.

Thus, it was established that there is a strong association between coding discrepancies and learning disabilities. In a previous section, presented evidence indicated planning-related deficits to also be strongly associated with learning disabilities. For instance, research suggested the

LD child had difficulties selecting the most effective means of processing given tasks. Furthermore, as Naglieri and Das (1988a) have pointed out, "The application of coding processes is an important function of planning processes" (p. 38). In other words, substantial evidence has been presented indicating a relationship between coding discrepancies and learning disabilities, a relationship between planning-related deficits and learning disabilities, and the dependence of coding upon planning. Therefore, to more fully understand the above relationships or associations, it would seem feasible to examine the relationship between planning and coding discrepancies. Furthermore, since learning disabilities are defined by achievement being significantly below IQ, investigation of the relationships between planning, coding discrepancies, and achievement as compared to IQ would also seem to be warranted. Potential findings regarding the above relationships yield implications for better understanding the learning difficulties of both LD and normal children.

Final Summary

The present literature review has shown that there is an abundance of planning-related research. Incongruently, however, the measurement of planning was found to be inadequate. Since the PASS model has provided the theoretical framework for the present investigation, it was described and validated. Among the most salient findings in validation of the PASS model was that distinct factors have consistently emerged for simultaneous processing, successive processing, and planning in numerous factor analytical studies. Furthermore, factor analysis has also shown two distinct general factors for coding and planning, justifying the PASS model distinction between coding and planning.

Review of research regarding the relationships between planning, coding, IQ, and achievement yielded numerous findings. Of most relevance to the present study, however, were the following:

(1) planning and coding were discrete, though interdependent functions;

(2) the relationship of coding to both IQ and achievement was significant; and

(3) the relationship of planning to both IQ and achievement was inconsistent.

The inconsistent nature of findings involving the relationship of planning to both IQ and achievement indicated the need for further research.

Research focusing on the LD child supported the conclusion that planning-related deficits were significantly related to inferior processing and performance. More specifically, there was evidence of failure to appropriately employ available strategies and resources among the learning disabled. Presented research also indicated the possibility that coding discrepancies were more prevalent among LD children than among normal children. Thus, it was argued that the possibility of a common association of both planning deficiencies and coding discrepancies to learning disabilities, would warrant investigation of the relationship between planning and coding discrepancies. Furthermore, since learning disabilities are defined by achievement being significantly below IQ, it also seemed feasible to investigate the relationships between planning, coding discrepancies, and achievement as compared to IQ.

CHAPTER III

METHOD

Sample

The sample for the present study was drawn from a fourth-grade population of 174 students attending a suburban public elementary school near a large metropolitan area. While the socioeconomic status (SES) of students attending this elementary ranged from that of significantly below average to that of significantly above average, the overall SES was considered moderately above average. A description of the fourth-grade population of the given elementary is presented in Table III.

The sample size of the present study totaled 117 subjects. Excluded from the sample were 16 students for whom parental permission to participate in the study was not obtained. Forty additional students were excluded from the study because of lacking the necessary scores from district-wide testing to represent the variables of IQ and achievement. Of this group of 40 students, 21 were regular or gifted classroom students who were new to the district and had been unable to take part in district-wide IQ testing since it had been administered the previous year. The other 19 students were special education students who did not have the same requirements for participation in district-wide testing as other students. A description of the sample for this study is presented in Table IV.

TABLE III

DESCRIPTION OF FOURTH-GRADE POPULATION

Distribution of Students Across Available Educational Programs (N = 174):

Program	Number of Students
Regular classroom (full-time)	106
Gifted classroom (full-time)	38
Learning disabilities classroom (full-time)	4
Educable mentally handicapped classroom (full-time)	2
Trainable mentally handicapped classroom (full-time)	1
Learning disabilities lab/regular classroom	12
Reading lab/regular classroom	6
Math lab/regular classroom	2
Serious emotional disturbances lab/regular classroom	3

Racial Group Composition:

Racial Group	Percent of Students
Black	4.6
Alaskan or American Indian	10.9
Hispanic	1.7
Asian or Pacific Islander	2.3
White	80.5

TABLE IV

DESCRIPTION OF FOURTH-GRADE SAMPLE

Distribution of Students Across Available Educational Programs (N = 117):

Program	Number of Students
Regular classroom (full-time)	83
Gifted classroom (full-time)	26
Learning disabilities classroom (full-time)	0
Educable mentally handicapped classroom (full-time)	0
Trainable mentally handicapped classroom (full-time)	0
Learning disabilities lab/regular classroom	2
Reading lab/regular classroom	4
Math lab/regular classroom	2
Serious emotional disturbances lab/regular classroom	0

At this point, there is a need to address the loss of special education students from the sample Since the given elementary received transfer students from other elementaries into most of its special education programs, actual losses in terms of the given school population were less than it appeared Excluding transfer students while including both students who lacked parental permission and those who lacked the necessary test scores, yielded the following in terms of special education students missing from the given sample 11 LD, 2 reading lab, 1 EMH, and 2 emotionally disturbed Considering the sample for this study totaled 117 subjects, the absence of 16 special education students was insignificant in terms of the effect upon statistical power The possible effects of range restriction from losing this subgroup, however, were a concern Fortunately, subsidiary analyses investigating the effects of, and correcting for, restriction of range were available (See Chapter V, Subsidiary Analyses) Thus, it seemed feasible to proceed with the given sample

On the contrary, it could be argued that the loss of 11 LD students from a study aimed at LD characteristics would create conceptual difficulties As mentioned previously, although research questions for this study have been derived from characteristics of LD children, it has been the purpose of the present study to examine the variables of interest using the full range of student abilities from that of gifted to that of slow learner By means of using the full range of student abilities, it has been possible to examine variability in terms of the population as a whole Furthermore, conclusions could be drawn regarding normal relationships among the variables of interest

Determining how the given variables are normally related has seemed prerequisite in guiding subsequent causal-comparative or experimental studies which are, perhaps, more specifically directed at the LD population Thus, although the loss of subjects as described falls short of ideal, the present sample can be defended in terms of providing adequate statistical power and accomplishing the purposes of the given study

Instruments

The assessment of planning and coding for the present study was accomplished by means of experimental, rather than standardized, instrumentation Though use of the given instruments to measure planning and coding has been documented in numerous research studies as cited in the Literature Review Chapter, formal test development and standardization procedures have not been completed However, as verified by both J P Das (personal communication, January 12, 1989) and The Psychological Corporation (personal communication, April 13, 1989 & March 14, 1990), Naglieri and Das (1988b) have submitted to publication procedures a formal instrument for the assessment of planning and coding This instrument, the Cognitive Assessment System (CAS), is said to be comprised of tasks which are either similar to, or adaptations of, the present planning and coding tests Nevertheless, since the CAS was not available for the purpose of the present study, the use of previously documented experimental instruments for the measurement of planning and coding was the most feasible alternative Considering the experimental nature of the given tasks, reported indicators of reliability and validity do not conform to the standards of formal instrumentation The assessment of achievement and IQ, however, was accomplished by means of formal, nationally standardized instruments for which sufficient reliability and validity data have been made available

<u>Variable. Planning</u>

The variable of planning was measured by means of the Trail Making Test, Intermediate Version (TMT) (Reitan, 1979) As described elsewhere, TMT was an individually administered test given in two parts, Part A and Part B Part A required the subject to connect encircled numbers quasi-randomly distributed on a page, in correct numerical order The numbers ranged from one through fifteen Part B was similar to Part A, except that letters were involved in addition to numbers The subject was required to connect the numbers in numerical order and the letters in alphabetical order by alternating between the two sequences The numbers ranged from one through eight, while the letters ranged from A through G Scores were the time in seconds taken to complete each part Thus, lower scores indicated better performance In that subjects were required to immediately correct errors, errors counted only in increased time of performance Test administration time did not exceed five minutes

TMT was originally part of the Army Individual Test (1944) It was later adopted by Reitan (1955, 1979) and Spreen and Gaddes (1969) to screen for possible neurological deficits TMT had been found to be particularly sensitive in discriminating brain damaged from normal individuals (Armitage, 1946, Reitan, 1955, Spreen & Benton, 1965) In discussing tests of brain injury, Armitage (1946) claimed the TMT "seemed to measure the following functions (1) ability to perceive a double relationship, (2) ability to plan, (3) ability to 'shift', and (4) related to the preceding point, the presence of any perseverative tendency" (p 31) Thus, TMT has been considered to measure planning

Very little reliability data has been obtained for TMT However, Lezak (1983) has reported a high coefficient of concordance throughout three administrations of Part A to 19 normal subjects at six and twelve month intervals ($\underline{w}$ = .78). The coefficient of concordance was somewhat lower for Part B ($\underline{w}$ = .67). Furthermore, a significant cumulative practice effect was found for Part A ($\underline{p}$<.001), but not for Part B, on the third administration.

In terms of establishing validity, TMT has been shown to consistently load on a planning factor in several different factor analytic studies. Moderate-to-high loadings for TMT on a planning factor were stable across age groups from that of grade two to that of college (Ashman, 1978; Das, 1984c; Das & Dash,1983; Das & Heemsbergen, 1983; Naglieri & Das, 1988a).

Research concerning a multidimensional model of planning by Kirby and Ashman (1982) yielded further validity to the use of TMT for measuring planning. Tasks representative of various planning domains: neuro-psychological, memory and cognition, and metacognition, were administered to 120 fifth-grade students. TMT was among the neuro-psychological tasks selected for the study and was adapted for group administration. Factor analysis, using scores from all given tasks, yielded four factors which were labeled as follows: Search, Rehearsal, Clustering, and Metacognition. TMT had a factor loading of .74 on the Search factor. Analysis of variance, using the four planning factors as independent variables and math achievement as a dependent variable, indicated that adequate Search ability acted as a prerequisite for the effective implementation of the other planning skills. Thus, it would seem justifiable to use tasks which loaded heavily on the Search factor, as did TMT, to represent planning.

Finally, additional support for the validity of TMT as a planning measure has been deduced by means of the close relationship of TMT to

Visual Search (VS), a task which has been shown to be related to performance on a game strategy. The relationship of TMT to VS has been characterized by consistently loading together on a planning factor. For instance, Ashman's (1978) study had a factor loading of .77 on planning for VS while that of TMT was .69. Das and Heemsbergen (1983) had a factor loading of .63 on planning for VS while that of TMT was .72. Thus, if Visual Search could be said to represent characteristics of the planning factor it shares with TMT, then the following study by Das and Heemsbergen (1983) may contribute to the validity of using TMT to measure planning.

Using a sample of 60 adult volunteers from a community college, Das and Heemsbergen (1983) investigated whether there was a significant relationship between VS and the game of Master Mind. Master Mind was described as a "strategy game in which the subject cracks a code involving color and positions, [and] seems to require most of the components of planning, such as the generation of hypotheses, selecting and testing hypotheses, and the evaluation of feedback" (p. 9). VS was administered to all 60 subjects. Those whose performance on VS ranked in either the top or the bottom quartile of the group were selected to play Master Mind. Analysis of variance, using VS performance as the independent variable and Master Mind performance as the dependent variable, indicated those scoring high on VS performed significantly better on Master Mind than those scoring low on VS. Thus, if Master Mind can, indeed, be said to "require most of the components of planning" (p. 9), then the Das and Heemsbergen study may function to support the validity of using tasks which share a common planning factor with VS for the measurement of planning. In other words, results of this study have implied the validity of using TMT to measure planning.

Variable: Coding

The variable of coding, or discrepancy between simultaneous and successive processing, was measured by means of tasks compiled by Das, Kirby, and Jarman (1979). These tasks frequently have been included in simultaneous-successive test batteries. Memory-for-Designs (MFD) was used to measure simultaneous processing, while Digit Span (DS) was used to measure successive processing.

Memory-for-Designs. MFD consisted of 15 simple straight line designs. The subject was shown the designs one at a time for five seconds each. Immediately following each presentation, the subject was required to reproduce the given design from memory. Each design was scored according to the number of errors as designated by Graham and Kendall's (1960) objective scoring system. However, in order to increase variability among subjects' scores for the present study, a minor alteration in scoring from that of Graham & Kendall was made. Graham and Kendall awarded a score of zero points to reproductions that contained no more than two errors. In the present study, a score of zero points was awarded to perfect reproductions or to those containing only minor inaccuracies regarding proportion. A score of one point was awarded reproductions with one or two errors. Consequently, one point had to also be added to each subsequent scoring level designated by Graham and Kendall. The total score for MFD represented error scores, in other words, lower scores indicated better performance. Test administration time was less than five minutes.

MFD was developed by Graham and Kendall (1946, 1960) for the assessment of brain damage in both children and adults. Graham and Kendall (1960) demonstrated high reliability of the scoring method for MFD in that a correlation of .99 was yielded for total raw scores assigned between the two authors for the 140 original validation subjects. Similarly, Howard and Shoemaker (1954) found 93% agreement in independent scoring of MFD designs. Regarding the immediate retest of MFD, Graham and Kendall (1960) found reliability indices of .81 and .85 for child and adult samples, respectively. A range of test-retest reliabilities from .72 to .90 have been reported in an overview of MFD (Spreen, 1965) as well. Finally, Heron and Chown (1967) reported a split-half reliability if .73. In general, reliability data for MFD has indicated a satisfactory instrument in this regard.

Although MFD was developed for the assessment of brain damage, as stated previously, MFD was utilized as an indicator of simultaneous processing ability in the present study. Validity for the measurement of simultaneous processing by means of MFD has been indicated by consistent, moderate-to-high loadings of MFD on a simultaneous factor across age and gender groups for numerous factor analytic studies (Ashman, 1978; Das, 1973; Das & Dash, 1983; Das & Heemsbergen, 1983; Kirby, 1976; Molloy, 1973).

Digit Span. DS involved the aural presentation of digit sequences, beginning with three digits and increasing to a maximum length of nine digits. Digits were presented at the rate of one per second with a drop in the voice on the last digit of each sequence. The subject was required to orally repeat each digit sequence immediately following presentation. If the subject was unable to correctly repeat the first of any digit sequence, he was given a second sequence of identical length. When the subject incorrectly repeated both sequences of any one length, the test was discontinued.

In order to increase variability among subjects' scores, the scoring was altered somewhat from that used by Das et al. (1979) to scoring which was similar to that of the WISC-R Digit Span subtest (Wechsler, 1974) (WISC-R DS). Originally, the score for DS was equivalent to the number of digits in the highest digit sequence correctly recalled. Possible scores ranged from three to nine points. The altered scoring system involved awarding, for each pair of digit sequences of a given length, two points for correctly repeating the first sequence and one point if only the second sequence was correctly repeated. The number of points achieved for each pair of digit sequences was summed to determine the total score. Using the altered scoring system, possible total scores ranged from two to fourteen points. For DS, the higher scores were indicative of better performance. Test administration time was less than five minutes.

DS was adapted by Das et al. (1979) from the Digits Forward segment of the WISC-R DS. The Digits Backward segment of this subtest was omitted. No reliability data have been made available for DS. However, reliability has been shown to be quite adequate for the WISC-R DS. Using a 1-month interval between testing, a test-retest reliability coefficient of .71 was obtained for approximately 50 subjects, age 10 1/2, on this subtest (Wechsler, 1974). It should be cautioned, however, that since the WISC-R DS is comprised of both Digits Forward and Digits Backward, the ability to generalize reliability characteristics of WISC-R DS to that of DS would be limited.

Another measure from which reliability characteristics of DS could possibly be generalized is the Aural-Oral subtest (AO) of The Visual Aural

Digit Span Test (VADS) (Koppitz, 1977). With a mean interval of 6 1/2 months between two administrations of the VADS, a test-retest reliability coefficient of .84 ($p<.001$) was obtained for AO using 35 subjects ages 6 to 10. Task administration and scoring for AO is identical to that of the original, unaltered version of DS. The main difference between the two measures is that the length of AO digit sequences ranges from two to seven digits, whereas the length of DS digit sequences ranges from three to nine digits. Considering the high degree of similarity between AO and DS, it would seem that the ability to generalize reliability characteristics from AO to DS would also be high. Since the given statistics indicate strong reliability for WISC-R DS and even stronger reliability for AO, it would seem justifiable to assume that reliability of DS would be at least adequate.

To reiterate, DS was used as an indicator of successive processing ability in the present study. The validity of using DS to measure successive processing has been established by consistent moderate-to-high loadings of DS on a successive factor in numerous factor analytic studies (Ashman, 1978; Das & Dash, 1983; Das & Heemsbergen, 1983; Kirby, 1976; Molloy, 1973; Williams, 1976). This finding was stable across age groups from that of grade two to that of college.

Variable: Achievement

The variable of achievement was measured by means of a district-mandated, group-administered test, the sixth edition of the Metropolitan Achievement Tests, Elementary Level, Form M (MAT6-EM) (The Psychological Corporation, 1986) designed for grades 3.5 to 4.9. A composite score, the MAT6-EM Total Complete Battery (TCB) score was used to represent this variable. On the following page, Table V lists the scope and sequence for the MAT6-E complete battery.

The MAT6 was standardized during the fall and spring of the 1984-85 school year. Norming groups for this instrument were selected to be representative of students in grades K-12 throughout the United States. The national population was matched in terms of four geographic regions. The percent of subjects drawn from each region during spring standardization was as follows: Northeast, 26.5%; Midwest, 24.6%; Southeast, 20.4%; and West, 28.5%. Ethnic group composition of the spring standardization sample was 75% White, 15% Black, 7.9% of Spanish surname, and 2.1% other. Other considerations included in matching the normative sample to the national population were socioeconomic status, school system enrollment, and public vs. nonpublic schools.

Reliability and validity data were obtained for each grade level (K-12) of the fall and spring national standardization samples. However, only data relevant to the sample for the present study will be reported. Furthermore, exact data will be provided for the TCB score only, since it is the score which is to be utilized in the present study.

The number of fourth-grade students completing the total MAT6-EM battery during the spring national standardization equaled 5,838. Internal consistency (KR 20) reliability coefficients for this group ranged from .84 to .98 on the MAT6-EM. A coefficient of .98 was obtained for TCB. The standard error of measurement for TCB in terms of raw scores for a total of 359 items was 8.3. Although an alternate-form reliability coefficient was not obtained for TCB, that of Total Reading, Total Mathematics, and Total Language was .92, .91, and .87, respectively. On the basis of given reliability information, the MAT6-EM would be considered a reliable instrument.

TABLE V

MAT6-E SCOPE AND SEQUENCE

	I[a]	T[b]
Reading		
Vocabulary	22	15
Word Recognition Skills	29	20[c]
Reading Comprehension	60	40
Total Reading	111	
Mathematics		
Mathematics: Concepts	35	25
Mathematics: Problem Solving	30	27[c]
Mathematics: Computation	30	23
Total Mathematics	95	
Spelling	21	10[c]
Language	42	30
Total Language	63	
Science	45	32
Social Studies	45	32
Research Skills	43[d]	
Total Basic Battery	269	190
Total Complete Battery	359	254

[a]I = Number of Items. [b]T = Testing time in minutes. [c]Test is dictated or partially dictated. [d]Items appear across several content areas.

Reference: The Psychological Corporation, 1986, p. 6.

Regarding validity, content validity were established in that "the authors and editors who built the MAT6 sought to measure a national core curriculum" (The Psychological Corporation, 1986, p. 24). Criterion-related validity was addressed by means of correlating performance on the MAT6 with that of the Otis-Lennon School Ability Test (O-LSAT) (Otis & Lennon, 1979). Although not available in regard to spring standardization, the grade four fall standardization yielded a moderately high correlation of .86 (N = 4,050) between the O-LSAT and the TCB. Correlations between the O-LSAT and individual subtests plus totals for subject areas ranged from .57 to .86. It was also reported that "earlier editions of the Metropolitan Achievement Tests yielded correlations with other achievement tests regularly in the .60-.85 range" (The Psychological Corporation, 1986, p. 24). The authors of the MAT6 felt that construct validity was provided by means of, but not limited to, the following: "(1) grade-to-grade progression of item p-values, (2) Rasch model fit statistics, and (3) test and domain total intercorrelations that are lower than reliability coefficients" (The Psychological Corporation, 1986, p. 25). The above has indicated that the authors of the MAT6 took sufficient measures to develop a valid tool for assessing achievement.

Variable IQ:

The variable of IQ was measured by means of another district-mandated, group-administered test, the Otis-Lennon School Ability Test, Primary II, Form S (O-LSAT) (Otis & Lennon, 1979). Primary II was designed for grades two and three. Scores from this level of the O-LSAT were utilized in the present study since the most recent O-LSAT scores for the given sample were, as mentioned previously, those obtained in third grade. The School Ability Index (SAI) was the score used to represent IQ. The SAI has been derived in the same manner and has the same statistical properties as the Deviation IQ of the Otis-Lennon Mental Ability Test (O-LMAT) from which the O-LSAT was revised. According to the authors, "those who prefer to designate this score [SAI] as IQ and feel they can use this term without misinterpretation may, of course, do so" (Otis & Lennon, 1979, p. 6).

The O-LSAT, Primary II was comprised of three parts and required a total testing time of approximately 80 minutes. All test items were administered orally by the examiner and were pictorial in nature. This test involved the mental processes of analogizing, classification, following directions, quantitative reasoning, and verbal comprehension. Test performance yielded a single raw score based on the number of correct answers.

The O-LSAT was standardized during October, 1977. Approximately 130,000 pupils in 70 school systems participated. Sample selection procedures for the national standardization program were designed to be representative of United States students enrolled in grades 1 through 12. The percent of pupils by geographic region in the O-LSAT standardization sample was as follows: Northeast, 33%; Midwest, 27%; Southeast, 22%; and West, 18%. The ethnic group composition was 74% White, 20% Black, 4% Hispanic, and 2% other. Additionally, the standardization sample closely matched the national population in terms of socioeconomic status, school system enrollment, and school system type, public or nonpublic.

Reliability of the O-LSAT, Primary II was shown to be quite adequate. An internal consistency (KR 20) reliability coefficient of .92 was obtained on Form S with a sample size of 11,139 third graders. For the same sample and test administration, 3.4 was the standard error of measurement in raw score points for 75 items. While data on grade three was not available, test-retest stability over a six-month interval for 348 second graders on the O-LSAT, Primary II was equivalent to a correlation of .84.

In regard to test validity, criterion-related validity was established by means of correlating the O-LSAT with end-of-year course grades, achievement test scores, and data based on other accepted measures of general ability. Using a sample size of 236-238 third graders, correlations between O-LSAT, Primary II scores and end-of-year course grades were as follows: reading, .41; mathematics/arithmetic, .59; and English/language, .57. A correlation of .72 was obtained between the O-LSAT, Primary II, Form R and the Total Complete Battery score of the MAT6, Elementary, Form M with a sample size of 4,246 third graders. The above substantial correlations between the O-LSAT and academic performance have yielded strong evidence that the O-LSAT is a valid indicator of mental ability or IQ as defined by the test publishers.

Procedures

Each subject was removed from regular classtime to be individually tested by one of three trained examiners in separate, quiet rooms. Subjects were administered each of the following tests by a single examiner in the given order: DS, TMT, MFD. Total testing time ranged from 10-15 minutes per subject. The testing of subjects was accomplished by a total of three examiners, each of whom had been trained to administer the given tests. MAT6 and O-LSAT scores were obtained from the cumulative records of each subject. Performance on all measures was recorded in terms of raw scores for the purpose of data analysis. A coding discrepancy score (CDS) was an additional derived score and represented the difference between simultaneous and successive processing. CDS required the conversion of MFD and DS raw scores to z scores. Since the directionality of scores was opposite for MFD as compared to that of DS, z scores for MFD were corrected to have the same directionality as DS. CDS was derived by means of subtracting the z score for DS from the corrected z score for MFD and recording the absolute value of the difference. Finally, the raw scores for TMT, MFD, DS, and TCB of the MAT6-EM and SAI of the O-LSAT, as well as the derived scores for CDS were submitted to data analysis as outlined in the following section.

The present study is of a correlational design and would be classified as descriptive research.

Hypotheses

One of the main research problems for this study was whether planning ability is more closely related to achievement than IQ. Another was whether deficient planning ability is related to discrepancies between coding processes. In order to investigate the above problems, the following statistical, or null, hypotheses were formulated:

Hypothesis One: The correlation between planning and absolute value coding discrepancy scores is not significant.

Hypothesis Two: The correlation between achievement and absolute value coding discrepancy scores is not significant.

Hypothesis Three: The correlation between IQ and absolute value coding discrepancy scores is not significant.

Hypothesis Four: The correlation between planning and achievement does not differ from that of planning and IQ.

Hypothesis Five: The correlation between planning and simultaneous processing does not differ from that between planning and successive processing.

Data Analysis

Data analysis for the present study primarily involved the investigation of relationships. This was accomplished by means of generating a Pearson product-moment correlation matrix comprised of the following variables: planning, simultaneous processing, successive processing, coding discrepancies, achievement, and IQ. The correlation matrix was computer generated using the SPSS-X (Nie, Hull, Jenkins, Steinbrenner, & Bent, 1988) statistical program. The testing of Hypothesis One, Two, and Three was completed by means of reference to the correlation matrix. In addition to the correlation matrix, a single sample t test to test the difference between two correlations (Blalock, 1960) was selected for testing Hypotheses Four and Five. One-tailed tests of significance were utilized in the present study since the directionality of the given relationships had been predicted in accordance with the literature (see Research Hypotheses in Chapter I and Hypothesis-Based Conclusions in Chapter V for the predicted directionality of given relationships). For a moderately large sample size like that of the present sample, correlation coefficients that indicate only small or slight relationships can still be found statistically significant. Thus, to increase the practical significance of present findings, a conservative alpha level of .01 was set.

CHAPTER IV

RESULTS

The purpose of this chapter is to present statistical findings in terms of given null hypotheses. Descriptive statistics for the variables of interest are presented in Table VI. Included are the number of scores obtained as well as the mean, standard deviation, and range in terms of raw scores for the various tests used to measure each variable. Table VII presents the Pearson product-moment correlation matrix generated to analyze relationships among the variables of interest. Figure 1 provides a model displaying the relationships of interest.

In examining the correlational coefficients of Table VII and Figure 1 it should be noted that most of the given negative correlations were merely a function of differing directionality of scoring and, in fact, represented positive relationships. Scores for measures of successive processing, achievement, and IQ were based on correct responses. Thus, higher scores indicated better performance for these variables. In contrast, scores for measures of planning and simultaneous processing were based on error responses and resulted in higher scores indicating lower performance. Similarly, higher coding discrepancy scores were indicative of greater differences between simultaneous and successive processing.

TABLE VI

DESCRIPTIVE STATISTICS FOR VARIABLES OF INTEREST IN TERMS OF RAW SCORES FOR THE ORIGINAL SAMPLE (N = 117)

Variable	Mean	Standard Deviation	Range[a]
Planning (TMT)	49.316	15.076	70.000
Simultaneous Processing (MFD)	5.957	4.983	27.000
Successive Processing (DS)	7.077	1.767	8.000
Coding Discrepancy (MFD-DS)	.996	.733	4.170
Achievement (MAT6-EM)	301.838	24.556	116.000
IQ (O-LSAT)	64.368	7.382	37.000

[a]Difference between the highest and the lowest scores.

TABLE VII

PEARSON PRODUCT-MOMENT CORRELATION COEFFICIENTS, NUMBER OF CASES, AND ONE-TAILED SIGNIFICANCE OF CORRELATION FOR VARIABLES OF INTEREST FOR THE ORIGINAL SAMPLE (N = 117)

	Planning	Simultaneous Processing	Successive Processing	Coding Discrepancy	Achievement	IQ
1. Planning	--	.1856 p=.023	-.1679 p=.035	.0312 p=.369	-.2201 p=.009*	-.2604 p=.002*
2. Simultaneous Processing		--	-.2267 p=.007*	.2610 p=.002*	-.3983 p=.000*	-.3321 p=.000*
3. Successive Processing			--	-.1257 p=.088	.3634 p=.000*	.2139 p=.010*
4. Coding Discrepancy				--	-.2392 p=.005*	-.0634 p=.249
5. Achievement					--	.5392 p=.000*
6. IQ						--

*p<.01

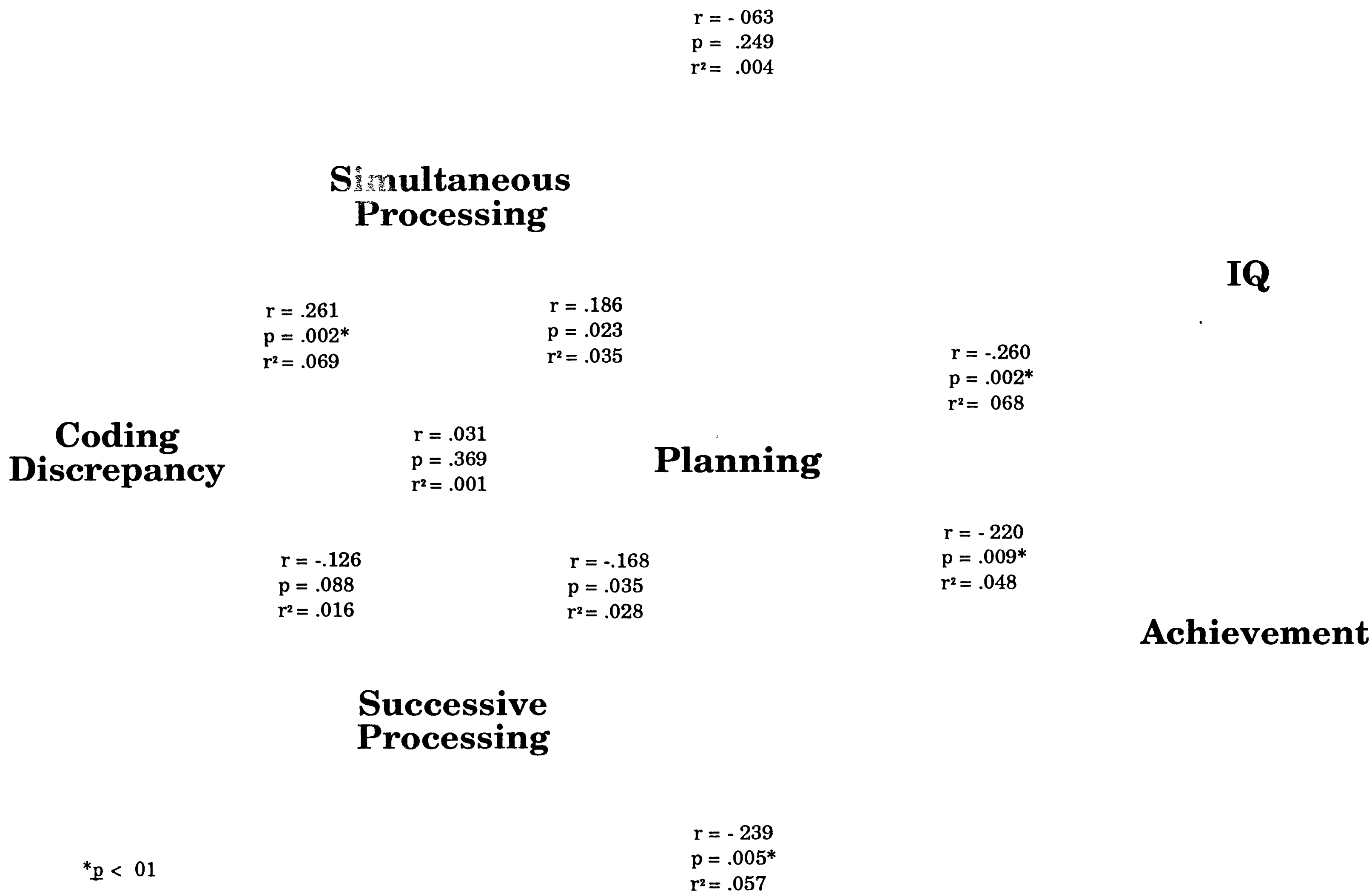

Figure 1. Model of Relationships Indicating Pearson Product-Moment Correlation Coefficients, One-Tailed Significance of Correlation, and Coefficient of Determination

Hypothesis One: The correlation between planning and absolute value coding discrepancy scores is not significant. This hypothesis was not rejected (r = .031, NS).

Hypothesis Two: The correlation between achievement and absolute value coding discrepancy scores is not significant. This hypothesis was rejected (r = -.239, p<.01, one-tailed). A small, but definite, negative relationship was found between achievement and coding discrepancies. Shared variability between the two variables was 5.7%.

Hypothesis Three: The correlation between IQ and absolute value coding discrepancy scores is not significant. This hypothesis was not rejected (r = -.063, NS).

Hypothesis Four: The correlation between planning and achievement does not differ from that of planning and IQ. This hypothesis was not rejected. Shared variability for planning and achievement was 4.8%. The correlation between these variables indicated a small, but definite, positive relationship (r = -.220, p<.01, one-tailed) (negative r is a function of directionality of scoring). Shared variability for planning and IQ was 6.8%. A small, but definite, positive relationship was also indicated for these two variables (r = -.260, p<.01, one-tailed) (negative r is a function of directionality of scoring). A t test of the difference between correlations for that of planning and achievement and that of planning and IQ was not significant [t (114) = .463, NS].

Hypothesis Five: The correlation between planning and simultaneous processing does not differ from that of planning and successive processing. This hypothesis was not rejected. Both the correlation between planning and simultaneous processing (r = .186, NS) as well as between planning and successive processing (r = -.168, NS) were nonsignificant.

Since both of the above correlation coefficients were nonsignificant, a *t* test of the difference was both inappropriate and unnecessary in order to conclude that the difference between these two correlation coefficients was also nonsignificant.

In summary, of the five null hypotheses for the present study, Hypothesis Two was the only one to be rejected.

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary of the Investigation

The present study has been concerned with planning as a cognitive function. One of the major research problems has been whether planning ability is more closely related to achievement than to IQ. Another problem has been whether deficient planning ability is related to coding discrepancies, discrepancies between simultaneous and successive processing.

Numerous researchers from a variety of theoretical backgrounds have postulated planning to be a major cognitive function. Examples include the following: Das et al. (1979), Feuerstein (1979), Goldin and Hayes-Roth (1980), Luria (1973), Naglieri and Das (1988a), Shallice and Evans (1978), Sternberg (1986), and Torgeson (1980). Naglieri and Das (1988a) developed the theoretical framework utilized in this study, that of the Planning-Arousal-Simultaneous- Successive (PASS) model of information-integration. The PASS model is based on Luria's (1973, 1980) proposal that the brain has three major functional divisions: Block 1, which involves arousal; Block 2, which controls coding of information; and Block 3, which is concerned with planning and decision making.

The present study has been concerned with the coding and planning functions of Luria's Block 1 and Block 2. While planning has been the focal point, planning and coding have been examined one in relationship to the other, and both in relationship to achievement and IQ.

Research problems for this study have been derived from the conclusion that LD children have planning-related deficiencies, which was voiced by numerous researchers (Bradley & Bryant, 1978; Das, 1984a; Das et al, 1984; Hallahan & Reeve, 1980; Leong, 1974; Naglieri & Das, 1988a; Ryckman, 1981; Torgesen, 1980; Wong, 1980). Basic to the definition of learning disabilities is the characteristic that achievement is significantly below what would be expected on the basis of IQ. In other words, LD children are characterized by underachievement. Since both planning deficiencies and underachievement have been associated with learning problems, it seemed that the relationship between planning deficiencies and underachievement should be explored. Thus in this study, the relationship of planning and achievement has been compared to that of planning and IQ, with the comparison of achievement to IQ serving as an index of underachievement.

Naglieri and Das (1988a) went further and questioned whether the apparent coding deficits typical of LD children were actually a planning-related difficulty, that of properly planning how to allocate coding processes. In an attempt to address the above query, a coding discrepancy score (CDS), the difference between simultaneous and successive processing scores, was formulated to represent apparent coding deficits. Determining the relationship between CDS and planning was considered vital in resolving the question posed by Naglieri and Das.

While research problems for this study have been formulated on the basis of characteristics of LD children, the given problems have been examined using the full range of student abilities from high to low. It was expected that the LD characteristics of underachievement and coding discrepancies exist in the normal population in terms of a continuum from nonsignificant to extreme. The purpose of examining the variables of interest using a full range of abilities was to determine normal relationships, broaden the scope of possible inferences, and thereby establish a framework for future research. Five hypotheses were formulated for the present study. These hypotheses were designed to help resolve the two major research problems presented above.

The sample for this study consisted of 117 fourth-grade students drawn from a population of 174 fourth graders attending a suburban public elementary school. Measures of planning, simultaneous processing, and successive processing were individually administered to each subject. Scores for measures of achievement and IQ were obtained from student records of district-mandated group testing. An additional score, CDS, was derived by computing the difference between simultaneous and successive processing scores. Obtained data were analyzed by means of generating a matrix of Pearson product-moment correlation coefficients (Nie et al., 1988) comprised of all variables of interest: planning, simultaneous processing, successive processing, CDS, achievement, and IQ. In addition, a t test for single samples (Blalock, 1960) was used to determine whether the difference between correlation coefficients was significant for Hypotheses Four and Five.

Conclusions

The following section presents conclusions based upon the findings and limitations of the present study. The first subsection includes the discussion of findings in terms of specific hypotheses. The next subsection is a more general discussion of findings and how they relate to the major research problems outlined for this study. Conclusions have been drawn by means of integrating present with past research.

Hypothesis-Based Conclusions

Hypothesis One: The relationship between planning and absolute value coding discrepancy scores was not significant. This finding was contrary to expectations based upon the literature. The suggestion of previous researchers (Das, 1984a; Leong, 1974; Naglieri & Das, 1988a) that apparent coding deficits were actually a planning-related difficulty, that of improperly allocating coding processes, was not supported by this finding.

Hypothesis Two: The relationship between achievement and absolute value coding discrepancy scores was a small, but definite, negative relationship. The negative relationship found between these two variables could be considered consistent with the literature in that LD subgroups, typified by underachievement, were found to have greater coding discrepancies than the normal population (Gordon, 1984; Hooper & Hynd, 1983; Kaufman & Kaufman, 1983b; Rugel, 1974; Smith et al., 1988). It should be noted, however, that although a statistically significant relationship has been indicated between achievement and coding discrepancies, the practical significance of this relationship is quite limited in that the shared variability between these variables is only 5.7%.

As discussed in regard to Hypothesis One, planning was expected to be negatively related to CDS. Findings, however, ran contrary to expectations indicating a nonsignificant relationship between planning and CDS. Therefore, planning bore no indirect implications in regard to the relationship between achievement and CDS. On the other hand, since CDS was representative of a deficit in either simultaneous or successive processing, it has seemed possible that CDS was actually mirroring the relationships between achievement and either simultaneous or successive processing. In this study, shared variability of achievement and simultaneous processing was 15.9% (r = -.398, p<.001) (negative r is a function of directionality of scoring). Shared variability for achievement and successive processing was 13.1% (r = .363, p<.001, one-tailed). These small, but definite positive relationships between achievement and both simultaneous and successive processing may explain the small, but definite, negative relationship also found between achievement and CDS. The above findings regarding achievement and coding have been considered generally consistent with that of the literature. Significant relationships ranging from small to substantial have been found between achievement and coding in previous studies (Das, 1984c; Kirby & Das, 1977; Naglieri & Das, 1987; Rykman, 1981).

Hypothesis Three: The relationship between IQ and absolute value coding discrepancy scores was not significant. This finding has indicated that coding discrepancies occur regardless of IQ. Previous research related to coding discrepancies and IQ was not found. However, findings again yielded evidence that CDS mirrored the relationships of simultaneous and successive processing in regard to IQ. As the correlations for both simultaneous and successive processing with IQ were somewhat smaller than their respective correlations with achievement, likewise was the trend for CDS.

Hypothesis Four: The relationship between planning and achievement did not differ from that of planning and IQ. It had been anticipated, however, that planning would be more closely related to achievement than to IQ. Previous research had indicated negligible to small relationships between planning and IQ (Das & Dash, 1983; Schofield & Ashman, 1986). Relationships between planning and achievement, on the other hand, ranged from negligible to substantial (Das, 1984c; Kirby & Ashman, 1982; Kirby & Ashman, 1984; Naglieri & Das, 1987). Thus, overall it appeared that the relationship was stronger in regard to planning and achievement than for planning and IQ. Furthermore, using the LD child as an example also led to expectations in converse to actual findings. The LD child has been identified as having achievement which is deficient in comparison to IQ and also as having planning difficulties (Das et al., 1979; Hallahan & Reeve, 1980; Johnson & Myklebust, 1967; Torgesen, 1980). Since both achievement and planning have been described as deficient with IQ remaining within the normal range for LD children, it seemed that this group yielded evidence of planning being more closely related to achievement than to IQ.

In regard to given findings, the correlation between planning and IQ was within the realm of what was expected. That of planning and achievement, however, was somewhat smaller than expected. One possible explanation was that achievement was measured by means of a composite achievement score. As mentioned above, previous research indicated a wide range of correlations from negligible to substantial for planning and achievement. It was possible that the use of a composite achievement score merely obscured the relationship of planning to achievement if, in fact, correlations for planning and achievement vary greatly from one academic area to another.

Other possible explanations for the small correlation between planning and achievement included the presence of subgroups with differing correlations and the effects of a restricted range. Both the presence of subgroups and range restriction can reduce the indicated size of a correlation. This can be illustrated by means of describing scattergram patterns. A scattergram is a plot of bivariate points representing scores on two variables as achieved by each subject of a given sample. The larger the correlation coefficient between two given variables, the more elliptical will be the pattern of plotted points on the scattergram. In contrast, the smaller the correlation coefficient between two given variables, the rounder will be the pattern of plotted points. An example of the presence of subgroups lowering the obtained correlation coefficient would be a situation in which two subgroups at opposite extremes have high correlations on the given variables, while two subgroups in the middle have small correlations. Scattergrams for the two extreme subgroups alone, and perhaps also together, would be relatively thin and elliptical in shape. Scattergrams for the middle subgroups would tend to be relatively wider and rounder. When all groups are combined into a single sample and their scores are plotted together on one scattergram, the former elliptical patterns of the extreme subgroups will be rounded out by the round patterns of the middle subgroups. Thus, the scattergram of combined subgroups will be indicative of a lower correlation coefficient than was previously indicated by that of the two extreme subgroups alone.

In regard to a lowered correlation coefficient due to range restriction, an example would be a situation in which a complete group, or non-restricted sample, has a high correlation between two variables. A scattergram of this high correlation would produce a thin, elliptical shape. If the lower range of the sample were removed, a restricted sample would be produced. In plotting a scattergram for the restricted sample, the lower end of the former scattergram would be cut off. The new pattern of plotted points would be much closer to having an equal length and width than did the former pattern. Thus, the scattergram of the restricted sample would be rounder in shape than that of the nonrestricted sample, and would also be indicative of a lower correlation coefficient.

Hypothesis Five: The relationship between planning and simultaneous processing did not differ from that of planning and successive processing. Correlations between planning and either simultaneous or successive processing were nonsignificant. These results were consistent with that of previous factor analytic studies and other correlational research (Ashman, 1978; Das & Dash, 1983; Das & Heemsbergen, 1983; Naglieri & Das, 1988a; Schofield & Ashman, 1986). The above findings that simultaneous and successive processing were similarly related to planning, conformed to prior research showing these two variables belonged to the same entity, that of coding. Likewise, the finding that both of these coding variables had nonsignificant correlations with planning supported previous conclusions that coding and planning were separate entities.

In the way of a general caveat, consideration should be given to the fact that the large size of the present sample ($\underline{N} = 117$) allows a correlation coefficient as low as $\underline{r} = .214$ to be statistically significant at the .01 level. Although such a correlation is statistically significant for the present sample size, the practical significance of $\underline{r} = .214$ is almost negligible in that this correlation would account for only 4.6% of shared variability. Thus, it should be noted that many of the statistically significant relationships indicated by the present correlation matrix (Table VII) are, nevertheless, of limited practical importance.

General Conclusions

As shown in the previous subsection, present findings were consistent with expectations for Hypotheses Two, Three, and Five. Findings ran contrary to expectations, however, for Hypotheses One and Four. The unexpected findings for Hypothesis One had implications for one of the major research problems of the present study. This research problem questioned whether deficient planning ability is related to coding discrepancies. Findings for Hypothesis One suggested that there is no relationship between deficient planning and coding discrepancies. Das (1984a), Leong (1974), and Naglieri and Das (1988a) postulated that apparent coding deficits, represented in this study as a coding discrepancy score (CDS), were a symptom of deficient planning. Apparent coding deficits were thought to be the result of improperly planning how to employ coding processes. The lack of relationship found between planning and CDS, however, did not support the above postulation. Rather, this finding yielded evidence that coding discrepancies occur independently of planning. Furthermore, the possibility remains that coding discrepancies are exactly what they appear to be, a relative deficiency in either simultaneous or successive processing. In terms of the PASS model, coding discrepancies may be entirely a product of Block 2 functioning, that which controls coding of information.

Findings for this study indicated the variability in CDS was neither accounted for by that of planning nor that of IQ. These findings and also the fact that CDS was derived from coding variables supported the likelihood that CDS was a coding function. This possibility was further substantiated in that CDS seemed to mirror the other coding variables, simultaneous and successive processing. Similarities between CDS, simultaneous processing, and successive processing included the following: small, but definite relationships between each variable and achievement; nonsignificant relationships between each variable and planning; and the tendency of all three variables to have higher correlations with achievement than with IQ. Given evidence that CDS was functioning as a coding-related variable rather than as a planning-related variable, and additional indicators that simultaneous and successive processing were likewise relatively independent of planning, have further shown that coding and planning are separate and distinct. These findings were both consistent with previous research (Ashman, 1978; Das & Dash, 1983; Das & Heemsbergen, 1983; Naglieri & Das, 1988a; Schofield & Ashman, 1986) and supportive of the PASS model which has presented coding and planning as separate functional divisions.

The present study was also concerned with a research problem which asked whether planning ability is more closely related to achievement than to IQ. In addressing this question, findings for Hypothesis Four showed the relationship between planning and achievement to be no different from that of planning and IQ. However, these findings ran contrary to expectations and were, consequently, held in doubt. Within the following section, Subsidiary Analyses, some of the issues regarding the validity of findings for this research problem have been investigated. Furthermore, the need for further study of this problem has been indicated.

Subsidiary Analyses

The main purpose of performing subsidiary analyses was to cross-validate findings of this study. The validity of present results was of concern due to the possibility of a restricted range. In question were the effects of losing special education students and students new to the school system from the sample. It was felt that the loss of these students possibly created a restricted sample with consequent lowered correlation coefficients. To cross validate given results, an additional matrix of Pearson product-moment correlation coefficients (Nie et al., 1988) was generated utilizing a more complete nonrestricted sample. This nonrestricted sample was comprised of 150 subjects, the original sample plus 33 subjects who had previously been excluded on the basis of lacking the necessary group-administered test scores. The composition of the 33 additional subjects was as follows: 2 reading lab students, 10 LD lab students, and 21 regular classroom students new to the school system. For the nonrestricted sample, 150 subjects had scores for the variables of planning, simultaneous processing, successive processing, and CDS. One hundred forty-eight subjects had scores for the achievement variable (two regular classroom students were missing this score), while only the 117 subjects from the original sample had scores for the IQ variable. Since the nonrestricted sample provided no additional scores for IQ, a correction formula for restricted samples (Thorndike, 1949) was utilized to derive estimated correlation coefficients for the nonrestricted sample on this variable.

Results of all subsidiary analyses have been presented in Appendix B. See Table VIII for descriptive statistics of the variables of interest for the nonrestricted sample. See Table IX for the Pearson product-moment correlation matrix of the nonrestricted sample including estimated correlations for IQ. For the most part, results of the correlation matrix of the nonrestricted sample were very similar to those of the original sample. Furthermore, the outcomes of all five hypotheses for this study remained the same for the nonrestricted sample as for the original sample. It has, therefore, been concluded that any restriction of range effects due to the loss of LD and new students has been inconsequential to the present study.

Another concern regarding the validity of given results was whether correlations involving CDS could have been curvilinear, resulting in underestimated relationships. This seemed like a possibility since subjects who scored high on both the simultaneous and successive tasks could achieve the same score on CDS as subjects who scored low on both tasks. Scattergrams were computer generated (Nie et al., 1988) for the correlations between CDS and each of the following: planning, achievement, and IQ. No indications of curvilinearity were detected in the scattergrams. Thus, it has been concluded that results involving CDS were not confounded by curvilinear relationships.

A final concern regarding the validity of present results was whether differing correlations among subgroups could have lowered correlation coefficients for the total sample. To investigate the possibility of subgroup differences, the original sample was divided into three subgroups according to IQ: high ($\underline{N}$ = 35), middle ($\underline{N}$ = 45), and low ($\underline{N}$ = 37). Pearson product-moment correlation matrices were computer generated (Nie et al., 1988) for each subgroup on the following variables: planning, simultaneous processing, successive processing, CDS, and achievement. (See Appendix B, Tables X-XV for descriptive statistics and correlation matrices.) Considering the effects of a smaller sample size upon statistical significance (larger $\underline{r}$'s are necessary), and also that the purpose of the subgroup analysis was merely to investigate possibilities, a less conservative alpha of .05 was set to determine the significance of subgroup findings. Comparison across the three subgroups revealed noteable differences between correlations for the following variables: successive processing and achievement, simultaneous processing and achievement, planning and achievement, and CDS and simultaneous processing. Of most relevance to the present study, however, was the difference across subgroups for correlations between planning and achievement. A significant, positive relationship was found for the high IQ subgroup for planning and achievement ($r = -.306$, $p = .037$, one-tailed) (negative r is a function of directionality of scoring). In contrast, relationships between these variables were not significant for either the middle IQ or the low IQ subgroup (respectively, $r = -.055$ and $r = .004$).

The significance of the above subgroup differences regarding correlations between planning and achievement was heightened by the comparison of correlations between the original and nonrestricted samples. The addition of 12 LD and 21 new students to the original sample to formulate the nonrestricted sample resulted in an increased correlation between planning and achievement (from that of $r = -.220$, $p = .009$, one-tailed to that of $r = -.372$, $p = .000$, one-tailed) (negative r is a function of directionality of scoring). The increase in r yielded the possibility that the LD subgroup, like the high IQ subgroup, represented a subgroup for which the correlation between planning and achievement was significant.

In spite of the increased correlation for planning and achievement, however, the outcome for Hypothesis Four did not change for the nonrestricted sample as compared to that of the original sample. Using Thorndike's (1949) estimated r for the correlation between planning and achievement and the correlation between planning and achievement obtained for the nonrestricted sample, the difference between the two correlations (Blalock, 1960) was again found to be nonsignificant [$\underline{t}$ (145) = 1.201, NS].

As mentioned previously, the consistency of outcomes between the two samples verified the adequacy of the original sample and indicated that conceivable effects from restriction of range were inconsequential to the present study. Nevertheless, the possibility of subgroups, as evidenced above, suggested that the correlation for planning and achievement using the sample as a whole may not have yielded a true picture of the relationship between these variables. It could be postulated that certain subgroups, such as high IQ subgroups, effectively utilize their planning ability to aid in achieving at an optimum level. For example, this subgroup may utilize planning to develop compensatory strategies for areas of weakness. In contrast, middle and low IQ subgroups may fail to utilize their planning resources to academic advantage. Thus, the relationship between planning and achievement is insignificant for them. Regarding LD subgroups, it could be that they suffer from deficient planning and, consequently, lack the resources to compensate for other weaknesses. As a result, achievement is deficient for this subgroup.

Of possible relevance is the fact that a majority of the high IQ subgroup students have been receiving gifted programming based on an educational philosophy that encourages independent, self-motivated learning. It is feasibile that this curriculum has also had the effect of promoting the development of learning strategies, or the independent use of planning-related skills, in these students. By contrast, such abilities would attest to the value of implementing a learning strategies approach which teaches planning-related skills to LD students. Lerner (1985) has outlined a learning strategies approach for use with LD students which teaches specific planning-related skills such as self-questioning, use of organization, monitoring errors, and memory strategies. The above findings yield evidence that the effectiveness of utilizing a learning strategies approach, such as that of Lerner, for LD students as well as all other subgroups, should be explored. In general, the presented evidence of subgroup differences regarding the relationship between planning and achievement, as well as suggested implications for such differences, has indicated the need for further investigation of relationships between these variables.

A final subsidiary analysis involved the comparison of available scores from 12 LD and 6 reading lab students to that of the original sample. Scores were available for the following variables: planning, simultaneous processing, successive processing, CDS, and achievement.

A comparison of means, standard deviations, and ranges of the LD/reading lab group and original sample have been provided in Appendix B, Table XVI. In general, means for all variables were lower for the LD/reading lab group than for the original sample. As compared to the original sample, the most severe area of weakness for the LD/reading lab group was achievement. Comparative weaknesses in planning and CDS were the least severe.

The small size of the LD/reading lab group ($\underline{N} = 18$) has limited conclusions. Nevertheless, it could be concluded that the indications of deficiency in planning, coding, and achievement for the LD/reading lab group were consistent with the literature. Consideration of the LD child's apparent tendency to have both planning and coding deficiencies, as implied by the finding that there is no relationship between planning and coding discrepancies, has led to another postulation. Since present findings have placed doubt upon the conclusions of Das (1984a), Leong (1974), and Naglieri and Das (1988a) that the LD child's coding weaknesses are the by-product of deficient planning, it is proposed, instead, that both coding and planning deficiencies occur independently and can be found in the normal population as well as the LD population. However, it is the simultaneous occurrence of both deficiencies that results in the severe underachievement which characterizes a learning disability. In other words, without adequate planning ability, one who has a coding deficit is rendered unable to compensate for coding weaknesses and, consequently, requires remedial assistance.

The importance of planning as a means of compensating for weaknesses and improving achievement in general, seems to deserve further study. The possible relationships between planning and achievement evidenced by contrasting the high IQ subgroup, middle IQ subgroup, low IQ subgroup, and LD/reading lab subgroup has attested to this research need.

In summary, the above subsidiary analyses have provided cross-validation for the adequacy of the original sample and the coding discrepancy score. Furthermore, the possible effects and implications of subgroup differences upon the relationship of planning and achievement were discussed. The LD/reading lab group was compared to the original sample in regard to planning, coding, and achievement. Areas for further research were suggested.

Recommendations

1. To improve the ability to generalize results, it is recommended that subjects be randomly selected from a population that is more representative of the normal population than is the present sample.

2. To improve the power of statistical findings, it is recommended that restriction of range be avoided by representing all subgroups and the full range of abilities in sample selection.

3. The development of standardized instrumentation with substantial reliability and validity for measuring coding and planning abilities would also improve the strength and replicability of findings for these variables.

4. CDS should be included in a factor analysis with other coding and planning measures to verify that it is a function of coding rather than that of planning.

5. In spite of the distinction between coding and planning demonstrated by this study, the interaction between these two variables should continue to be investigated.

6. It seems possible that memory is a confounding variable masking the relationship between coding and planning. Thus, it is recommended that the effect of memory upon both coding and planning be determined. Furthermore, it seems feasible to study the relationship between coding and planning, partialing out the memory component.

7. Further research investigating the relationship between achievement and planning is needed. It needs to be determined whether the relationship between these variables differs among age groups or for various subgroups, such as gifted, average, slow learner, or LD. The extent

to which this relationship differs according to specific academic areas should be determined.

8. The possibility that good planning helps compensate for coding deficits deserves further investigation. Findings could yield implications for the remediation of learning disabilities.

9. Experimental studies implementing planning-based curriculums or learning strategies approaches to remediation, such as that of Lerner (1985), are needed in order to determine educationally significant cause-and-effect relationships regarding planning. These experimental studies could be utilized to investigate the differences between subgroups, such as gifted, average, slow learner, and LD.

10. In general, the importance of planning needs to be better established. The present study has indicated small to nonsignificant relationships between planning and the other investigated variables. In fact, even the highest correlation found between planning and another variable, that of achievement for the high IQ subgroup, accounted for only 9.7% of shared variability. Though statistically significant, such relationships are of very limited practical significance. In order to justify either the inclusion of planning measures in tests of cognitive ability or the emphasis in educational settings upon students' planning ability, more substantial relationships between planning and educationally significant areas need to be found.

Implications

The results of this investigation primarily contributed to the substantiation of theory and direction of future research. In attempting to expand the PASS model of information-integration, Naglieri and Das

(1988a) proposed that the LD child's observed difficulties engaging in simultaneous or successive processing may actually be a relative incompetence for appropriately planning how to employ coding processes. In other words, they hypothesized that coding deficits were related to planning deficits. Findings for this study, however, failed to support the hypothesis of Naglieri and Das. Instead, findings yielded indications that coding deficits were coding-related functions. These findings were consistent with the original PASS model which presents coding and planning as separate, distinct functional divisions of the brain (Naglieri and Das, 1988a). Thus, present findings provided additional substantiation of the PASS model. In response to the above proposal by Naglieri and Das, however, present findings further implied the likelihood that the LD child's observed coding deficits are exactly what they appear to be, deficits in simultaneous and/or successive processing.

Also investigated was whether planning is more closely related to achievement than to IQ. Results indicated no difference between these two relationships. The implications would be that planning accounts for neither underachievement nor overachievement. Subsidiary analyses, however, yielded evidence that the relationship of planning and achievement may be more significant for certain subgroups such as high IQ or LD than for others such as middle IQ or low IQ. This evidence contributed direction for future research. Potential findings have implications that planning may be of importance in achieving at an optimum or in compensating for weaknesses.

A final contribution of this study was that planning was shown to have from small to negligible relationships with simultaneous processing, successive processing, coding discrepancies, achievement, and IQ.

Present findings would imply that planning, as defined by the Trail Making Test (TMT), is of little educational significance. These findings challenge the inclusion of TMT on measures of cognitive functioning withstanding further evidence of concurrent validity and relevance to the educational setting.

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APPENDIX A

TYPICAL SIMULTANEOUS - SUCCESSIVE - PLANNING TEST BATTERY

Measures of Simultaneous Processing

Memory-for-Designs

This instrument was developed by Graham and Kendall (1960). Test material consists of 15 simple straight line designs. The subject is shown the designs one at a time for five seconds each. Immediately following each presentation, the subject is required to reproduce the given design from memory.

Raven's Colored Progressive Matrices

This is traditionally a test of nonverbal reasoning (Raven, 1965). Test material consists of 36 matrices or designs, each having a part which has been removed. The subject is required to determine which of six alternatives correctly completes each design. The earlier items require visual discrimination, while the latter items involve analogies, permutation and alternation of pattern, and other logical relations.

Measures of Successive Processing

Digit Span

According to Das et al. (1979) this is similar to the WISC-R (Wechsler, 1974) Digit Span Forward subtest. The subject is aurally presented digit sequences of increasing lengths. He is required to orally repeat each digit sequence immediately following presentation.

Serial Recall

This task (Das et al., 1979) includes twenty-four lists of four words each presented by means of a tape recorder. Immediately following the presentation of individual lists, the subject must orally duplicate the given sequence. Twelve of the lists are composed of unrelated words (e.g., day, hot, cow, wall). The other 12 are of acoustically similar words (e.g., man, mat, can, mad).

Measures of Planning

Trail Making Test

The Trail Making Test was originally part of the Army Individual Test of General Ability (1944). It was later used by Reitan (1955) and Spreen and Gaddes (1969) to screen for neurological deficits. It has been used as a measure of planning since Ashman's 1978 study. This test is individually administered in two parts. The first part requires the subject to connect encircled numbers, quasi-randomly distributed on a page, in correct numerical order. The second part is similar to the first, except that letters are involved in addition to numbers. The subject must connect the numbers in numerical order and the letters in alphabetical order by alternating between the two sequences. The score is the time taken to complete either task. Consequently, lower scores indicate better performances.

Visual Search

In its original form, Visual Search was used by Teuber, Battersby, and Bender (1949) to identify visual search deficits following cerebral lesion. Ashman (1978) later adapted this task to be used for the measurement of planning. In its present form, Visual Search includes 16 overhead transparencies consisting of randomly distributed arrays of geometric shapes, letters, and numbers. Each transparency has an encircled "target" in the center which matches one of the other items on the transparency. The subject's task is to locate the copy of the target as quickly as possible. Each transparency is viewed through a box-like apparatus by means of the subject depressing a light switch on the side of the box. After locating the copy of the target, the subject is required to release the light switch and quickly point to the copy. The amount of time the light switch is depressed, is scored as "search time". Thus, the lower the search time score, the better is the subject's performance.

APPENDIX B

STATISTICAL RESULTS OF SUBSIDIARY ANALYSES

TABLE VIII

DESCRIPTIVE STATISTICS FOR VARIABLES OF INTEREST IN TERMS OF RAW SCORES FOR THE NONRESTRICTED SAMPLE (N = 150)

Variable	Mean	Standard Deviation	Range[a]
Planning (TMT)	50.107	17.268	129.000
Simultaneous Processing (MFD)	6.387	5.319	27.000
Successive Processing (DS)	6.900	1.737	8.000
Coding Discrepancy (MFD-DS)	1.022	.743	4.170
Achievement (MAT6-EM)	296.540	32.504	199.000
IQ (O-LSAT)[b]			

[a] Difference between the highest and lowest scores. [b]Scores for IQ were not available for the nonrestricted sample.

TABLE IX

PEARSON PRODUCT-MOMENT CORRELATION COEFFICIENTS, NUMBER OF CASES, AND ONE-TAILED SIGNIFICANCE OF CORRELATION FOR VARIABLES OF INTEREST FOR THE NONRESTRICTED SAMPLE (N = 150)

	Planning	Simultaneous Processing	Successive Processing	Coding Discrepancy	Achievement	IQ
1. Planning	--	.2345 p=.002*	-.1525 p=.031	.0744 p=.183	-.3716 p=.000*	-.298[a]
2. Simultaneous Processing		--	-.2413 p=.001*	.2458 p=.001*	-.4554 p=.000*	-.354
3. Successive Processing			--	-.1340 p=.051	.3714 p=.000*	.210[a]
4. Coding Discrepancy				--	-.2055 p=.006*	-.064[a]
5. Achievement					--	.679[a]
6. IQ (estimated r)[a]						--

[a]Since correlations for IQ were not available for the nonrestricted sample, r was estimated using Thorndike's (1949) correction formula for restricted samples.
* $p < .01$

TABLE X

DESCRIPTIVE STATISTICS FOR VARIABLES OF INTEREST IN TERMS OF RAW SCORES FOR THE HIGH IQ GROUP (N = 35)

Variable	Mean	Standard Deviation
Planning (TMT)	47.371	15.763
Simultaneous Processing (MFD)	4.114	4.150
Successive Processing (DS)	7.543	1.578
Coding Discrepancy (MFD-DS)	.786	.595
Achievement (MAT6-EM)	318.229	19.600
IQ (O-LSAT)	71.486	1.380

TABLE XI

PEARSON PRODUCT-MOMENT CORRELATION COEFFICIENTS, NUMBER OF CASES, AND ONE-TAILED SIGNIFICANCE OF CORRELATION FOR VARIABLES OF INTEREST FOR THE HIGH IQ GROUP (N = 35)

	Planning	Simultaneous Processing	Successive Processing	Coding Discrepancy	Achievement
1. Planning	--	.1378 p=.215	-.2625 p=.064	-.0333 p=.425	-.3064 p=.037*
2. Simultaneous Processing		--	-.3151 p=.033*	-.0274 p=.438	-.4346 p=.005*
3. Successive Processing			--	-.1945 p=.131	.3752 p=.013*
4. Coding Discrepancy				--	-.0528 p=.382
5. Achievement					--

*$p<.05$

TABLE XII

DESCRIPTIVE STATISTICS FOR VARIABLES
OF INTEREST IN TERMS OF RAW SCORES
FOR THE MIDDLE IQ GROUP ($\underline{N}$ = 45)

Variable	Mean	Standard Deviation
Planning (TMT)	45.511	13.092
Simultaneous Processing (MFD)	5.111	3.393
Successive Processing (DS)	7.022	1.803
Coding Discrepancy (MFD-DS)	1.076	.704
Achievement (MAT6-EM)	303.600	20.360
IQ (O-LSAT)	66.111	2.080

TABLE XIII

PEARSON PRODUCT-MOMENT CORRELATION COEFFICIENTS, NUMBER OF CASES, AND ONE-TAILED SIGNIFICANCE OF CORRELATION FOR VARIABLES OF INTEREST FOR THE MIDDLE IQ GROUP (N = 45)

	Planning	Simultaneous Processing	Successive Processing	Coding Discrepancy	Achievement
1. Planning	--	.0003 p=.499	-.1353 p=.188	-.0019 p=.495	-.0551 p=.360
2. Simultaneous Processing		--	-.1036 p=.249	-.1265 p=.204	-.1296 p=.198
3. Successive Processing			--	-.2880 p=.028*	.4096 p=.003*
4. Coding Discrepancy				--	-.2271 p=.067
5. Achievement					--

*p<.05

TABLE XIV

DESCRIPTIVE STATISTICS FOR VARIABLES OF INTEREST IN TERMS OF RAW SCORES FOR THE LOW IQ GROUP (N = 37)

Variable	Mean	Standard Deviation
Planning (TMT)	55.784	14.946
Simultaneous Processing (MFD)	8.730	6.131
Successive Processing (DS)	6.703	1.839
Coding Discrepancy (MFD-DS)	1.099	.854
Achievement (MAT6-EM)	284.189	22.097
IQ (O-LSAT)	55.514	5.905

TABLE XV

PEARSON PRODUCT-MOMENT CORRELATION COEFFICIENTS, NUMBER OF CASES, AND ONE-TAILED SIGNIFICANCE OF CORRELATION FOR VARIABLES OF INTEREST FOR THE LOW IQ GROUP (N = 37)

	Planning	Simultaneous Processing	Successive Processing	Coding Discrepancy	Achievement
1. Planning	--	.1145 p=.250	-.0449 p=.396	-.0540 p=.376	-.0044 p=.490
2. Simultaneous Processing		--	-.3030 p=.034*	-.5578 p=.000*	-.3918 p=.008*
3. Successive Processing			--	-.1495 p=.189	.1819 p=.141
4. Coding Discrepancy				--	-.2266 p=.089
5. Achievement					--

*p<.05

TABLE XVI

DESCRIPTIVE STATISTICS FOR VARIABLES OF INTEREST IN TERMS OF RAW SCORES COMPARING THE ORIGINAL SAMPLE (N = 117) TO THE LD/READING LAB GROUP (N = 18)

Variable	Group	Mean	Standard Deviation	Range
Planning (TMT)	OS	49.316	15.076	70.000
	LD/R	55.167	14.407	52.000
Simultaneous Processing (MFD)	OS	5.957	4.983	27.000
	LD/R	11.833	7.270	25.000
Successive Processing (DS)	OS	7.077	1.767	8.000
	LD/R	5.778	1.353	4.000
Coding Discrepancy (MFD-DS)	OS	.996	.733	4.170
	LD/R	1.294	.702	2.320
Achievement (MAT6-EM)	OS	301.838	24.556	116.000
	LD/R	249.889	39.034	178.000

Note. OS = original sample; LD/R = LD/reading lab group.

[a] Difference between the highest and lowest scores.

VITA

Julia Brassfield Shackelford

Candidate for the Degree of

Doctor of Philosophy

Thesis: PLANNING AND ITS RELATIONSHIP TO CODING, ACHIEVEMENT, AND IQ

Major Field: Applied Behavioral Studies

Biographical:

Personal Data: Born in Tulsa, Oklahoma, February 14, 1953, the daughter of Stanford S. and Jane K. Brassfield.

Education: Graduated from Hale Senior High School, Tulsa, Oklahoma, in May, 1971; received Bachelor of Science degree in Music with minor in Psychology from Indiana University at Bloomington in August, 1976; received Master of Arts degree in Communicative Disorders from Northwestern University, Evanston, Illinois, in June, 1979; completed requirements for the Doctor of Philosophy degree at Oklahoma State University in December, 1990.

Professional Experience: Teacher of children with varying exceptionalities, Alachua County Public Schools, Gainesville, Florida, 1978-1979; Diagnostician, University of Tulsa Psychoeducational Testing, Tulsa, Oklahoma, Fall, 1979; Pre-school Teacher, St. Dunstan's Preschool, Tulsa, Oklahoma, Fall, 1979; Learning Disability Teacher/ Diagnostician, Sapulpa Public Schools, Sapulpa, Oklahoma, Spring, 1980; Teaching Assistant, Department of Applied Behavioral Studies, Oklahoma State University, Spring, 1981; Psychometrist, Jenks Public Schools, Jenks, Oklahoma, 1982-1983; School Psychologist, Jenks Public Schools, 1983-present.