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A CROSS-VALIDATION STUDY OF DAS'S SIMULTANEOUS-SUCCESSIVE-PLANNING MODEL

The Ohio State University

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A CROSS-VALIDATION STUDY OF DAS'S
SIMULTANEOUS-SUCCESSIVE-PLANNING MODEL

Dissertation

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

by

Rick Lloyd Stutzman

* * * * *

The Ohio State University

1986

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CHAPTER I
INTRODUCTION

The aim of this study is to examine the construct validity of tasks designed to measure cognitive processes according to a model of information processing proposed by A. R. Luria and J. P. Das (Das, Kirby & Jarman, 1975). The model proposes three cognitive processes labeled successive-simultaneous coding, planning, and arousal (S-S-P-A). Additionally, this study is concerned with the relationship between the cognitive processes measured in the model with academic achievement in reading.

Origins of the Model

Sechenov proposed that the human brain processes sensory information successively and simultaneously. He differentiated these processes in his volume, The Elements of Thought (1878), (Das, Kirby & Jarman, 1979). Sechenov extended the sensory psychologist's premise that sensation was the basis for thought by stating that sensation itself is organized by an individual's psychological structure (Das, et al., 1979). He proposed that stimuli, upon reception, are analyzed regarding their sensory qualities and then synthesized by successive and simultaneous processing (Das, et al., 1979). Sechenov proposed the cortical areas for vision and kinesthesis as the basis for a spatial organization of sensation and auditory and motor areas as the basis for
a temporal organization of sensation (Das, et al., 1979). For Sechenov, simultaneous processing was closely allied to visions and touch while successive processing was closely allied to hearing and movement (Das, et al., 1979).

The work of Sechenov was extended by Alexander Luria. Luria (1966a, 1966b) used a method referred to as syndrome analysis in his clinical work with brain damaged individuals. Through a careful analysis of an individual's performance on a wide variety of tasks, Luria was able to discriminate a pattern of performance suggesting an underlying functional organization of the brain.

Luria (1970) proposed three functional units within the human brain and labeled these areas Block I, Block II, and Block III. Luria (1970) noted that Block I controlled arousal and regulated cortical tone and waking. Block II was noted to be involved with the coding and storage of information via simultaneous and successive coding processes (Luria, 1970), while Block III was said to be involved with the planning and organization of behavior (Luria, 1970).

Das and colleagues (Das, et al., 1979) have used factor analytic methods to corroborate and extend Luria's work. Das, et al. (1975, 1979), have demonstrated the feasibility of a model of information processing based on Luria's clinical work. Their model encompasses all the functional areas delineated by Luria including arousal, planning, and coding (successive and simultaneous). Their factor analytic studies have provided evidence for the construct validity of these functional units especially successive and simultaneous coding (Das, et al., 1979).
The primary focus of the early research of Das and his colleagues (Das, 1972; Das, et al., 1975, 1979) was Block II or successive and simultaneous coding. The constructs of simultaneous and successive coding have been differentiated by Das and colleagues a number of times (Das, et al., 1975, 1979; Naglieri & Das, 1986, in press). Successive processing is noted to be temporal in nature. Stimuli are serially ordered such that each element is related only to the next. It is not possible to survey all the elements at once in their entirety. This is contrasted to simultaneous processing which is quasi-spatial in nature. Stimuli are integrated into groups in which each element is related to every other element. The group is surveyable all at once in its entirety.

Luria's Block III, the planning unit, received limited attention in the early factor analytic studies of Das, et al (1975, 1979). Das (1984d) noted the planning unit to be involved in the generation, selection, and execution of plans as well as the evaluation of one's own and other's behavior and responses based on that evaluation.

Das and colleagues have addressed Luria's Block I, the arousal unit, in their model although research on this unit within the model has been limited (Das, et al., 1975, 1979). Arousal is noted to be a nonspecific state of alertness having to do with wakefulness and cortical tone (Naglieri & Das, 1985). Das, et al. (1979) have especially stressed the importance of the interaction of the planning and coding units with the arousal unit.

While the accumulated research of Das and his colleagues has provided evidence for the constructs of successive and simultaneous coding
and planning, it has also raised questions which have suggested the direction for further research. This study is designed to address several of these questions.

A review of the research to date notes many studies which have examined the construct validity of the S-S-P model. Tasks used in these studies have varied with regard to cognitive level, mode of presentation, manner of expression, and item content. Many of these studies, however, have used the same or similar tasks. Would the inclusion of a greater number and variety of tasks continue to support the constructs of successive-simultaneous coding and planning? This study will address the issue of construct validity using a wider variety of tasks selected to be representative of cognitive level, mode of presentation, manner of expression, and item content.

An additional aim of this study is to explore the relationship of successive and simultaneous coding and planning to reaching achievement. Research has suggested that the factors correlate to overall academic achievement (Das, et al., 1979; Das, 1986). There is evidence which suggests that, at the early levels of reading or with disabled readers, successive coding has a greater influence on reading decoding than does simultaneous coding (Cummins & Das, 1977; Das & Snart, 1982). At the more advanced levels of reading, there is evidence suggesting that simultaneous coding has a greater influence on reading comprehension than does successive coding (Cummins & Das, 1977; Das & Snart, 1982; McLeod, 1978; Robinson, 1983). The relationship of successive and simultaneous coding and planning to reading is not well established. Is one factor more influential than the others? Are the factors differentially
related to reading decoding and comprehension? Are various aspects of reading comprehension, such as literal and inferential comprehension, more influenced by one factor than another? These questions are addressed in the present study in an effort to more thoroughly understand the relationship between reading achievement and successive and simultaneous coding and planning.
CHAPTER II
REVIEW OF THE LITERATURE

An Overview of the Model
A. R. Luria

Luria worked extensively with brain damaged individuals using a method he called syndrome analysis. Through analysis of an individual's performance on a wide variety of tasks, Luria was able to determine a pattern of performance suggesting an underlying functional organization of the brain. Luria stated that, "the presence of a primary defect, interfering with the proper function of a given part of the brain, inevitably leads to disturbances of a group of functional systems, i.e., to the appearance of a symptom-complex, or syndrome, composed of externally heterogeneous but, in fact, internally interconnected symptoms." (Luria, 1966a, p. 83).

It was not Luria's purpose, however, to correlate an individual's performance to specific structural damage in their brain. Luria's contention was that the focus, especially in understanding the higher cortical functions of man, should be on the functional organization of the brain rather than its structural organization (Luria, 1970).

Luria proposed three functional units for the brain and labeled these Block I, Block II, and Block III. Further, each of these functional units was divided into three distinct cortical zones, layered
one upon the other, in an hierarchical structure. These zones controlled the functions of each of the three Blocks and were labeled the projection zone (primary), projection-association zone (secondary), and the overlapping zone (tertiary).

Luria (1970) noted Block I to be comprised of subcortical structures including the thalamus, hypothalamus, and brain stem, including the reticular formation. This Block was said to control arousal and to regulate cortical tone and waking.

Block II was comprised of areas posterior to the central gyrus, including the occipital, parietal, and temporal lobes (Luria, 1970). It was noted to be involved with the coding and storage of information via simultaneous and successive processes (Luria, 1966a).

Block III (Luria, 1970, 1966a) was said to be comprised of those areas anterior to the precentral gyrus, most specifically the frontal lobes and especially the prefrontal areas. Luria proposed that the frontal lobes were involved with the planning and organization of behavior. It was here that plans are generated, selected, executed, and evaluated. Such characteristically human abilities as decision making, goal setting, judgment, and intention are associated with Block III (Das, et al., 1979).

J.P. Das and Colleagues

Das, et al. (1975, 1979) have used factor analytic methods to corroborate and extend Luria's clinical work. Das, et al. (1979) have used the results of their factor analytic studies in an explanatory rather than taxonomic manner. While Das, et al. (1979) have generally
used exploratory factor analyses, they note that their research is con-
firmatory in the sense that factor analytic studies confirm the clinical
work of Luria. Luria noted the compatibility of syndrome analysis and
factor analysis by stating, "Syndrome analysis, concerned with the fac-
tual pathology of higher mental functions, can be regarded as a legiti-
mate variant of factor analysis, the only difference being that syndrome
analysis is directed toward the investigation of the organization of
mental processs in a single subject." (Luria, 1966a, p. 84).

Das, et al. (1975, 1979) have demonstrated the feasibility of a
model of information processing based on Luria's clinical work. Their
model encompasses all the functional areas delineated by Luria includ-
ing arousal, planning, and successive-simultaneous coding. While the
work of Das and his colleagues has provided support for the construct
validity of the three functional units, Das and others (Das, 1984c;
Naglieri & Das, 1986, in press) have emphasized the integral relation-
ship which exists between these units. An understanding of any one of
the units is incomplete without a thorough understanding of how it in-
fluences, and is influenced by, the remaining units. To focus on any
one area of the exclusion of the others, is likely to result in simpli-
ification of human functioning.

Das (1984a) has elaborated several characteristics of successive
and simultaneous coding. He notes that successive and simultaneous
coding occur at each of the three levels of cognition including percep-
tion, memory, and conception. Further, successive and simultaneous
coding are not hierarchical (Das, 1984a). Successive coding may appear
earlier than simultaneous coding, but this does not imply that the
development of successive coding is necessary for the development of simultaneous coding (Das, 1984c). By age 8, or the third grade, both processes have developed sufficiently as to be equal (Das, 1984c).

Das (1984a) also notes that any one task may be approached using either successive or simultaneous processing, depending upon an individual's competencies regarding the two processes, their preference for one or the other of the processes when competent with both, and the requirements of the task. Further, the use of either one of the coding processes is not dependent on the form of sensory reception or motor expression (Das, 1984a). Thus, either successive or simultaneous processing could be used to process the information of a task regardless of whether the information is presented visually or auditorally or expressed verbally or nonverbally.

Das (1984a) notes that an appropriate assessment of an individual's use of the coding processes would assess the use of these processes at each of the three levels of cognition (perceptual, conceptual, memory), across sensory modalities (visual, auditory), and across other known dichotomies (verbal, nonverbal).

While Luria's Block III, or planning unit, received limited attention in the early factor analytic studies of Das, et al. (1979), it has recently been the focus of a number of studies (Ashman & Das, 1980; Das & Heemsbergen, 1983; Das & Dash, 1983; Snart, O'Grady & Das, 1982; Snart & Swann, 1982).

Das (1984d) notes that planning has three aspects: structure, process, and a knowledge base. Structure refers to the cortical area typically associated with planning activities. Luria (1966a) has noted the
frontal lobes, especially the prefrontal areas, as the cortical areas for planning. The process of planning underlies those activities typically associated with planning. Das (1984d) noted the planning unit to be involved in the generation, selection, and execution of plans as well as the evaluation of one's own and other's behavior. The knowledge base consists of information gained from experience and coded; properly analyzed, synthesized, and stored. As with the coding processes, Das, et al. (1979) have noted planning to occur at each of the three cognitive levels.

The interrelatedness of the planning unit with the coding and arousal units is stressed in the model (Das, 1984b; Naglieri & Das, 1986, in press). Das has noted, "Without coded information, planning is empty, and in the absence of a plan, information coding is blind." (Das, 1984a, p. 36). Further, an appropriate state of arousal, neither too much nor too little, is needed before planful behavior is possible. Naglieri & Das state, "Selectively inhibiting arousal is one of the important functions of the third functional unit which is associated with planning." (Naglieri & Das, 1986, in press, p. 10).

Das and colleagues have addressed Luria's Block I, the arousal unit, in their model although research on this unit within the model has been limited (Das, et al., 1979). Das, et al. (1979) have especially stressed the important interaction of the planning and coding units with the arousal unit. They have stated, "Inappropriate arousal interferes with attentional processes, affects the processing which occurs in Block III, and can produce deficiencies in the planning functions of Block III." (Das, et al., 1979, p. 43).
Arousal is not equated with attention in the model. Arousal is a nonspecific state of alertness having to do with wakefulness and cortical tone whereas attention is specifically directed to objects or ideas (Naglieri & Das, 1986, p. 5, in press). There is, as such, an integral relationship between the two concepts since a low level of arousal would prohibit a high level of attention.

The body of research on successive and simultaneous coding and planning processes as conceptualized within the information processing model proposed by Das, et al. (1975, 1979) has been gathered in slightly more than a decade beginning with Das’ article of 1972 (Das, 1972). A review of this literature reveals a number of tasks to have been included in the factor analytic research relevant to the model.

**Successive Processing**

(Das, Leong & Williams, 1978), and Memory for Words (Naglieri, Kaufman, Kaufman & Kamphaus, 1983). A brief review of each of the above-named tasks is included in Appendix A.

Das (1984c) noted that a comprehensive assessment of the coding processes requires that the tasks used occur at each of the three levels of cognition (perception, conception, memory) and vary regarding their mode of presentation (visual, auditory) and manner of expression (verbal, nonverbal). A review of the tasks specified above found tasks presented visually (Visual Short-Term Memory, Hand Patterning) as well as auditorially (Serial and Free Recall, Digit Span Forward, Cross-Modal Coding, the Auditory subtest of the ITPA, Dichotic Listening, and Memory for Words). Further, variation was found regarding the expression required by the above tasks as several required verbalization (Serial and Free Recall, Digit Span Forward, the Auditory Memory subtest of the ITPA, Dichotic Listening) and several required nonverbal expression (Visual Short-Term Memory, Cross-Modal Coding, Hand Patterning, Memory for Words).

A review of these tasks in regard to cognitive level, however, revealed that few tasks have been studied which assess successive coding at the cognitive levels of perception and conception. Each of the above tasks, with the exception of Dichotic Listening and Cross-Modal Coding, requires successive processing at the cognitive level of memory. Cross-Modal Coding and Dichotic Listening are tasks which have been studied and proposed to occur at the level of perception.

Cross-Modal Coding, as studied by Das (1972, 1973) and Das & Molloy (1975), was conceived as a task requiring successive processing.
at the perceptual level. The research on this task, however, yielded many different results and it appears that the processing of this task is influenced by a number of variables.

Das (1972) found the information of this task to be processed simultaneously by a nonretarded sample while a retarded sample obtained a split loading of .546 and .482 for the simultaneous and successive factors respectively. A later study (Das, 1973), however, found almost equal loadings for this task on successive (.457), simultaneous (.433), and speed (.423) factors using a mixed sex sample of Caucasian children with average intelligence. In contrast, the same study found that a sample of Indian children of similar age and intelligence obtained a factor loading of -.640 for the speed factor and .233 and .206 for the successive and simultaneous factors respectively. Das & Molloy (1975) found that for their population of grade 1 and grade 4 boys of average intelligence and mixed social economic level (SES) the only factor on which Cross-Modal Coding loaded significantly was the simultaneous factor. These studies indicate that Cross-Modal Coding is not a task which has loaded consistently higher on the successive factor versus other factors.

The Dichotic Listening tasks (Das, Leong & Williams, 1978) loaded significantly on the successive factor with loadings of .753 for Sides and .800 for Types. This study, however, is the only one to have included dichotic listening tasks in their factor analysis.

Tasks assessing successive processing at the conceptual level have not been extensively studied. Much of the research on successive processing at this level has involved the function of language. Luria
(1966b) claimed that successive processing is involved in the organization and understanding of narrative speech. He divided language constructions into two groups including contextual grammatical structure and communication of relationships (Luria, 1966b). Contextual grammatical structures relate to syntactic structure involving predicate forms and were noted by Luria (1966b) to be coded successively.

Cummins (1979), based on the work of Jakobson (1971), distinguished these two classes of language construction as syntagmatic and paradigmatic relationships between words. Syntagmatic relationships involved noun-verb relationships such as boat-sail while paradigmatic relationships involved noun-noun or class and category relationships such as boat-ship.

A task used by Cummins (1979) to study the relationship of logico-grammatical language structures to simultaneous-successive processing was Sentence Ambiguities. This was a 12 item test taken from Kessel (1970). It assessed a child's understanding of ambiguities based on lexical, surface, and underlying sentence constructions. Cummins (1979) found a significant loading on the successive factor for ambiguous sentences involving surface structure and underlying structure constructions. Ambiguous sentences involving lexical structure loaded significantly on the simultaneous factor.

This review provides support for Das, et al.'s (1975, 1979) contention that coding and planning processes operate across modality, cognitive level, and dichotomies such as verbal/nonverbal. Tasks obtaining their highest loading on the successive factor have varied with regard to mode of presentation (visual, auditory), manner of expression
(verbal, nonverbal), and cognitive level (conceptual, perceptual, memory). Tasks operating at the cognitive level of memory have been more frequently used in the research than tasks operating at the perceptual and conceptual levels of cognition.

Simultaneous Processing


Other tasks, less frequently studied but also found to load significantly higher on the simultaneous factor than on other factors, include Spatial Relations (Kirby & Das, 1978), Card Rotations (Kirby & Das, 1978), WISC-R Block Design (Naglieri, Kaufman, Kaufman & Kamphaus, 1983), Figure Copying (Kirby & Das, 1978), Overlapping Design (Naglieri, et al., 1983), Triangles (Naglieri, et al., 1983), Word Grouping (Kirby & Das, 1978), ITPA Visual Memory (Das, Leong & Williams, 1980), Concept Formation (Naglieri, et al., 1983), Memory for Places (Naglieri, et al., 1983), Short-Term Visual Memory (Das, 1972), and Cross-Modal Coding (Das, 1972, 1973; Das & Molloy, 1975). A brief description of each of these tasks is presented in Appendix B.
Of the three most frequently studied tasks, simultaneous processing operates at the conceptual level of cognition on the information of the Raven's Progressive Matrices, at the perceptual level on the Figure Copying task, and at the level of memory on the Memory for Designs Test. The less frequently studied tasks are also representative of the cognitive levels with simultaneous processing noted to occur at the conceptual level (Spatial Relations, WISC-R Block Design, Figure Grouping, Overlapping Design, Triangles, Word Grouping, Concept Formation), perceptual level (Cross-Modal Coding, Card Rotations), and at the level of memory (ITPA Visual Memory, Memory for Places, and Short-Term Visual Memory). The tasks found to load highest on the simultaneous factor provide the opportunity for a more comprehensive assessment of simultaneous processing than the tasks which have loaded highest on the successive factor.

A review of these tasks with regard to mode of presentation finds a predominance of visually presented tasks. Each of the three most thoroughly studied tasks, Raven's Progressive Matrices, Figure Copying, and Memory for Designs, are visual in their presentation. Of the remaining tasks, only Cross-Modal Coding involves an auditory component. Further, the majority of the tasks are nonverbal in nature with lesser language involvement than is evident for the tasks reviewed under successive processing. This predominance of visual, nonverbal tasks might be expected given the quasi-spatial nature of simultaneous processing (Das, et al., 1975, 1979). It does not, however, permit the comprehensive assessment of simultaneous processing stressed by Das (1984c).
There are a number of language tasks in the literature for which there is evidence of simultaneous processing. As noted previously, Luria (1966b) divided language constructions into contextual grammatical constructions and communication of relations. He proposed that the communication of relationships largely involves simultaneous processing (Luria, 1966b). These relationships are typically quasi-spatial in nature such as prepositional relationships, e.g., above, near, or spatial comparisons, e.g., taller than, farther than.

Cummins (1979), based on the work of Jakobson (1971), researched syntagmatic and paradigmatic relationships between words. Jakobson (1971) worked with aphasics experiencing either similarity or contiguity disorders. Similarity is related to paradigmatic relationships, e.g., plane-jet, while contiguity is related to syntagmatic relationships, e.g., plane-fly. These concepts are noted by Cummins (1979) to be similar to Luria's distinctions between nominative and predicative speech.

Cummins (1979) found evidence to support the involvement of simultaneous processing when children were required to make paradigmatic associations to words. A well documented shift from syntagmatic to paradigmatic word associations occurs between the ages of 6 and 9 (Cummins, 1979). As such, children more adept with simultaneous processing would be expected to give a higher rate of paradigmatic associations than children less adept with simultaneous processing.

Cummins' (1979) research provided further evidence for the involvement of simultaneous processing with language tasks. He found that while successive processing was related to understanding surface and
underlying language ambiguities, simultaneous processing was involved in understanding lexical (single word) ambiguities, e.g., "The boy picked up the bat," referring to either a baseball bat or flying bat. These relationships were predicted by Luria's work on nominative and predicative speech functions.

Cummins (1979) also found evidence that simultaneous processing is involved with the Piagetian task of Class Inclusion. In this task, children were asked questions such as, "In the whole world, are there more animals or more cows?" Questions of this type require an understanding of superordinate and subordinate classes. These relationships are quasi-spatial in nature and related to Juria's concept of communication of relationships.

Reviewing the work of Cummins and Luria, it is apparent that simultaneous processing, while quasi-spatial in nature, operates on information presented auditorily as well as visually and on verbal items as well as nonverbal items.

The above review found that tasks obtaining their highest loadings on the simultaneous factor varied regarding mode of presentation, manner of expression, and cognitive level. While visual, nonverbal tasks have been more frequently used in the research, verbal tasks received auditorially have also been found to measure simultaneous processing.

Planning

Several tasks have been used by Das and colleagues and found to load highest on the factor labeled planning. Ashman & Das (1980), in an initial study which included the successive-simultaneous and planning factors, found the Trial Making Test and the Visual Search, Verbal
Fluency, and Planned Composition tasks to obtain their highest loadings on the planning factor. Several subsequent studies also found these tasks to load highest on the planning factor. The Trail Making Test was included in studies by Snart, O'Grady & Das (1982), Snart & Swann (1982), Das & Heemsbergen (1980), and Kirby & Ashman (1984). Visual Search was used in studies by Snart, O'Grady & Das (1982), Snart & Swann (1982), and Heemsbergen (1980), and Word Fluency in studies completed by Snart, O'Grady & Das (1982), Snart & Swann (1982), and Kirby & Ashman (1984). A brief description of these tasks is included in Appendix C.

While the three tasks of Trail Making, Visual Search, and Verbal Fluency represent the most frequently studied tasks, other tasks have been found to load significantly on the planning factor. Ashman (Ashman & Das, 1980) found that a Planned Composition task loaded significantly on the planning factor while Kirby & Ashman (1984) found the Mazes task and Matching Familiar Figures Test to load significantly on the planning factor. Descriptions of these tasks are included in Appendix C.

Heemsbergen (Das & Heemsbergen, 1980) extended the basic factor analytic findings of Ashman (Ashman & Das, 1980) and related the marker tasks of Trail Making, Visual Search, and Verbal Fluency to another task, Syllogistic Reasoning. Syllogistic Reasoning consisted of four sets of eight, three term syllogisms. The sets were distinguished by the operations needed to solve the syllogisms, e.g., whether the premises needed to be converted or reordered. Each set contained a similar type of syllogism. Heemsbergen (Das & Heemsbergen, 1980) found that the time required to complete this task loaded on the planning factor.
while total number of correct responses did not. He noted that this was likely due to how quickly an individual realized that all the problems in a given set were of the same type and that each set differed from the others regarding the operation needed to solve the syllogisms. He noted this to be due to the possible influence of good planning.

Heemsbergen (Das & Heemsberger, 1980) also hypothesized that individuals who were determined to be good or poor planners based on their performance on one of the marker tasks of planning (Visual Search) would perform differentially on a task which required strategy development. The game selected was mastermind. Heemsbergen found that those individuals who performed adeptly on the Visual Search task also performed well at Mastermind while those who had difficulty with the Visual Search tasks also had difficulty with Mastermind.

Kirby & Ashman (1984) included a number of tasks other than those discussed above. The tasks were taken from various areas of research including memory and metacognition and it was hypothesized that the tasks would cluster forming a common planning factor. Kirby & Ashman (1984) found four separate factors, however, which they termed selective attention, rehearsal, clustering, and metacognition. The selective attention factor included the Trial Making, Visual Search, and Verbal Fluency tasks previous studies had found to cluster forming a separate factor. Kirby & Ashman conclude that planning is multidimensional, consisting of at least three qualitatively different domains, function-specific strategies (Rehearsal and Clustering factors), Metacognition, and Selective Attention (Kirby & Ashman, 1984, p. 17).
The above review provides evidence for a third factor, planning, in addition to the successive and simultaneous factors. Tasks loading on the planning factor varied regarding mode of presentation, manner of expression, and level of cognition.

Successive-Simultaneous Coding, Planning, and Reading Achievement

As the factor analytic evidence for successive-simultaneous coding and planning has accumulated, recent research has begun to study the relationship between these cognitive factors and academic achievement. Initial studies established the distinctiveness of successive, simultaneous, and planning factors from an achievement factor. Subsequent studies correlated factor scores for the cognitive processing tasks to various measures of achievement. Additionally, there have been remedial studies which have sought to establish a link between achievement and the cognitive factors via training programs. While the literature addresses achievement in many areas, this review will focus on reading achievement and successive-simultaneous and planning cognitive processes.

Das (1973), Krywaniuk (1974), and Das and Molloy (1975) found that, when assessments of academic achievement were included with the tasks designed to assess simultaneous and successive coding, they formed a separate factor. Das, et al. (1979) have described this factor as Vernon's verbal-educational factor. Group administered intelligence tests, such as the Lorg Thorndike, also grouped on this factor attesting to the variance shared by achievement tests and group administered tests of intelligence. The formation of this factor is expected (Das,
et al., 1979) since the assessments of academic achievement and intelligence have more in common with one another than with the tasks assessing the coding processes. They frequently shared a similar format and skills largely learned in school. Subsequent studies were designed to explore the relationship between various measures of achievement and successive-simultaneous coding and, more recently, planning.

Kirby and Das (1977) established the general procedure used to study the relationship of successive, simultaneous, and planning factor scores and various tests of achievement. Briefly, Kirby and Das administered, to a group of fourth grade students, tasks designed to assess successive-simultaneous coding and measures of reading vocabulary and comprehension (the Gates-MacGinitie Reading Test). The successive-simultaneous tasks were factor analyzed and two distinct factors, successive and simultaneous coding, were obtained. Factor scores were then derived for each child and the total group was divided into four groups by use of median scores. The four groups formed included high simultaneous-high successive, high simultaneous-low successive, low simultaneous-high successive, and low simultaneous-low successive.

The analysis of variance indicated a strong main effect for successive-simultaneous coding. Those children in the high simultaneous-successive group scored highest on the reading tests while those in the low simultaneous-successive group score lowest. Children with high scores in only one of the coding areas obtained scores in between the other groups. Kirby and Das (1977) concluded that both successive and simultaneous coding were important for reading achievement.
Leong (1980) studied the factor structure for grade two children he had divided into above average and below average readers. He found that the factor structure for the two groups was significantly different using traditional successive-simultaneous tasks. His results were similar to those of Kirby and Das (1977) in that the below-average readers had less well-developed skills of both successive and simultaneous coding than did the above-average readers. Leong noted, however, that this processing deficiency was especially true as regards successive coding.

A series of studies by Das and Cummins provided interesting results with regard to the differential relationship between successive and simultaneous coding and academic achievement. Cummins and Das (1977) studied a group of Educable Mentally Retarded (EMR) children. Pearson Product-Moment Correlations between successive and simultaneous factor scores and achievement and I.Q. variables indicated that the simultaneous factor correlated significantly with WISC-R Performance I.Q. and the Arithmetic subtest of the Wide Range Achievement Test (WRAT). The successive factor correlated significantly with Spelling and Word Recognition subtests of the WRAT and the Verbal I.Q. of the WISC-R.

Das and Cummins (1978), also using a population of EMR children, found the simultaneous factor score to correlate significantly with the WISC-R Perceptual Organization and Freedom from Distractability factors as well as the WRAT Arithmetic subtest. The Successive factor score significantly correlated with the WISC-R Verbal factor and the Spelling and Word Recognition subtests of the WRAT.
Cummins and Das (1977) concluded that successive coding may be more important for acquiring the decoding skills important in the early stages of learning to read for EMR populations. They indicated, however, that simultaneous coding would be expected to exert a greater affect at more advanced levels of reading due to its importance in the understanding of logico-grammatical relationships.

Cummins and Das (1977) found significant main effects for simultaneous coding in both decoding and comprehension in a population of third-grade students. A main effect for successive coding was not found, however, in contrast to the Kirby and Das (1977) study with fourth graders. Das, et al. (1979) suggest that these differences may be due to different criterion measures of reading or the discrepant I.Q.'s of the two populations studied.

In order to test the hypothesis that simultaneous coding is more important at advanced reading levels, Cummins & Das (1977) further divided the children into high and low groups for reading decoding and comprehension. They found that simultaneous coding correlated significantly with reading comprehension for the high group in comprehension but not the low group. No relationship was found for the high and low groups in decoding. They conclude that simultaneous coding may be more important at advanced stages of reading as decoding skills are mastered and comprehension requirements increase.

McLeod (1978) divided 40 fourth grade children into four groups also using the split median procedure. He found a significant main effect for simultaneous coding but not for successive coding. This finding was consistent with that of Cummins and Das (1977), but, again
contrasted with the Kirby and Das (1977) study which found significant main effects for both successive and simultaneous coding. Das (1985) notes, however, that all the children in the McLeod study had reading vocabulary above the 70th percentile. Thus, reading decoding skills may play a limited role in reading comprehension at this level. This supports the role of successive coding in younger, disabled, or early readers (Leong, 1980; Cummins and Das, 1977) where decoding skills are being developed. At more advanced reading levels, decoding skills are largely mastered and their effect on reading comprehension is consequently limited. For children possessing an adequate reading vocabulary relative to the level of their instructional material, simultaneous processing plays the greater role.

McLeod (1978) also studied the relationship between the coding processes and the ability to make inferences from a given text. He was specifically interested in two types of inferencing, forward and backward. Briefly, McLeod found that children possessing a high level of simultaneous processing produced significantly more inferences than children possessing high levels of successive processing. He found significant main effects for simultaneous processing for forward inferences and significant main effects (negatively related) for successive processing and backward inferences. Children with low successive processing ability had increased difficulty with backward inferencing. Inasmuch as inferencing correlates with reading comprehension, this study supports the more important role of simultaneous coding versus successive coding in reading comprehension.
Das and Snart (1982) studied the relationship between reading achievement and successive-simultaneous coding and planning using groups of normal and disabled readers at the fourth and sixth grade levels. They divided their population into normal readers at the fourth and sixth grade levels, disabled fourth grade readers reading at a second grade level, and disabled sixth grade readers reading at the fourth grade level. Market tasks for successive-simultaneous coding and planning were given to all children and factor scores were correlated with measures of reading achievement. All the tasks discriminated normal readers from disabled readers in both the fourth and sixth grades. Normal readers scored significantly higher on all tasks than did disabled readers of the same chronological age providing evidence for the importance of successive-simultaneous coding and planning to reading achievement.

Das & Snart (1982), found significant correlations between decoding scores and the simultaneous and planning market tasks with grade four normal readers and between decoding scores and the successive, simultaneous, and planning market tasks for normal sixth grade readers. Comprehension scores did not correlate with the successive marker asks as either grade level. Comprehension scores did correlate with simultaneous and planning market tasks at both grade levels. Das and Snart concluded, as had Cummins and Das (1977), that successive coding has a greater effect on decoding scores at the lower grade levels or early levels of reading, while simultaneous coding has a greater effect on comprehension at any grade level. The correlation between decoding and the marker tasks for successive coding at grade six, however,
suggests that successive coding may also be important for decoding at higher levels of reading.

Gordon (1982) examined the relationship of successive-simultaneous coding and reading comprehension in third, fourth, fifth, and sixth graders. He did so by altering the type of presentation of reading material, e.g., passages were presented either in a normal, canonical format or in a mixed form -- one word at a time, in inappropriate chunks, or in chunks obeying rules of syntax. He divided the students into three groups -- good, poor, average -- based on their reading comprehension scores. He found significant main effects for both the successive and simultaneous factor scores. Closer analysis revealed that children high in both successive and simultaneous coding ability scored higher on the comprehension test regardless of the type of presentation than did those in other groups. No special relationships between reading comprehension and successive and simultaneous coding were found. The general conclusion drawn was similar to that of Kirby & Das (1977) as the authors indicate that both coding processes are important for reading comprehension.

Robinson (1983), used disabled readers and found simultaneous coding to be more closely correlated with semantic aspects of language while successive coding was more related to syntactic aspects of language. When the focus was shifted from language to reading processes, however, he found that simultaneous coding correlated to prediction of language patterns as well as the ability to recognize the meaning of whole words. Successive coding failed to relate to any of the reading process factors. Thus, simultaneous coding was associated with reading
comprehension is disabled readers while successive coding was not. Das (1985) notes that reading disabled children may contribute to their dis-ability in that they do not use more effective successive coding pro-
cesses at the early levels of reading where decoding skills seem to play
a more important role.

Ramey (1985) extended the above studies by including the planning
factor with the successive and simultaneous factors. He used the median
split procedure which resulted in eight groups. Factor scores were cor-
related with tests of reading vocabulary and level and speed of reading
comprehension using Junior High school students were used. Ramey (1985)
found significant main effects for successive-simultaneous coding and
planning and each of the three reading tests. Differences were noted,
however. The successive coding main effect was significant for speed
of comprehension while neither simultaneous coding or planning were.
Simultaneous coding and planning had significant main effects for level
of comprehension while successive coding did not.

Summary

The above studies suggest that overall reading achievement is de-
pendent on the development of both successive and simultaneous coding
(Kirby & Das, 1977; Leong, 1980; Gordon, 1982; Das & Snart, 1982). There
is also evidence for the importance of planning and reading achievement
(Ramey, 1985; Das & Snart, 1982). The literature further suggests that
successive coding may play a greater role in reading decoding particu-
larly in the early stages of reading or with disabled readers (Cummins &
Das, 1977; Leong, 1980; Das & Snart, 1982), while simultaneous coding
plays a greater role with regard to reading comprehension especially at the more advanced levels of reading (Cummins & Das, 1977; McLeod, 1978; Das & Snart, 1982; Robinson, 1983; Ramey, 1985). It is apparent, however, that the relationships between successive-simultaneous coding, planning, and reading achievement are complex and more research is needed to further clarify these relationships.
Rationale and Hypotheses

Past factor analytic research has consistently yielded a dichotomy of factors termed successive and simultaneous by Das, et al. (1975, 1979). More recently a third factor, planning, has also been found to consistently emerge forming a three factor structure of successive and simultaneous coding and planning (Das, 1985).

A review of this research reveals some restriction in the number and variety of tasks used. Much of the research has utilized the same tasks, or modified versions of these tasks, in establishing the three factor structure. This has had the advantage of establishing market tasks for each factor, but further operationalization of the Luria/Das model is warranted. This study has been designed to address the validity of the three factor structure of successive and simultaneous coding and planning by using less studied tasks in addition to tasks well represented in the literature. The tasks will be varied according to language and non-language content and will be more diverse according to the three levels of conception, perception and memory.

The general question to be addressed in this study is, therefore: Will the three factor structure of successive and simultaneous coding
and planning found in previous studies emerge with a wider variety of tasks.

Recently there has been an interest in the relationship of successive-simultaneous coding and planning to academic achievement. The results of this research have been varied although there seems to be general support for a strong correlation between development of successive-simultaneous coding and planning and academic achievement. More specific to reading achievement, there is evidence which suggests a greater role for successive coding at the early stages of reading where decoding skills play a more important part and for simultaneous coding and planning at more advanced levels of reading where comprehension is emphasized and decoding skills are largely mastered. The role of planning in reading achievement has received limited attention, but needs to be included to gain a more comprehensive knowledge of the relationship of successive-simultaneous model and reading achievement.

A second purpose of this study is to further explore the apparently complex relationships between successive and simultaneous coding, planning, and reading achievement particularly reading comprehension. This study will examine the relationship of successive and simultaneous coding and planning to reading vocabulary (word recognition) and two components of reading comprehension, inferential and literal comprehension. The general question to be addressed is, therefore: What is the relationship between successive-simultaneous coding and planning with reading achievement as assessed by measures of work recognition and reading comprehension?
Subjects

A sample of 120 fourth grade students was used from the Mt. Vernon City School District in Mt. Vernon, Ohio. The students were taken from two classrooms in the East elementary building, one classroom at the Elmwood elementary building, three classrooms at the Pleasant Street elementary building, and two classrooms at the Dan Emmett elementary building. The mean age was 119 months and nonverbal intelligence, as assessed by the MAT-EF, was 92 with a standard deviation of 11. The students came from predominantly white, middle income families residing in a small town in a rural part of central Ohio.

Permission to test was obtained from the superintendent of the school system. Parent permission was obtained for each student before they were included in the study.

Procedures

Each of the students was administered each of the 14 tasks according to administration criteria specified in the appropriate manuals. All tasks with the exception of the Stanford Diagnostic Reading Test were administered individually in a quiet, appropriate room in the school building where the child normally attended school. Individual test time was approximately 60 minutes. The Stanford Diagnostic Reading Test was administered to groups of 20 to 25 students and time required for test administration was 30 minutes.

The individually administered tasks were grouped according to the factor on which they were most likely to load, successive or simultaneous coding or planning. These factor groups were to be administered
in counterbalanced format, e.g., Successive-Simultaneous-Planning; Planning-Successive-Simultaneous; Simultaneous-Planning-Successive; etc. The word recognition reading test was administered at the end of each session. All tasks were administered by two individuals trained prior to task administration.

Task Description

Simultaneous Tasks

Matrix Analogies Test-Expanded Form

This is a standardized, individually administered test developed by Naglieri (1985) as a measure of nonverbal ability. The task requirements of the MAT-EF are similar to those of Ravens' Progressive Matrices (Ravens, 1956). Ravens' matrices have been used as a marker task for simultaneous processing by Das, et al. (1979). This task has consistently loaded highest on the simultaneous factor in the factor analytic literature (Das, 1972, 1973; Das & Molloy, 1975; Das, Leong & Williams, 1978; Kirby & Das, 1977, 1978; Jarman, 1978; Naglieri, Kaufman, Kaufman & Kamphaus, 1980).

The MAT-EF consists of 64 abstract designs, 16 each within four item groups, Pattern Completion, Reasoning by Analogy, Serial Reasoning, and Spatial Visualization. These item groups are the result of factor analytic study during test development and standardization. Each item is presented in the standard matrix format with the individual required to choose the correct element for the final matrix from several choices (5 or 6). The test was administered using procedures and scoring criteria specified in the manual (Naglieri, 1985).
Figure Memory

This task was developed by Naglieri and Das (1985) to assess simultaneous coding at the cognitive level of memory. It is similar in task demands to Graham and Kendell's Memory-for-Designs Test (1960) although there is an additional figure-ground element similar to that of the Embedded Figures Test. The Memory-for-Designs Test has been used as a market task for simultaneous coding by Das, et al. (1979). This task has consistently loaded highest on the simultaneous factor in the factor analytic research (Das, 1972, 1973; Das & Molloy, 1975; Das, Leong & Williams, 1978; Kirby & Das, 1977, 1978; Ashman & Das, 1980; Das & Jarman, 1981; Jarman, 1978).

The Figure Memory task consists of 15 different designs progressing in difficulty from simple shapes to three dimensional drawings. The stimulus design is exposed to the child for 5 seconds and the child is then presented with a stimulus field of lines and overlapping shapes. The child is required to find the original stimulus figure and to trace over it with a colored pen. Administration procedures and scoring criteria used in this study were developed by Naglieri and Das (1985).

Block Design

This task is taken directly from the Wechsler Intelligence Scale for Children-Revised (WISC-R) (Wechsler, 1974). It is similar in its task demands to several tasks used to assess simultaneous coding, e.g., Koh's blocks as used by Luria (1966), the Triangles subtest of the Kaufman Assessment Battery for Children (Kaufman & Kaufman, 1984). It loaded highest on the simultaneous factor in a cross-validation study.
by Naglieri, et al. (1983). Block Design is expected to assess simultaneous coding at the cognitive level of conception.

The Block Design subtest consists of 11 abstract designs which the child is required to reproduce using 4 and then 9 blocks. Each block has two solid red and two solid white sides and two sides which are both red and white with the resulting shapes being triangular. The designs increase in complexity from relatively simple, 4-block designs to more complex designs requiring 9 blocks to complete. Only the odd numbered designs were used, however, starting with item 3 and progressing to item 11 unless the discontinue criterion is met. Item 1 was used as needed (per administration procedures). This task was administered using procedures and scoring criteria specified in the manual (Wechsler, 1974).

**Tokens**

This task was developed by Naglieri and Das (1985) to assess simultaneous coding using a language task with minimal demands on memory (each item can be repeated as specified in the administration procedures). The task is expected to involve simultaneous processing since it requires a child to grasp and hold as a whole a series of instructions involving the understanding of positional prepositions, e.g., on, under, and the manipulation of such attributes as size, shape, and color. Luria (1966a) noted the ability to grasp logico-grammatical and spatial relationships to depend on the simultaneous integration of information.

The Tokens task consists of 18 sentences which require the child to perform an action while taking into account such attributes as shape,
size, and color. The instructional requirements progressively become more difficult as the child is required to deal with an increasing number of attributes and with the introduction of positional prepositions. This study used administration procedures and scoring criteria developed by Naglieri and Das (1985).

**Successive Tasks**

**Digit Span (Forward)**

This task is taken directly from the WISC-R (Wechsler, 1974). This task has been used as a successive marker and assesses successive coding at the level of memory. It has been used in the factor analytic research and has consistently loaded highest on the successive factor (Das & Molloy, 1975; Kirby & Das, 1977, 1978; Das, Leong & Williams, 1978; Jarman, 1978; Ashman & Das, 1980).

The Digit Span (Forward) task requires an individual to recall a series of randomly presented digits in the order in which they are presented by the examiner. The digits are presented orally at the rate of one per second and the series increase in length from 3 to 9 digits.

This study will use the administration procedures and scoring criteria specified in the WISC-R manual (Wechsler, 1974).

**Successive Hand Movements**

This task was developed by Naglieri and Das (1985) to assess successive coding using nonverbal/motor content. The task requirements are similar to those used by Luria in his clinical studies (Luria, 1966b) and several other tasks found to load on the successive factor, e.g.,
the Hand Movements subtest of the K-ABC (Kaufman & Kaufman, 1983); Sequential Hand Movements (Naglieri, et al., 1983).

This task requires the child to reproduce a series of hand movements demonstrated by the examiner. There are six hand movements including palm down, side of hand, fist, point, thumb up, and knuckles down. The task progressively increases in difficulty as the series of movements increases from two to seven. Hand movements are presented at the rate of one per second. This study will use administration procedures and scoring criteria specified by Naglieri and Das (1985).

**Successive Conceptual**

This task was designed by Naglieri and Das (1985) to assess successive coding at the conceptual level of cognition. It is a language task. Luria (1966a) noted that tasks requiring an individual to reproduce information in an exact order depend on successive coding. Luria (1966a) also noted the importance of successive coding in regards to narrative and syntactic aspects of speech and language.

This task is divided into two parts. The initial part, Repetition, requires the child to recall each word of an orally presented sentence in order. The second part, Questions, requires the child to answer a question after hearing the sentence read by the examiner. There are 10 sentences which become progressively more difficult. The same sentences are used for Questions as are used for Repetition. The sentences are syntactically correct, but use color words in place of nouns, verbs, etc. This study will use the administration procedures and scoring criteria specified by Naglieri and Das (1985).
Successive Ordering

This task was developed by Naglieri and Das (1985) to assess successive coding without item memory. The task is successive in that it requires an individual to reproduce in the same order a series of successive movements made by the examiner.

The task consists of a tray with 8 circular indentations. The examiner places a specified number of circular discs in the indentations and then proceeds to turn the discs over in a predetermined order. The child then turns the same discs over using the same order as the examiner. The number of discs manipulated increases from 3 to 8. This study will use the administration procedures and scoring criteria specified by Naglieri and Das (1985).

Planning Tasks

Visual Search

This task has been adapted by Das & Naglieri (1985) from one used by Teuber, et al. (1949). It was used by Ashman & Das (1980) as a task likely to load on the planning factor given its use in frontal lobe research and Luria's premise that the frontal lobes are involved in planning and regulating human behavior (Luria, 1973). It has consistently loaded highest on the planning factor (Ashman & Das, 1980).

This task requires the child to find the same stimulus as that presented in a box in the middle of a page somewhere else on the page. It is a timed task with the time measured being that from time of initial stimulus exposure to the child's pointing at the second stimulus. The task increases in difficulty as search requirements increase, e.g., the
child must search a larger number of items. This study will use administra-
tion procedures and scoring criteria specified by Naglieri and Das (1985).

**Trail Making**

This task was part of the Army Individual Test of General Mental
Ability (1944). It was adopted by Armitage (1946) who reported it as a
measure of planning. It has been found to consistently load highest on
the planning factor in the relevant factor analytic research (Ashman &
Das, 1980).

The task as used in this study was developed by Das & Naglieri
(1985) and requires a child to connect, in the appropriate order, a
series of numbers, letters, and then, numbers and letters combined (1-
A-2-B-3-C, etc.). It is a timed task with the time measured being that
from the child being told to begin until the child connects the last
two elements in the series. Difficulty is increased first through the
use of increased series length and then by the requirement to connect
numbers and letters in combination. This study will use administration
procedures and scoring criteria specified by Naglieri and Das (1985).

**Verbal Fluency**

This is a task developed by Thurstone and Thurstone (1941). Ashman
& Das (1980) initially used it as a planning task and it has consistently
loaded highest on the planning factor in the factor analytic research
(Ashman & Das, 1980).

The task as used in this study was developed by Das & Naglieri
(1985) and requires a child to name as many words as they can beginning
with the letter B, having three letters, and beginning with the letter S and having four letters. They are given two minutes in which to complete each task. This study will use administration procedures and scoring criteria specified by Naglieri and Das (1985).

**Successive Codes**

This task was developed by Das & Naglieri (1985) and loads high on the planning factor (Naglieri, 1986, personal communication) as it depends more on effective planning strategies than it does on effective coding strategies.

The task consists of seven codes, lettered A through G, composed of combinations of three X's and O's, e.g., XOX. The child is provided with a series of unmarked boxes divided into three parts and topped with a letter A through G. The child is required to fill in the corresponding code for each given letter. This study will use administration procedures and scoring criteria specified by Naglieri and Das (1985).

**Reading Tasks**

**Wide Range Achievement Test-Word Recognition**

This is a word recognition test consisting of 75 words of increasing difficulty. The child is asked to read the words out loud. This study will use the administration procedures and scoring criteria specified in the manual (Jastak, Bijou & Jastak, 1978).
Standard Diagnostic Reading Test

The Stanford Diagnostic Reading Test (Karlsen, Madden & Gardner, 1984) is a comprehensive reading test with various levels graded to curricular expectations. This study utilized the Green Level, Form G, the appropriate level for students in the fourth grade. The entire test was not administered. Only the Reading Comprehension subtest was administered. This subtest consists of 9 graded passages to be read silently by the student who then answers a series of comprehension questions presented in a multiple choice format. There are 48 items total with 24 items designed to measure inferential comprehension and 24 items designed to measure literal comprehension. This study used the administration procedures and scoring criteria specified in the manual (Karlsen, Madden & Gardner, 1984).
This chapter first presents the descriptive statistics (means, standard deviations, and correlation coefficients) for the various variables used in this study. These data are further examined using the factor analytic procedures of principal components and principal factor analyses. Rationale for use of orthogonal and oblique rotations is presented and justification is given for accepting a three-factor solution.

Descriptive Statistics

Table 1 presents the means, standard deviations, and highest possible score for each of the cognitive tasks and measures of reading achievement used in this study. Complete data were collected for each of the 120 subjects. The data presented for Verbal Fluency, Successive Codes, Digit Span, Hand Movements Successive Order, Successive Conceptual, Block Design, Figure Memory and Tokens are computed from raw scores. The scores for Visual Search and Trail Making are raw scores based on the number of seconds required to complete the task. The scores for the matrix Analogies Test-Expanded Form, the Reading Recognition subtest of the Wide Range Achievement Test, and the Literal and Inferential Comprehension subtests of the Stanford Diagnostic Reading Test are computed from standard scores.
Table 1

Descriptive Statistics

<table>
<thead>
<tr>
<th>Task</th>
<th>M</th>
<th>SD</th>
<th>Highest Possible Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Verbal Fluency</td>
<td>33.21</td>
<td>9.93</td>
<td>No Limit</td>
</tr>
<tr>
<td>Visual Search</td>
<td>122.63</td>
<td>29.14</td>
<td>Timed Task</td>
</tr>
<tr>
<td>Successive Codes</td>
<td>30.98</td>
<td>5.16</td>
<td>77</td>
</tr>
<tr>
<td>Trail Making</td>
<td>229.08</td>
<td>66.42</td>
<td>Timed Task</td>
</tr>
<tr>
<td>Digit Span</td>
<td>26.89</td>
<td>10.01</td>
<td>9</td>
</tr>
<tr>
<td>Hand Movements</td>
<td>14.78</td>
<td>4.94</td>
<td>81</td>
</tr>
<tr>
<td>Successive Order</td>
<td>27.46</td>
<td>9.24</td>
<td>99</td>
</tr>
<tr>
<td>Successive Conceptual Tokens</td>
<td>11.67</td>
<td>3.50</td>
<td>24</td>
</tr>
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<td>Tokens</td>
<td>15.20</td>
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<td>18</td>
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<td>Block Design</td>
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<tr>
<td>Figure Memory</td>
<td>42.18</td>
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<td>Matrix Analogies Test</td>
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<td>11.07</td>
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<td>Stanford Diagnostic Reading Test:</td>
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<tr>
<td>Literal Comprehension Subtest</td>
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<td>Inferential Comprehension Subtest</td>
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<tr>
<td>Total Comprehension</td>
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</tbody>
</table>
Examination of the raw scores for the variables indicated normal distributions with no highly skewed results. The mean score of 15 on Tokens, however, approached the maximum score of 18 for this task.

**Correlational Analyses**

Pearson product-moment correlations among all the cognitive tasks are presented in Table 2. The MAT-EF correlates most strongly with Figure Memory (.58) and Block Design (.40). Block Design also correlates strongly with Figure Memory (.36). These tasks are expected to load on the simultaneous factor. Digit Span correlates most strongly with Successive Conceptual (.52) and these tasks are expected to load on the successive factor. Visual Search has its strongest correlations with Successive Codes (-.51) and Trail Making (.41). Successive Codes also correlates strongly with Trail Making (-.48). These tasks are expected to load on the planning factor. Verbal Fluency, Successive Order, and Hand Movements have the fewest significant correlations.

**Factor Analyses**

Principal components analysis and principal factor analysis were performed. Principal components analysis was used as the initial factor method for a number of reasons. Much of the early research with Das, et al.'s model was based on principal components analysis and use of this method facilitates comparisons with this early work. Use of principal components analysis also aids in the selection of the number of factors to interpret (Silverstein, 1969). Principal components analysis analyzes all of the variance for a variable using 1's in the
Table 2
Pearson Product-Moment Correlation Coefficients
Between Each Of The Cognitive Tasks

<table>
<thead>
<tr>
<th></th>
<th>VS</th>
<th>SC</th>
<th>TM</th>
<th>DS</th>
<th>HM</th>
<th>SO</th>
<th>TKS</th>
<th>BD</th>
<th>FM</th>
<th>MAT</th>
<th>SCO</th>
</tr>
</thead>
<tbody>
<tr>
<td>VF</td>
<td>-24*</td>
<td>23*</td>
<td>-18</td>
<td>08</td>
<td>24*</td>
<td>18</td>
<td>13</td>
<td>13</td>
<td>16</td>
<td>22*</td>
<td>30**</td>
</tr>
<tr>
<td>VS</td>
<td>-51**</td>
<td>41**</td>
<td>-13</td>
<td>-17</td>
<td>-31**</td>
<td>-28**</td>
<td>-06</td>
<td>-03</td>
<td>-18</td>
<td>-11</td>
<td></td>
</tr>
<tr>
<td>SC</td>
<td>-48**</td>
<td>09</td>
<td>26**</td>
<td>26**</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>22*</td>
<td>30**</td>
<td>02</td>
<td></td>
</tr>
<tr>
<td>TM</td>
<td>-21*</td>
<td>-18</td>
<td>-40**</td>
<td>-35**</td>
<td>-23*</td>
<td>-22*</td>
<td>-26**</td>
<td>-26**</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>DS</td>
<td>13</td>
<td>22*</td>
<td>31**</td>
<td>16</td>
<td>12</td>
<td>09</td>
<td>52**</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HM</td>
<td>26*</td>
<td>14</td>
<td>27**</td>
<td>20*</td>
<td>26**</td>
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<td>14</td>
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<td>TKS</td>
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<td>32**</td>
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</tr>
</tbody>
</table>

a VF=Verbal Fluency, VS=Visual Search, SC=Successive Codes, TM=Trail Making, DS=Digit Span, HM=Hand Movements, SO=Successive Order, TKS=Tokens, BD=Block Design, FM=Figure Memory, MAT=Matrix Analogies Test, SCO=Successive Conceptual.

b Decimals have been omitted

* significant at .05

** significant at .01
diagonal of the correlation matrix and is an exact mathematical transformation of the original data (Rummel, 1970). Three factors with eigenvalues greater than 1 (3.65, 1.49, 1.34) emerged when the principal components analysis was used. The 3 factor varimax solution is presented in Table 3.

Visual Search, Successive Codes, Trail Making, Successive Ordering, and Verbal Fluency have their highest loadings on factor one. Visual Search, Trail Making, and Verbal Fluency have consistently attained their highest loadings on the factor Das, et al. (1979) labeled planning (Das & Ashman, 1980; Snart, O'Grady & Das, 1982; Snart & Swann, 1982; Das & Heemsbergen, 1980; Kirby & Ashman, 1984). Factor 1 of this analysis will be labeled as planning as it is defined by those tasks frequently found to represent the planning factor.

The second factor is largely defined by high loadings on Figure Memory, the Matrix Analogies Test-EF, Successive Codes, Block Design, and Hand Movements. Both Figure Memory and the MAT-EF are similar in task demands to Figure Copying and Raven's Progressive Matrices tasks used by Das, et al. (1979) as markers for their simultaneous coding factor. Block Design has also been found to load highest on factors termed simultaneous (Naglieri & Kaufman, 1983). The high loading of Hand Movements on this factor was unexpected. This factor, then, will be labeled simultaneous as it is largely defined by tasks which have frequently been said to represent the simultaneous factor.

The third factor is defined by loadings on the Successive Conceptual and Digit Span tasks as well as the Tokens task. Digit Span has
Table 3
Principal Components With Varimax Rotation*

<table>
<thead>
<tr>
<th>Task</th>
<th>Rotated Solution</th>
<th>Unrotated Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>I</td>
<td>II</td>
</tr>
<tr>
<td>Visual Search</td>
<td>-.815*</td>
<td>.078</td>
</tr>
<tr>
<td>Successive Codes</td>
<td>.805*</td>
<td>.190</td>
</tr>
<tr>
<td>Trail Making</td>
<td>-.671*</td>
<td>-.152</td>
</tr>
<tr>
<td>Successive Order</td>
<td>.459*</td>
<td>.217</td>
</tr>
<tr>
<td>Verbal Fluency</td>
<td>.363*</td>
<td>.223</td>
</tr>
<tr>
<td>Figure Memory</td>
<td>.032</td>
<td>.806*</td>
</tr>
<tr>
<td>MAT-EF</td>
<td>.206</td>
<td>.794*</td>
</tr>
<tr>
<td>Block Design</td>
<td>.068</td>
<td>.665*</td>
</tr>
<tr>
<td>Hand Movements</td>
<td>.341*</td>
<td>.415*</td>
</tr>
<tr>
<td>Successive Conceptual</td>
<td>.035</td>
<td>.187</td>
</tr>
<tr>
<td>Digit Span</td>
<td>.072</td>
<td>-.022</td>
</tr>
<tr>
<td>Tokens</td>
<td>.228</td>
<td>.267</td>
</tr>
</tbody>
</table>

*All loadings > .30 are indicated with an asterisk.
consistently been used as a marker task for the successive coding factor by Das, et al. (1979). On this basis, factor 3 was labeled successive.

The principal components analysis was followed by principal factor factor analysis. This method assumes that correlations between variables are due to one or more underlying factors and attempts to separate common and unique variance. Rather than using 1's in the diagonal of the correlation matrix, principal factor methods use an estimate of communality. As there are many ways to estimate communality, principal factor analysis is mathematically indeterminate as there are no clear-cut criteria for selecting which estimate of communality to use (Rummel, 1970). This study used squared multiple correlations. Rummel (1970) and others (Howard & Cartwright, 1962) have indicated that these are the best estimates of communality on both theoretical and empirical grounds.

The factor structure of any factoring method is not unique since it can be rotated into many different, although statistically equivalent, structures. Thus, it is necessary to make a decision regarding which rotational method, orthogonal or oblique, is to be used. Orthogonal rotation yields factors which are uncorrelated while oblique rotation takes into account the correlations between factors. The model of Das, et al. proposes that the cognitive processes represented by the factors are independent. In order to examine the validity of this independence, an orthogonal rotation (Varimax) was performed on the data. Das, et al. (1979) also note that, while independent, the processes
represented by the factors interact and consequently are intercorrelated. In order to examine the interrelatedness of the factors, an oblique (Oblimin) rotation was used. When discussing results of oblique rotations, the pattern matrix will be used as it discriminates between independent factor contributions to the variation in the variables. The loadings on the structure matrix are correlations and thus take into account the interaction between factors. The pattern matrix thus allows for better substantive interpretation of the factors (Rummel, 1970).

An additional issue in principal factor analysis is the determination of the number of factors to accept. Naglieri & Kaufman (1983) present objective methods for determining the number of significant factors. Four of the methods presented by these authors are Kaiser's "Little Jiffy" (Hollenbeck, 1972), the scree test (Cattell, 1966), and an approach proposed by Wrigley (1960) and consequently modified by Kiel (Kaufman, 1970).

The Kaiser method employs principal components analysis with the number of factors to be accepted determined by the number of actors obtaining eigenvalues of 1 or more. The principal components analysis performed on the data of this study produced three factors with eigenvalues greater than or equal to 1.

The scree test is used for the results of common factor analyses and requires that the eigenvalues be plotted. The point where the eigenvalues curve above a straight line formed by the smaller roots gives the number of factors accounting for the maximum amount of
variance (Gorsuch, 1974). Three factors were obtained when the criteria of the scree test were applied to the data of this study.

Wrigley's approach (1960) involves over-factoring (obtaining solutions for more than the assumed number of factors) and successively rotating a number of varimax factor solutions. The solution with the greatest number of factors in which each factor contains the highest loadings of at least two variables is accepted as the one best explaining the factorial composition of the correlation matrix (Naglieri & Kaufman, 1983). Kiel (Kaufman, 1970) modified Wrigley's approach by stipulating that each factor contain the highest loadings of at least three variables rather than two. Using either Wrigley's original criteria or Kiel's modification with the data of this study, the only acceptable factor solution is the 3-factor solution.

In order to use the scree test and the Wrigley and Kiel approaches, all principal factor analyses (orthogonal and oblique) were conducted with 2, 3, 4 and 5 factor solutions. The principal factor analysis results for the 2 factor solutions are presented in Table 4 (orthogonal rotation) and Table 5 (oblique rotation). The orthogonal solution resulted in a factor defined by the high loadings of the simultaneous and successive coding tasks (Successive Conceptual, MAT-EF, Figure Memory, Tokens, Block Design, Digit Span, and Successive Order) and one defined by the planning tasks (Successive Codes, Visual Search, Trail Making, and Hand Movements, and Verbal Fluency). Verbal Fluency split its loadings obtaining a loading of .262 on the first or coding factor and .270 on the second or planning factor. Successive Order also split its
Table 4

Principal Factor Analysis With Varimax
Rotation 2 Factor Solution

<table>
<thead>
<tr>
<th>Task</th>
<th>Rotated Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>I</td>
</tr>
<tr>
<td>Successive Conceptual</td>
<td>.661*</td>
</tr>
<tr>
<td>MAT-EF</td>
<td>.529*</td>
</tr>
<tr>
<td>Tokens</td>
<td>.510*</td>
</tr>
<tr>
<td>Figure Memory</td>
<td>.496*</td>
</tr>
<tr>
<td>Block Design</td>
<td>.489*</td>
</tr>
<tr>
<td>Digit Span</td>
<td>.456*</td>
</tr>
<tr>
<td>Successive Order</td>
<td>.415*</td>
</tr>
<tr>
<td>Successive Codes</td>
<td>.029</td>
</tr>
<tr>
<td>Visual Search</td>
<td>-.092</td>
</tr>
<tr>
<td>Trail Making</td>
<td>-.322*</td>
</tr>
<tr>
<td>Hand Movements</td>
<td>.271</td>
</tr>
<tr>
<td>Verbal Fluency</td>
<td>.262</td>
</tr>
</tbody>
</table>

*All loadings > .30 are indicated with an asterisk.
Table 5

Principal Factor Analysis With Oblimin
Rotation 2 Factor Solution

<table>
<thead>
<tr>
<th>Task</th>
<th>Rotated Solution</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>I</td>
<td>II</td>
</tr>
<tr>
<td>Successive Conceptual</td>
<td>.718*</td>
<td>.181</td>
<td></td>
</tr>
<tr>
<td>MAT-EF</td>
<td>.524*</td>
<td>-.151</td>
<td></td>
</tr>
<tr>
<td>Tokens</td>
<td>.519*</td>
<td>-.065</td>
<td></td>
</tr>
<tr>
<td>Figure Memory</td>
<td>.511*</td>
<td>-.029</td>
<td></td>
</tr>
<tr>
<td>Block Design</td>
<td>.504*</td>
<td>-.020</td>
<td></td>
</tr>
<tr>
<td>Digit Span</td>
<td>.487*</td>
<td>.077</td>
<td></td>
</tr>
<tr>
<td>Successive Order</td>
<td>.389*</td>
<td>-.259</td>
<td></td>
</tr>
<tr>
<td>Hand Movements</td>
<td>.242</td>
<td>-.232</td>
<td></td>
</tr>
<tr>
<td>Verbal Fluency</td>
<td>.237</td>
<td>-.208</td>
<td></td>
</tr>
<tr>
<td>Successive Codes</td>
<td>-.115</td>
<td>-.856*</td>
<td></td>
</tr>
<tr>
<td>Visual Search</td>
<td>.015</td>
<td>.645*</td>
<td></td>
</tr>
<tr>
<td>Trail Making</td>
<td>-.251</td>
<td>.496*</td>
<td></td>
</tr>
</tbody>
</table>

*All loadings > .30 are indicated with an asterisk.
loadings obtaining a loading of .352 on the coding factor and .415 on the planning factor. In addition, Hand Movements split its loadings (.271 vs. .290). Factor 1 was labeled Coding as it was largely comprised of successive-simultaneous coding tasks and factor 2 was labeled planning as it was comprised of planning tasks. The oblique rotation produced similar results except that the Hand Movements and Verbal Fluency tasks obtained their higher loadings on the Coding factor.

The results of the 3 factor principal factor analysis with orthogonal rotation are given in Table 6. The factor structure of this analysis is similar to that of the principal components analysis with orthogonal rotation. The slightly higher loadings on the principal components analysis is not unexpected as this factoring technique can yield inflated loadings especially when a small number of variables is used (Carroll, 1979). Successive Codes, Visual Search, and Trail making obtained their highest loadings on the planning factor with Successive Order and Verbal Fluency also loading on this factor. Successive Order also obtained a loading of .341 on the Successive factor. The MAT-EF, Figure Memory, and Block Design loaded highest on the simultaneous factor. Hand Movements has its highest loading (.290) on this factor although it has a similar loading (.272) on the planning factor. The final factor, successive, is comprised of Successive Conceptual, Digit Span, and Tokens. Tokens also has lower loadings on the planning factor (.230) and the simultaneous factor (.271).

The results of the principal factor analysis for 3 factors with an oblique rotation (Oblimin) are given in Table 7. Successive Conceptual,
Table 6
Principal Factor Analysis With Varimax Rotation 3 Factor Solution

<table>
<thead>
<tr>
<th>Task</th>
<th>Rotated Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>I</td>
</tr>
<tr>
<td>Successive Codes</td>
<td>.744*</td>
</tr>
<tr>
<td>Visual Search</td>
<td>-.706*</td>
</tr>
<tr>
<td>Trail Making</td>
<td>-.577*</td>
</tr>
<tr>
<td>Successive Order</td>
<td>.386*</td>
</tr>
<tr>
<td>Verbal Fluency</td>
<td>.263</td>
</tr>
<tr>
<td>MAT-EF</td>
<td>.203</td>
</tr>
<tr>
<td>Figure Memory</td>
<td>.061</td>
</tr>
<tr>
<td>Block Design</td>
<td>.119</td>
</tr>
<tr>
<td>Hand Movements</td>
<td>.272</td>
</tr>
<tr>
<td>Successive Conceptual</td>
<td>.031</td>
</tr>
<tr>
<td>Digit Span</td>
<td>.104</td>
</tr>
<tr>
<td>Tokens</td>
<td>.230</td>
</tr>
</tbody>
</table>

*All loadings > .30 are indicated with an asterisk.
Table 7
Common Factor Analysis With An Oblimin Rotation 3 Factor Solution

<table>
<thead>
<tr>
<th>Task</th>
<th>Rotated Solution*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>I</td>
</tr>
<tr>
<td>Successive Conceptual</td>
<td>.831*</td>
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<tr>
<td>Digit Span</td>
<td>.624*</td>
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<tr>
<td>Tokens</td>
<td>.362*</td>
</tr>
<tr>
<td>Successive Codes</td>
<td>-222</td>
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<tr>
<td>Visual Search</td>
<td>-.043</td>
</tr>
<tr>
<td>Trail Making</td>
<td>-.173</td>
</tr>
<tr>
<td>Successive Order</td>
<td>.279</td>
</tr>
<tr>
<td>Verbal Fluency</td>
<td>.132</td>
</tr>
<tr>
<td>MAT-EF</td>
<td>-.052</td>
</tr>
<tr>
<td>Figure Memory</td>
<td>-.021</td>
</tr>
<tr>
<td>Block Design</td>
<td>.108</td>
</tr>
<tr>
<td>Hand Movements</td>
<td>.017</td>
</tr>
</tbody>
</table>

*All loadings > .30 are indicated by an asterisk.
Digit Span, and Tokens have their highest loadings on the successive factor while the MAT-EF, Figure Memory, Block Design, and Hand Movements have their highest loadings on the simultaneous factor. Hand Movements has a very similar loading on the planning factor (-.223 vs. .257). The third factor, planning, is comprised of Successive Codes, Visual Search, Trail Making, Successive Order, and Verbal Fluency. Successive Order also has a similar loading on the successive factor (.279).

The results of the 4 factor principal factor analyses are given in Table 8 (orthogonal rotation) and Table 9 (oblique rotation). The results are essentially the same as for the 3 factor solution. In each case, the fourth factor was comprised of only one task, Verbal Fluency. The planning factor consisted of Successive Codes, Visual Search, Trail Making, and Successive Order. The simultaneous factor was comprised of the Matrix Analogies Test-EF, Figure Memory, Block Design, and Hand Movements. The successive factor consisted of Successive Conceptual, Digit Span, and Tokens.

The results of the 5 factor principal factor analyses are presented in Table 10 (orthogonal) and Table 11 (oblique). The 5 factor solution resulted in a different factor structure with the fourth factor defined by Block Design, Successive Order, and Hand Movements and the fifth factor defined by Verbal Fluency. The remaining three factors conformed to the factors previously labeled successive, simultaneous, and planning. The fourth factor did not lend itself to meaningful interpretation.
Table 8
Principal Factor Analysis With Varimax
Rotation 4 Factor Solution

<table>
<thead>
<tr>
<th>Task</th>
<th>Rotated Solution*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>I</td>
</tr>
<tr>
<td>Successive Codes</td>
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<tr>
<td>Visual Search</td>
<td>-.685*</td>
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<tr>
<td>Trail Making</td>
<td>-.605*</td>
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<tr>
<td>Successive Order</td>
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<td>Figure Memory</td>
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<td>Block Design</td>
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<td>Hand Movements</td>
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<tr>
<td>Successive Conceptual</td>
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<tr>
<td>Digit Span</td>
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<tr>
<td>Tokens</td>
<td>.247</td>
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<tr>
<td>Verbal Fluency</td>
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</tr>
</tbody>
</table>

*All loadings > .30 are indicated with an asterisk.
Table 9
Principal Factor Analysis With Oblimin
Rotation 4 Factor Solution

<table>
<thead>
<tr>
<th>Tasks</th>
<th>Rotated Solution*</th>
</tr>
</thead>
<tbody>
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<td></td>
<td>I</td>
</tr>
<tr>
<td>Successive Conceptual</td>
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</tr>
<tr>
<td>Digit Span</td>
<td>.592*</td>
</tr>
<tr>
<td>Tokens</td>
<td>.353*</td>
</tr>
<tr>
<td>Visual Search</td>
<td>-.032</td>
</tr>
<tr>
<td>Successive Codes</td>
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<td>Trail Making</td>
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<tr>
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</tr>
<tr>
<td>MAT-EF</td>
<td>-.060</td>
</tr>
<tr>
<td>Figure Memory</td>
<td>-.060</td>
</tr>
<tr>
<td>Block Design</td>
<td>.092</td>
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<tr>
<td>Hand Movements</td>
<td>-.005</td>
</tr>
<tr>
<td>Verbal Fluency</td>
<td>.104</td>
</tr>
</tbody>
</table>

*All loadings > .30 are indicated with an asterisk.
Table 10

Principal Factor Analysis With Varimax Rotation 5 Factor Solution

<table>
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<tr>
<th>Task</th>
<th>Rotated Solution*</th>
</tr>
</thead>
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<td></td>
<td>I</td>
</tr>
<tr>
<td>Successive Codes</td>
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</tr>
<tr>
<td>Visual Search</td>
<td>-.681*</td>
</tr>
<tr>
<td>Trail Making</td>
<td>-.594*</td>
</tr>
<tr>
<td>Successive Conceptual</td>
<td>-.042</td>
</tr>
<tr>
<td>Digit Span</td>
<td>.105</td>
</tr>
<tr>
<td>Tokens</td>
<td>.251</td>
</tr>
<tr>
<td>Figure Memory</td>
<td>.056</td>
</tr>
<tr>
<td>MAT-EF</td>
<td>.181</td>
</tr>
<tr>
<td>Block Design</td>
<td>.024</td>
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<tr>
<td>Successive Order</td>
<td>.326*</td>
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<tr>
<td>Hand Movements</td>
<td>.180</td>
</tr>
<tr>
<td>Verbal Fluency</td>
<td>.178</td>
</tr>
</tbody>
</table>

*All loadings > .30 are indicated with an asterisk.
Table 11

Principal Factor Analysis With Oblimin Rotation 5 Factor Solution

<table>
<thead>
<tr>
<th>Task</th>
<th>I</th>
<th>II</th>
<th>III</th>
<th>IV</th>
<th>V</th>
</tr>
</thead>
<tbody>
<tr>
<td>Successive Conceptual</td>
<td>.956*</td>
<td>.150</td>
<td>.098</td>
<td>.078</td>
<td>.256</td>
</tr>
<tr>
<td>Digit Span</td>
<td>.540*</td>
<td>-.056</td>
<td>-.034</td>
<td>-.061</td>
<td>-.052</td>
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<tr>
<td>Tokens</td>
<td>.340*</td>
<td>-.208</td>
<td>.185</td>
<td>-.106</td>
<td>-.166</td>
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<tr>
<td>Successive Codes</td>
<td>-.188</td>
<td>-.729*</td>
<td>.155</td>
<td>.035</td>
<td>.130</td>
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<tr>
<td>Visual Search</td>
<td>-.038</td>
<td>.704*</td>
<td>.087</td>
<td>-.021</td>
<td>-.066</td>
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<tr>
<td>Trail Making</td>
<td>-.155</td>
<td>.583*</td>
<td>-.068</td>
<td>.106</td>
<td>.116</td>
</tr>
<tr>
<td>Figure Memory</td>
<td>.034</td>
<td>.015</td>
<td>.820*</td>
<td>.025</td>
<td>-.003</td>
</tr>
<tr>
<td>MAT-EF</td>
<td>.008</td>
<td>-.088</td>
<td>.630*</td>
<td>-.143</td>
<td>.071</td>
</tr>
<tr>
<td>Block Design</td>
<td>-.002</td>
<td>.133</td>
<td>.187</td>
<td>-.655*</td>
<td>-.058</td>
</tr>
<tr>
<td>Successive Order</td>
<td>.191</td>
<td>-.226</td>
<td>-.113</td>
<td>-.452*</td>
<td>.236</td>
</tr>
<tr>
<td>Hand Movements</td>
<td>-.057</td>
<td>-.076</td>
<td>.036</td>
<td>-.374*</td>
<td>.236</td>
</tr>
<tr>
<td>Verbal Fluency</td>
<td>.130</td>
<td>-.099</td>
<td>.056</td>
<td>-.053</td>
<td>.484*</td>
</tr>
</tbody>
</table>

*All loadings > .30 are indicated with an asterisk.
Reading Tests

Table 6 presents the correlation coefficients for each of the reading tests with each of the cognitive tasks. The highest correlations in Table 12 are between the composite comprehension subtests of the Stanford Diagnostic Reading Test, the Literal and Inferential Reading Comprehension subtests. There is a moderate correlation between these subtests of the Stanford Diagnostic Reading Test and standard scores for the Reading Recognition subtest of the WRAT. These correlations were expected due to the similarity in content of these tests and the fact that they are both influenced by school curricula. Moderate correlations were also obtained for the MAT-EF and the reading comprehension subtests of the Stanford Reading Test and Reading Recognition subtest of the WRAT. Successive Conceptual also attained a moderate level of correlation with both tests of reading comprehension and the reading recognition test. This may be attributed to the language demands of this task. Correlations between the remaining cognitive tasks and the reading tests are less than .300.

In order to determine if the various reading tasks were more influenced by one of the cognitive factors (successive, simultaneous, planning), three principal factor analyses with orthogonal rotation were performed on the data. Each of the three reading tasks were inserted singly in the three analysis. A 3 factor solution was specified. The reading measures were inserted singly in the factor analysis to avoid their loading on a separate factor. The emergence of this separate factor, termed an educational factor by Das, et al. (1979), has been noted in previous studies of this model (Das, et al., 1979).
<table>
<thead>
<tr>
<th>Task</th>
<th>StnDiag-Lit</th>
<th>StnDiag-Inf</th>
<th>WRAT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Verbal Fluency</td>
<td>.204*</td>
<td>.278**</td>
<td>.226*</td>
</tr>
<tr>
<td>Visual Search</td>
<td>-.157</td>
<td>-.177</td>
<td>-.232*</td>
</tr>
<tr>
<td>Successful Codes</td>
<td>.122</td>
<td>.170</td>
<td>.269**</td>
</tr>
<tr>
<td>Trail Making</td>
<td>-.211*</td>
<td>-.138</td>
<td>-.288**</td>
</tr>
<tr>
<td>Digit Span</td>
<td>.256**</td>
<td>.099</td>
<td>.150</td>
</tr>
<tr>
<td>Hand Movements</td>
<td>.248*</td>
<td>.245*</td>
<td>.258**</td>
</tr>
<tr>
<td>Successful Order</td>
<td>.245*</td>
<td>.228*</td>
<td>.322**</td>
</tr>
<tr>
<td>Tokens</td>
<td>.322**</td>
<td>.235*</td>
<td>.226*</td>
</tr>
<tr>
<td>Block Design</td>
<td>.120</td>
<td>.077</td>
<td>.339**</td>
</tr>
<tr>
<td>Figure Memory</td>
<td>.293**</td>
<td>.290**</td>
<td>.297**</td>
</tr>
<tr>
<td>MAT-EF</td>
<td>.415**</td>
<td>.344**</td>
<td>.450**</td>
</tr>
<tr>
<td>Successful Conceptual</td>
<td>.382**</td>
<td>.328**</td>
<td>.447**</td>
</tr>
<tr>
<td>StnDiag-Lit</td>
<td>.675**</td>
<td>.675**</td>
<td>.457**</td>
</tr>
<tr>
<td>StnDiag-Inf</td>
<td>.675**</td>
<td>.499**</td>
<td></td>
</tr>
<tr>
<td>WRAT</td>
<td>.457**</td>
<td>.499*</td>
<td></td>
</tr>
</tbody>
</table>

a StnDiag-Lit=Stanford Diagnostic Reading Test-Literal Comprehension; StnDiag-Inf=Stanford Diagnostic Reading Test-Inferential Comprehension.

* Significant at .05.

** Significant at .01.
Table 13 presents the results for the Literal Comprehension subtest of the Stanford Diagnostic Reading Test. This subtest split its loadings between the simultaneous (.362) and successive (.379) factors. Table 14 presents the results for the Inferential Comprehension subtest of the Stanford Diagnostic Reading Test. This subtest obtained its highest loading on the simultaneous factor (.347) while obtaining a loading of .233 on the successive factor. Table 15 presents the results for the Reading Recognition subtest of the WRAT. This subtest splits its loading between the simultaneous (.448) and successive (.312) factors. The reading tasks did not obtain substantial loadings on the planning factor.

Limitations

The above results should be considered with the following limitations in mind. The results cannot be said to confirm the model of information processing put forth by Das, et al. (1975, 1979). The analyses were exploratory in nature rather than confirmatory. Thus, while it may be appropriate to say that the analyses produced results consistent with Das, et al.'s model, it would be inappropriate to say that the analyses confirmed the model.

The nature of these results is due in part to the number and variety of tasks selected as well as the population tested. An increased number of tasks, involving different formats and domains, would likely produce different results as would the use of a different population. Beyond task and population variation, the statistical techniques chosen certainly influenced the results. Different rotational techniques, for
Table 13
Principal Factor Analysis With Varimax Rotation 3
Factor Solution With The Stanford Diagnostic
Literal Comprehension Subtest*

<table>
<thead>
<tr>
<th>Task</th>
<th>Rotated Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>I</td>
</tr>
<tr>
<td>MAT-EF</td>
<td>.801*</td>
</tr>
<tr>
<td>Figure Memory</td>
<td>.693*</td>
</tr>
<tr>
<td>Block Design</td>
<td>.454*</td>
</tr>
<tr>
<td>Hand Movements</td>
<td>.297</td>
</tr>
<tr>
<td>Successive Codes</td>
<td>.204</td>
</tr>
<tr>
<td>Visual Search</td>
<td>.001</td>
</tr>
<tr>
<td>Trail Making</td>
<td>-.183</td>
</tr>
<tr>
<td>Successive Order</td>
<td>.212</td>
</tr>
<tr>
<td>Verbal Fluency</td>
<td>.193</td>
</tr>
<tr>
<td>Successive Conceptual</td>
<td>.197</td>
</tr>
<tr>
<td>Digit Span</td>
<td>.045</td>
</tr>
<tr>
<td>Tokens</td>
<td>.274</td>
</tr>
<tr>
<td>Stanford Diagnostic</td>
<td>.362*</td>
</tr>
<tr>
<td>Literal Comprehension</td>
<td></td>
</tr>
</tbody>
</table>

*All loadings ≥ .30 are indicated with an asterisk.
<table>
<thead>
<tr>
<th>Task</th>
<th>Rotated Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>I</td>
</tr>
<tr>
<td>MAT-EF</td>
<td>.780*</td>
</tr>
<tr>
<td>Figure Memory</td>
<td>.715*</td>
</tr>
<tr>
<td>Block Design</td>
<td>.460*</td>
</tr>
<tr>
<td>Stanford Diagnostic Inferential Comprehension</td>
<td>.347*</td>
</tr>
<tr>
<td>Hand Movements</td>
<td>.309*</td>
</tr>
<tr>
<td>Successive Codes</td>
<td>.215</td>
</tr>
<tr>
<td>Visual Search</td>
<td>-.011</td>
</tr>
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<td>Trail Making</td>
<td>-.190</td>
</tr>
<tr>
<td>Successive Order</td>
<td>.228</td>
</tr>
<tr>
<td>Verbal Fluency</td>
<td>.218</td>
</tr>
<tr>
<td>Successive Conceptual</td>
<td>.223</td>
</tr>
<tr>
<td>Digit Span</td>
<td>.055</td>
</tr>
<tr>
<td>Tokens</td>
<td>.283</td>
</tr>
</tbody>
</table>

*All loadings > .30 are indicated with an asterisk.
Table 15
Principal Factor Analysis With Varimax Rotation 3
Factor Solution With The Reading Recognition Subtest of the WRAT*

<table>
<thead>
<tr>
<th>Task</th>
<th>Rotated Solution</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>I</td>
<td>II</td>
<td>III</td>
</tr>
<tr>
<td>MAT-EF</td>
<td>.786*</td>
<td>.187</td>
<td>.093</td>
</tr>
<tr>
<td>Figure Memory</td>
<td>.674*</td>
<td>.056</td>
<td>.098</td>
</tr>
<tr>
<td>Block Design</td>
<td>.509*</td>
<td>.115</td>
<td>.180</td>
</tr>
<tr>
<td>WRAT Reading Recognition Subtest</td>
<td>.448*</td>
<td>.254</td>
<td>.312*</td>
</tr>
<tr>
<td>Hand Movements</td>
<td>.306*</td>
<td>.268</td>
<td>.091</td>
</tr>
<tr>
<td>Successive Codes</td>
<td>.214</td>
<td>.720*</td>
<td>-.073</td>
</tr>
<tr>
<td>Visual Search</td>
<td>-.003</td>
<td>-.711*</td>
<td>-.122</td>
</tr>
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<td>Trail Making</td>
<td>-.200</td>
<td>-.576*</td>
<td>-.249</td>
</tr>
<tr>
<td>Successive Order</td>
<td>.238</td>
<td>.386*</td>
<td>.329*</td>
</tr>
<tr>
<td>Verbal Fluency</td>
<td>.197</td>
<td>.257</td>
<td>.192</td>
</tr>
<tr>
<td>Successive Conceptual</td>
<td>.219</td>
<td>.010</td>
<td>.893*</td>
</tr>
<tr>
<td>Digit Span</td>
<td>.054</td>
<td>.110</td>
<td>.549*</td>
</tr>
<tr>
<td>Tokens</td>
<td>.268</td>
<td>.231</td>
<td>.374*</td>
</tr>
</tbody>
</table>

*All loadings > .30 are indicated with an asterisk.
instance, produce different results. Whether the variations mentioned here would produce results inconsistent with Das, et al.'s model is the question for continued research.
The factor analytic results of this study are consistent with the results of previous factor analytic studies regarding the model of information processing proposed by Das, et al. (1979). Three factors emerged which are consistent with the successive, simultaneous, and planning factors proposed by Das, et al. (1979). Tasks loading on the simultaneous factor operated at the conceptual level of cognition (MAT-EF, Block Design) and the level of memory (Figure Memory, Hand Movements). Tasks loading on the successive factor operated at the conceptual level (Tokens) and the level of memory (Successive Conceptual, Digit Span). The planning factor was defined by tasks operating at the cognitive levels of perception (Visual Search, Successive Codes) and memory (Trail Making, Verbal Fluency). These results provide support for Das' claim (Das, 1984c) that successive-simultaneous and planning processes occur at all three levels of cognition.

These results also support Das' (1984c) statement that the processes operate on information presented through different receptors and on information presented verbally or nonverbally. While the simultaneous factor in this study is comprised of visual, nonverbal tasks and the successive factor of auditory, verbal tasks, the planning factor is comprised of visual, nonverbal tasks (Visual Search, Successive
Codes, Trail Making) as well as an auditory, verbal task (Verbal Fluency).

The successive factor was defined by loadings on the Digit Span, Successive Conceptual, and Tokens tasks. Digit Span has consistently loaded highest on this factor and has been used as a market task for successive processing (Das, et al., 1979). The Successive Conceptual task was composed of two parts, Repetition and Questions. Repetition is a sentence memory task requiring an individual to recall each word in the order of presentation. The sentences are syntactically correct although nouns, adjectives, and adverbs are replaced with color words. It is similar to Digit Span in its requirements although more obviously language in content. Questions require the individual to listen carefully to a sentence (the same sentences used in Repetition) and answer a question. The memory requirement is lessened as the individual has just had exposure to the sentences on the Repetition task. Success on this task is more closely tied to an analysis of the syntactical structure of the sentence. As noted by Luria (1966b), the processing of narrative speech involves the fronto-temporal areas of the brain and relies on successive processing. Thus, the higher loading of these tasks on the successive factor was expected.

The loading of the Tokens task on this factor was unexpected, however, as it was expected that this language task would load higher on the simultaneous factor based on Luria's work. Luria (1966b) noted that the ability to grasp logico-grammatical relationship required simultaneous processing. Further, several items on Tokens consist of
comparatives (big, small) and positional prepositions (under, on top of). Luria (1966b) noted the visual-spatial nature of this type of language task and noted the involvement of simultaneous processing.

Tokens consistently obtained its highest loading on the successive factor although it also loaded on the simultaneous and planning factors (.230 and .271 vs. .408 for the three factor principal factor analysis with varimax rotation). It is possible that these results were affected by the fact that the mean on this task approached the maximum score. With more items at a higher level of difficulty, this task may have changed its loadings. It is also possible that this task is affected by developmental factors at this age. The children in this study (median age of 114 months) may have had more difficulty with the syntactical aspects of these items than anticipated. Thus for children at this age, this task may be more likely processed successively than simultaneously. Such developmental shifts have been noted in the literature (Das, et al., 1979).

The simultaneous factor in this study consisted of the MAT-EF, Figure Memory, Block Design, and Hand Movements tasks. As noted, the MAT-EF is similar in demands to Ravens' Progressive matrices while the demands of Figure Memory are similar to Ilg & Ames Figure Copying task. Both of these tasks have consistently received their highest loadings on the simultaneous factor and have been used as market tasks for simultaneous processing (Das, et al., 1979). Block Design has also been found to load on the simultaneous factor (Naglieri & Kaufman, 1983). It was expected that the Hand Movements task would load on the successive
factor due to its temporal nature and the requirement to reproduce the movements in the same order in which they were presented. This task consistently split its loadings between the simultaneous and planning factors never obtaining a substantial loading on any one of the factors.

A task similar to this task on the Kaufman Assessment Battery for Children (K-ABC) loaded highest on a sequential (successive) factor at younger ages, e.g., .57 vs. .19 at age 3 and on a simultaneous factor at older age levels, e.g., .37 vs. .43 at age 10 (Kaufman & Kaufman, 1983). It is possible, as suggested by the data from the K-ABC, that this task is affected by developmental factors. As children develop, they attempt to process the information of tasks similar to Hand Movements simultaneously. The task as used in this study may have been too difficult for the developmental level of the children forcing them to rely more on planning than coding processes. The very low loading on the successive factor, however, is inconsistent with previous research and may be attributable to variations in the population tested, administration of the task, or other variables as yet undetermined.

The planning factor was largely defined by Successive Codes, Visual Search, and Trail Making. Verbal Fluency and Successive Order also consistently loaded highest on this factor. The loadings of Visual Search and Trail Making were expected based on previous research (Ashman & Das, 1980; Kirby & Ashman, 1985). Successive Codes was also found to obtain its highest loading on the planning factor by Das & Naglieri (1986, personal communication). The consistent loading of Verbal Fluency
on this factor was also expected based on previous research (Ashman & Das, 1980, Kirby & Ashman, 1985). Successive Order consistently obtained very similar loadings on the planning and successive factors (.386 and .341 for the three factor principal factor analyses with varimax rotation). Thus, the successive factor accounts for a sizeable amount of the variance in this task as is expected given the successive nature of the task.

Memory-Reasoning

While the results of this study are consistent with the three factor model proposed by Das, et al., it is important to examine other possible interpretations of the factors to see if they may account for the results in a more parsimonious manner.

Jensen (1970, 1974) presents a model of human ability consisting of two levels, Level I and Level II, which are discriminated by the amount of transformation needed to process information. Level I is largely associative memory and is assessed by tasks requiring little transformation of information. Level II is reasoning, verbal or non-verbal, and requires a large amount of transformation of information.

The results of this study do not lend themselves to interpretation according to Jensen's theory. Memory tasks, for instance, loaded on each of the three factors rather than on one, e.g., Digit Span on successive, Figure Memory on simultaneous, Visual Search and Verbal Fluency on planning. The successive factor, while frequently assessed by tasks with high demands on memory, is not a memory factor. While Digit Span and Successive Conceptual have large memory demands, Tokens makes
limited demands on memory and requires transformation of the information before the task can be successfully performed. For similar reasons, the simultaneous factor cannot be considered a reasoning factor. While the MAT-EF and Block Design are assessments of nonverbal reasoning, Figure Memory and Hand Movements require little transformation and are compatible with Jensen's Level I. The planning factor is unaccounted for with Jensen's theory.

The popularity of the WISC-R (Wechsler, 1974) has generated explanations of human ability according to a verbal/nonverbal distinction (Wechsler, 1974; Kaufman, 1979). The verbal/nonverbal dichotomy, however, would not explain the results of this study. The successive factor in this study could be termed a verbal or language factor as each task has language content and would require some degree of language ability for adequate performance. Verbal Fluency, however, another language content task, loaded highest on the planning factor. The simultaneous factor could be interpreted as a nonverbal factor as no verbal or language tasks loaded highly on this factor, but the verbal/nonverbal approach would not account for the planning factor which also had high loadings for nonverbal tasks as well as a verbal task.

Further, the two factor solution of the principal factor analyses discussed earlier is more appropriately interpreted as a coding-planning dichotomy rather than a verbal-nonverbal dichotomy. Both factors in this solution have high loadings for nonverbal tasks making a two factor distinction based on the verbal/nonverbal dichotomy untenable. Luria (1966b) and Das' (1979) claim that successive-simultaneous coding
operate across such ability distinctions as verbal/nonverbal is more consistent with the results of this study.

**Theories of Lateralization and Cerebral Specialization**

Recent theories regarding laterality and cerebral specialization have focused less on ability distinctions such as verbal/nonverbal and more on processing distinctions. Gazzaniga (1983) has noted that a strict left-right hemispheric distinction is misleading while Nebes (1974) has noted that it is the coding required to perform a task that determines which hemisphere will be dominant. Nebes (1974) notes that the left hemisphere analyzes information sequentially associating verbal symbols to the details. The right hemisphere analyzes information in terms of its totality or holistically. Cohen (1973) too has emphasized the processing distinctions noting the left hemisphere to process information serially and the right to process information in parallel.

The comments of Gazzaniga, Nebes, and Cohen shift the focus from distinctions based on content (verbal/nonverbal) to distinctions based on processing. This does not negate the larger role of the left hemisphere with language and the right with visuo-spatial information for, as noted by Semmes (1968), the left hemisphere may be arranged in a more focal manner which requires it to process information serially while the right hemisphere may be arranged in a more diffuse manner allowing it to process information holistically.
Dual coding theories such as those proposed by Cohen and Nebes, are similar in many respects to the successive-simultaneous coding processes proposed in the Luria/Das model. The constructs of serial or sequential coding are similar to successive coding as the constructs of holistic or parallel coding are similar to simultaneous coding. Dual coding theories, however, do not entirely explain the results of this study specifically with regard to the planning factor. The Luria/Das model is more comprehensive in that it proposes a planning factor and this model is more consistent with the data of this study.

Visual-Auditory

Psycholinguistic theories such as the one underlying the ITPA (Kirk, McCarthy, Kirk, 1968), attempt to differentiate human functioning based on perceptual abilities, largely visual and auditory. The simultaneous factor in this study could be labeled a visual factor since all the tasks are presented visually. This does not account, however, for Trail Making, Visual Search, and Successive Codes, all visual tasks, loading on a separate factor. Further, the successive factor could also be labeled an auditory factor since all tasks are presented via the auditory modality. This would not account, however, for Verbal Fluency, an auditory task, loading highest on the planning factor. It is not possible to interpret the results of this study using a visual-auditory distinction. The Luria/Das model proposes that successive-simultaneous and planning processes operate on information without respect to sensory receptor. This statement is more consistent with the results of this study.
The Relationship With Reading Achievement

The Inferential Comprehension subtest of the Stanford Diagnostic Reading Test obtained its highest loading on the simultaneous factor (.347) while obtaining a loading of .233 on the Successive factor. This suggests that simultaneous coding may exert a greater influence on inferential comprehension than successive coding. This is consistent with the results of McLeod's study (1977) which found a main effect for successive coding (in the negative direction) for the production of backwards inferencing. The Literal Comprehension subtest of the Stanford Diagnostic Reading Test split its loadings between the successive (.379) and simultaneous (.362) factors indicating a relatively equal role for the coding processes with regard to literal comprehension. The WRAT Reading Recognition subtest also split its loadings between the successive (.372) and simultaneous (.448) factors. Perhaps the most defensible interpretation of these results is that, for this grade 4 population of normal students, successive and simultaneous coding are equally important for reading achievement. This is consistent with the results of Kirby & Das (1977) with a similar grade 4 population. At this age level, the planning factor accounted for little of the variance in the measures of reading achievement.

Implications for Future Research

This research addressed the validity of the Successive-Simultaneous-Planning constructs as proposed by Das, et al. (1975). It did not address the comprehensive model, however, which also includes the construct of arousal. The importance of this construct has been emphasized
(Das, 1986, in press) and future research regarding the validity of the model should include the construct of arousal.

Another important concern for future research is the affect of cognitive development on the loadings of various tasks. The limited developmental research done to date (Das & Molloy, 1975; Jarman & Das, 1981) indicate that development is a variable which affects not only the strength of a factor loading, but the factors on which a task will load.

It will also be important, in light of the present study, to further explore the relationship of various aural, verbal tasks to the simultaneous factor and visual, nonverbal tasks to the successive factor.

The relationship between the model and reading achievement also needs to be further researched. The differential relationship of the successive, simultaneous, and planning constructs to various areas of reading achievement is far from clear. The role of planning in particular needs to be studied. This study, in contrast to others, indicated a limited role for planning. The relative affects of successive-simultaneous and planning processes on reading decoding and reading comprehension needs to be explored and particularly in regards to such specific concerns as phonetic and whole word instruction, speed and level of comprehension, and literal and inferential reading comprehension. Additionally, the affects of development on the various relationships between the constructs of the model and various aspects of reading would prove a valuable addition to the literature on the model.


APPENDIX A

DESCRIPTIONS OF SUCCESSIVE TASKS
Digit Span (Forward)

This task is taken directly from the WISC-R (Wechsler, 1974) Digit Span subtest. Scoring and administration procedures are the same as those contained in the manual. The task requires one to recall, verbally, progressively longer series of digits presented orally at the rate of one digit per second.

Serial Recall

This task requires one to immediately recall, verbally, a list of four words. Twenty-four groups of 4 words are given. The words in each group are either acoustically similar or neutral. Each series of words is scored for words repeated in the correct serial position. Individuals are not penalized for recalling words not actually presented. Further details regarding scoring and administration are presented in Das, et al. (1979).

Free Recall

The same list of words used in Serial Recall are used in free recall. The scoring, however, depends on the total number of words correctly recalled without regard to their serial position. Thus, if an individual recalls two of the four words presented, their score is 2. It is possible, in one administration, to obtain both Serial Recall and Free Recall scores. See Das (1972, 1973).

Visual Short-Term Memory

This test consists of 12 items each of which is a five-cell cross-shaped matrix with one number in each cell. The items are presented on
a screen by a slide projector. Each item is viewed for 5 seconds and is followed by a 2 second color naming task to prevent rehearsal. The individual is then required to recall, by writing down the correct position of the numbers. One earns one point for each number correctly placed. The maximum score is 50. See Das, et al. (1979).

**ITPA Auditory Sequential Memory**

This task is taken from the ITPA (Kirk, McCarthy & Kirk, 1968). It is said to measure one's ability to reproduce a series of digits presented orally. The series increases in length from 2 to 8 digits. The digits are presented at the rate of 2 per second contrasted to the one per second presentation of the WISC-R Digit Span subtest. See the manual of the ITPA (Kirk, McCarthy & Kirk, 1968) for more detailed scoring and administration procedures.

**Sequential Hand Movements**

This task requires one to produce a series of hand movements (using palm, fist, side of hand, and knuckles) demonstrated by the examiner. The number of movements increases from 1 to 6. This task is said to measure sequential memory although motor coordination also affects performance. See Naglieri, et al. (1981).

**Dichotic Listening (Sides)**

In this task, the child is instructed to report all the elements heard first in one ear and then in the other. The elements are digits and letters. See Das, Leong & Williams (1978).
**Dichotic Listening (Types)**

In this task, the child is instructed to report either all the digits first or all the letters first irrespective of ears. See Das, Delong & Williams (1978).

**Hand Patterning**

This task requires the child to reproduce a repetitive pattern of hand movements (using palm, side of hand, and fist). The patterns increase in length from 1 to 7 movements. The movements are demonstrated by the examiner who taps out three sequences of movements at the rate of one movement per second. Each sequence must be reproduced correctly for the child to receive credit. See Naglieri, et al. (1981).

**Memory for Words**

The child is orally presented with a series of familiar words given at the rate of one per second. The series increase in length from 2 to 6 words. The child is then presented a card with the silhouettes of the pictures of each word. They are asked to point to each silhouette in the same order as they were orally presented. The difficulty is increased with later items by the presentation of an interference task. See Naglieri, et al. (1981).
APPENDIX B

DESCRIPTIONS OF SIMULTANEOUS TASKS
Raven's Progressive Matrices

This test was introduced by Raven in 1960 as a measure of intellectual reasoning for children 5 to 11 years of age. The test consists of 36 matrices each missing a part. The individual is to choose the missing part from six possible choices. There are three series of twelve matrices of increasing difficulty. The total number of correct responses is recorded as the individual's score. Administration procedures and scoring criteria are contained in the manual (Raven, 1960).

Graham and Kendell's Memory for Designs Test

This test was introduced in 1960 by Graham and Kendell. It was devised as a measure of visual memory. The test consists of 15 straight line designs which the individual views for 5 seconds and then reproduces. Scoring criteria and administration procedures are detailed in the manual (Graham & Kendell, 1960).

Figure Copying

This task is taken from the school readiness battery developed by Ilg and Ames (1960). It requires the individual to copy 10 geometric designs from a model. The designs increase in difficulty. The scoring emphasizes reproduction of the basic gestalt rather than an exact reproduction. Scoring criteria and administration procedures are given in the manual (Ilg & Ames, 1960).

Cross-Modal Coding

This task was adapted by Das from one used by Birch and Belmont (1964). The task requires individuals to listen to patterns of sounds
and identify which of three visually presented dot patterns resemble the auditory stimuli. As such, the task was to tap one's ability to code auditory information and recall it visually. Das (1972, 1973) modified the task to take into account two possible defects. These defects were in the presentation and included the timing of the taps and the fact that the individuals could see the examiner tapping thus introducing a visual component in an allegedly auditory-visual integrative task. Das corrected these defects by tape recording the entire task. For more information see Das, et al. (1979).

**ITPA Visual Sequential Memory**

This task is a subtest of the ITPA (Kirk, McCarthy & Kirk, 1968) and administration and scoring procedures are detailed in the manual. This test is said to assess one's ability to reproduce sequences of non-meaningful figures from memory. The child looks at a series of figures, increasing in length from 2 to 8, for 5 seconds then uses chips to reproduce the sequence.

**Figure Grouping**

This task is from the Science Research Associates Primary Mental Abilities Kit (Thurstone & Thurstone, 1962). It is said to be a measure of reasoning. The individual is to choose which of four figures is not like the others. See Kirby & Das (1978).
Work Grouping

This task was also taken from Thurstone & Thurstone (1962). It is said to be a measure of reasoning. The task requires one to choose which four words is not like the others. See Kirby & Das (1978).

Spatial Relations

This task (Thurstone & Thurstone, 1962) requires one to choose which of 4 shapes will make a square when added to an already given shape.

Card Rotations

This task is taken from French, Ekstrom & Price's kit (1963). It is said to be a measure of spatial ability. The task requires one to indicate whether a given figure has been rotated within the same plans or flipped. Guessing is penalized on this task by subtracting the number wrong from the number right. See French, Ekstrom & Price (1963) as well as Kirby & Das (1978).

WISC-R Block Design

This task is a subtest of the WISC-R (Wechsler, 1974) and is said to measure nonverbal reasoning. The task requires one to reproduce a two color abstract design with from 4 to 8 blocks. It is a timed task. Score and administration procedures are contained in the manual (Wechsler, 1974).
**Triangles**

This task is said to measure spatial reasoning. It is also noted to be affected by one's visual motor coordination. The task requires one to reproduce a one color abstract design with from 2 to 9 triangular shaped pieces. This task is not timed. It is intended to be a variant of Wechsler's Block Design subtest (Wechsler, 1974). See Naglieri, et al. (1981).

**Overlapping Designs**

This task requires the child to reproduce 25 hexagon shaped designs of varying amounts of 4 colors (yellow, white, blue, black) using a set of 8 irregular geometric shapes, 2 of each color. The child must place the irregular shapes one on top of the other using the number necessary to duplicate both the hexagon shape and size. This task is not timed. See Naglieri, et al. (1981).

**Concept Formation**

This task is based on Bruner's research. The individual is given 6 pictures or drawings 3 of which are a positive instance of a concept and 3 of which are not. The individual is told what the unifying concept is for the first 2 items. For the remaining 45 items, the examiner simply identifies which of the stimuli are or are not examples of the concept. After this set, the child is shown 5 new drawings and asked to identify whether each is or is not an example of the concept. The visual stimuli consist of 1/4 abstract shapes/designs and 3/4 concrete, meaningful pictures. See Naglieri, et al. (1981).
Memory for Places

This task presents the individual with a page on which 1 to 7 drawings of familiar objects are arranged in varying positions. The individual observes this page for a time corresponding to one second for each pictured object. The page is then removed and replaced with a page divided into a grid of boxes. The individual is required to point to the locations corresponding to the position of the objects previously exposed. The grid increases from one 3x3, to one 3x4, and, finally, to one 4x4. There are 32 total items. See Naglieri et al. (1981).
APPENDIX C

DESCRIPTIONS OF PLANNING TASKS
Trail Making Test

This test was part of the Army Individual Test of General Mental Ability (1944). It was adopted by Armitage (1946) who reported it as a measure of planning. The test has an intermediate level for ages 5 to 14 which is divided into two parts. In Part A, one is to connect encircled numbers in the correct numerical order while in Part B letters and numbers are presented and one is required to connect the letters and numbers in the correct increasing sequence. The procedure used by Armitage was used by Ashman & Das (1980) with the exception that the test was given individually. See Ashman & Das (1980).

Visual Search

Ashman & Das (1980) adapted this task from one used by Teuber, et al. (1949). Overhead transparencies were prepared consisting of 48 geometric shapes, letters, and numbers. A circle in the center of each transparency contained a copy of the target. One is required to point to the one among the 48 which matches the target. Both search time and reaction time are electronically recorded. See Ashman & Das (1980).

Verbal Fluency

This task is taken from Thurstone and Thurstone (1941). It is divided into two parts, each prepared in an individual booklet form. In the first part, one is required to write as many words beginning with the letter "B" as possible in 2 minutes. In the second part, one is to write as many four-letter words beginning with the letter "C"
as possible in 2 minutes. Total number of words written minus repeated, meaningless, or foreign words is recorded as an individual's score. See Ashman & Das (1980).

**Planned Composition**

To obtain written composition, Picture 2 of the Thematic Apperception Test of Murray (1943) was projected onto a screen for 20 minutes. Individuals were required to write a one-page story about the picture. Each essay was transcribed onto a rating form and distributed to four grade 8 language arts teachers for evaluation. The teachers were to read each story, then assess the essay according to the perceived quality of the underlying plan and logic. The rating of the compositions was carried out employing a Likert-type scale similar to that of Diedrich (1974). The rating of interest for planning was organization which would indicate the underlying plan and logic. See Ashman & Das (1980).