Field dependence-independence and reading achievement of sixth grade children
by Dorothy Fay Bush Schillings

A thesis submitted in partial fulfillment of the requirements for the degree of Doctor of Education
Montana State University

Abstract:
The problem of the study was composed of two parts: (1) could reading achievement scores be predicted from scores of a measure of field dependence-independence and (2) to determine if a composite of the independent variables (field dependence-independence, intelligence, gender, race, age, and socioeconomic status) might be used to classify individuals into selected reading groups.

Stepwise multiple regression was used to analyze the data for prediction. The F test was applied to determine if the was significant at the P <.05 level.

Discriminant function analysis techniques were used to determine composites of the independent variables to classify the cases in the study into reading group membership. The chi square statistic was used to test for the significance of the discriminating functions at the P < .05 level.

The conclusions of the study indicated that the measure of field dependence-independence used in the study was statistically significant at the < .05 level from the stepwise multiple regression analysis. However, the variance was so small and combined with other variables that the measure alone could not predict reading scores. Discriminant analysis revealed significant discriminant composites for identifying likely reading group membership for individuals. It was concluded that the measure of field dependence-independence utilized in the study could be helpful as a supplement to the assessment procedures used by educators in the development of programs to enhance the reading achievement of sixth grade children.

Recommendations included suggestions for studies in field settings applied to field dependence-independence and (1) information processing; (2) stability or change in individuals over the time spent in school; (3) black children, especially females , to determine possible school influences; (4) classroom influences such as classroom organizational patterns; (5) the study profiles of children; (6) different types of curriculum materials; (7) teacher awareness of information processing differences of individuals; (8) parent awareness and involvement; and (9) teacher education programs.

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APPROVAL

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This thesis has been read by each member of the thesis committee and has been found to be satisfactory regarding content, English usage, format, citations, bibliographic style, and consistency, and is ready for submission to the College of Graduate Studies.

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ABSTRACT

The problem of the study was composed of two parts: (1) could reading achievement scores be predicted from scores of a measure of field dependence-independence and (2) to determine if a composite of the independent variables (field dependence-independence, intelligence, gender, race, age, and socioeconomic status) might be used to classify individuals into selected reading groups.

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CHAPTER ONE

Introduction

Educators have long been aware of individual differences in children and that gaps in achievement widen, especially in reading (Chall, 1983), as students progress through elementary school (Daneman, Carpenter, and Just, 1982). Authorities (Bloom, 1976; Bruner, 1966; Carroll, 1963; and Lesser, 1971) considered those differences to be related to the failure of accommodating instructional programs to individual differences as the learning environment is structured and instructional methods and strategies are planned.

Sternberg and Powell (1983) suggested that if the variables which account for individual differences can be identified and if instruction is adapted to individual needs, then maximum individual achievement might be realized. Educators included many different variables such as achievement, intelligence, and age in planning for individual differences. However, cognitive styles which also vary with individuals, have been considered infrequently (Saracho, 1984).

Cognitive styles, a psychological term defined by investigators, referred to the relatively stable ways individuals tend to process information. The investigators used the term to describe how one perceives, remembers, thinks, and solves problems. Of the more than nineteen cognitive styles identified, the common element underlying all of them was that each represented a contrast between two ways of cognitive functioning influenced by different sets of interacting characteristics within individuals (Messick, 1976; 1979).

Field dependence-independence, a cognitive style investigated by Witkin and his associates for more than thirty years (Witkin, Moore, Goodenough, and Cox, 1977), has generated more than 3000 references (Kogan, 1980). Field dependence-independence was described as contrasting ways in which individuals do the following: (1) locate and use basic elements from materials that are already organized (2) structure information that is unorganized, and (3) provide a different structure from that suggested in the available information (Frank, 1983).

According to Witkin and Goodenough (1977), field dependent individuals differed from field independent individuals in how they structured information and in how they reacted to cues available to them in a task situation. Field dependent subjects often required outside help (teachers) to structure material that had little or no

structure. They were dominated by the most obvious cues in a task situation while they ignored cues that were important but not as obvious.

In contrast, field independent individuals functioned with little outside help in organizing and structuring tasks. They attended not only to the obvious cues but also the other less obvious ones that were available (Goodenough, 1976; Witkin and Goodenough, 1977). Witkin and Goodenough (1981; cited in Frank, 1983: 90) considered field independent individuals to be more "flexible information processors" than field dependent individuals.

Field dependence-independence was grounded in Gestalt psychology with its emphasis on mental organization (Witkin and Goodenough, 1981). An area of cognitive psychology, information processing theory, influenced the developers of reading models that emphasized basic thinking processes (Anderson and Pearson, 1984). It could be hypothesized that field dependence-independence might be related to the cognitive processes underlying reading comprehension. In information processing theories, people were viewed as having the capacity to transform, store, retrieve, and use information when it is needed. Thus, how "information from print is taken in and transformed to meaning" was described in information processing models of reading (Samuels and Kamil, 1984: 191).

The influence of an information processing approach to

the study of cognitive processes related to reading can be seen in the reading models developed during the 1970s and 1980s (Gough, 1972; Kintsch and van Dijk, 1978; LaBerge and Samuels, 1977; Rumelhart, 1977). Although all of these reading models were developed with an information processing base they differed in several important ways. Models were conceptualized according to how reading processes flowed through an information processing sequence.

If reading comprehension were an information processing activity as suggested by these models and since field dependence-independence, assessed by the Group Embedded Figures Test, was described as a measure of differences in how individuals process information, then it might be helpful for curriculum directors, reading specialists, classroom teachers, or others to be aware of these differences. The specialists might utilize information on each child's cognitive style, field dependence-independence, in the development of a most effective reading program for each individual.

Kirby (1984: 51) expressed the idea that as more elaborate models of human information processing, taking into account individual differences, were developed from cognitive psychology, such models needed to be applied in schools. He pointed out that curriculum specialists should work to add the analysis of cognitive processes to assessment procedures used in schools. After that,

instruction might be designed to include information concerning individuals' cognitive processes. Using that type of approach would provide "a more realistic and coherent framework" for the investigation of educational problems than an approach using only information gathered about individuals from the traditional psychometric perspective.

Mayer (1981) argued that the psychometric approach now used in schools in locating and measuring individual differences was inadequate since the processes underlying these differences were not described. In addition, Anastasi (1984: 181) stated:

> Analyzing individual performance at the level of basic cognitive processes should eventually make it possible to pinpoint each person's sources of weakness and strength and thus enhance the diagnostic use of tests.

Lohman and Kyllonen (1983) commented that good psychological models of individual differences in school learning have not been generated. They pointed to recent developments in cognitive psychology for attempts to understand individual differences in cognitive processes and structures as those processes and structures relate to complex problem solving and school learning. This (Lohman and Kyllonen, 1983: 106) might help educators "to adapt instruction to the relatively stable charactistics of the learner or to directly train these characteristics." Wittrock (1978: 90) agreed and contended that "potentially

significant contributions ... to the individualization of instruction" might be made through research on cognitive style.

The present investigator first became interested in reading comprehension as a reasoning, thinking process while teaching in the elementary classroom. The interest continued with work in teacher training at the university level. In the elementary school, at the upper levels, the curriculum began to require reading tasks that demanded not only the ability to decode the material but also to organize and restructure it for comprehension. Due to these needs, numerous requests from classroom teachers for extension courses and for workshops concerned with reading comprehension were made to interested individuals at the university. It is hoped that the present study will point to an area of individual differences not widely examined by teachers and that it may offer aid in instructional planning to enhance the reading achievement of children.

Statement of the Problem

The problem of the study was to investigate the relationships between reading comprehension and field dependence-independence of sixth grade children. The problem had two components: (1) to study relationships between reading achievement and field dependence-independence, intelligence, age, gender, race, and socioeconomic status at the sixth grade level; and (2) to

examine the composites of the variables (field dependence-independence, intelligence, age, gender, race, and socioeconomic status) that show maximum differences and minimum overlap among reading achievement groups.

Need for the Study

The need for the study was derived from three viewpoints: (1) the continuing commitment of educators and the public to identify and provide for individual differences of children to assure their competency in reading; (2) suggestions from investigators from the fields of education and psychology concerning the need for a better understanding of how children process information; and (3) because of limited and confusing results revealed from an examination of studies on the relationship of field dependence-independence to the reading achievement of upper-elementary children.

Recognition of differences in individuals and the commitment to accommodate them has been accepted by educators and expected by the public regardless of these differences (Wardhaugh, 1969). Many different types of instructional materials and organizational plans for schools have been tried to meet these expectations (Fries, 1963; Smith, 1969). Gibson and Levin (1975) commented that in spite of more than forty years of concentrated effort problems still existed. One of the problems they cited is that as many as twenty-five percent of the children in

school read below their expected level. Guthrie (1984) reported that a study commissioned by corporations with sales of over $100 million found deficiencies in reading of their employees that were severe enough to cause a loss of time and productivity.

Williams (1981) stated that since the 1950s courts and legislatures assume an active part in public education. He interpreted the court as saying each child comes to school with individual differences implying that teachers are obligated to develop reading instruction based on each child's needs. Pavlonnis reported (1985) that, in Montana, the courts ruled that juvenile delinquents were handicapped students. As such, school districts were required to provide an appropriate education or bear the expense of a suitable program wherever it could be found.

Educators, as well as the public, pointed to the seeming inability of schools to assure success in reading after the primary grades (Durkin, 1978-1979). The editors of Reading Research Quarterly (1982) stated that although reading achievement test scores from many systems compared favorably in the primary grades they began to fall in the upper-elementary grades. The concerns expressed by these authors implied that different approaches to reading instruction may be needed to assure the success of all children.

Durkin (1978-1979) stated that there is already a

considerable body of knowledge on decoding but little on the processes underlying the comprehension of written material. Travers (1982) added that little is known about how the reader organizes what he reads. Otto and White (1983) recommended research that focused on the reader since the question of what thinking processes the reader uses as he reads is not understood (Golinkoff, 1975-1976; Travers, 1982). However, the failure to consider how children process information could result in having them placed in a series of inappropriate and unsuccessful programs in school (Saracho, 1984).

Research on field dependence-independence and reading achievement has been limited and conflicting (Saracho, 1984; Spiro and Tirre, 1980). Only a few studies concerning sixth grade children, field dependence-independence and reading achievement were located. The studies differed in size of sample, test used to measure cognitive style, and the type of statistical analyses applied. Logan's (1983: 706) recommendation that "future investigations of pupils' cognitive styles and their relationships to reading development are warranted" might have been influenced by those reported differences.

General Questions to be Answered

The following questions will be investigated in the study:

1. What is the relationship between reading

achievement and field dependence-independence, intelligence, age, gender, race, and socioeconomic status?

a. How strong is the relationship?

b. How important are the various independent variables to the relationships?

c. What is the relationship between reading achievement and field dependence-independence with the effect of the other independent variables removed?

2. What are the dimensions along which the reading groups differ?

a. Which independent variables contribute to the differences among groups on the dimensions?

b. What is the degree to which members of the reading groups may be accurately classified?

General Procedures

The general procedures followed in this study were:

1. Completed an extensive literature search related to the theoretical basis and research. An ERIC search was conducted in the spring of 1984 for the years from 1963-1984. The descriptors used were: field-dependence-independence, cognitive style, sixth grade, reading achievement. A manual search through April, 1985 supplemented the ERIC search.

2. Identified the variables of the study and selected the statistical analyses.

3. Selected a school and obtained permission to

conduct the study.

4. Developed precautions to assure anonymity of the children.

5. Arranged a testing schedule and tested the children.

6. Tabulated, coded, checked, analyzed, and corrected the data.

7. Drew conclusions and made recommendations.

Limitations of the Study

Limitations of the study are:

1. The sample was limited to the children from one school composed of nine classrooms of sixth grade students situated in a small southern city where a university is located.

2. Data utilized in the study were limited to the following variables: (1) reading achievement, (2) field dependence-independence, (3) intelligence, (4) race, (5) sex, (6) age, and (7) socioeconomic status.

3. Some data obtained for the study were dependent on information maintained and collated by personnel from the school district.

4. The references used in the study were limited to those available at Auburn University and Montana State University or those obtained through the interlibrary loan at Montana State University.

Definitions of Terms

The following terms were used throughout the study:

Embedded Figures Test (EFT). Individual measure of field dependence-independence. It is a twelve item verbal-manual test which requires the subject to "locate and trace a previously seen simple figure within a larger complex figure" from a card set (Sweetland and Keyser, 1983).

Cognitive Style. A person's characteristic and consistent manner of processing information (Messick, 1976).

Construct. A particular form of a concept, an idea or perception resulting from an orderly arrangement of facts or impressions. A constructed variable is in contrast to an observed variable (Messick, 1976).

Field Dependence-Independence (FDI). Cognitive style process variables representing restructuring skills described as contrasting ways individuals (1) locate and use basic elements from organized material, (2) structure information that is unorganized, and (3) provide a different structure from that suggested by the materials utilized. Field dependents are less autonomous and need outside help in structuring or organizing tasks. Field independents are more self-reliant and more likely to impose structure themselves. This cognitive style is associated with thinking and problem solving (Frank, 1983; Witkin and Goodenough, 1981).

Group Embedded Figures Test (GEFT). A paper-pencil

test used to assess field dependence-independence developed by P. K. Oltman, E. Raskin, and H. A. Witkin (1971). The test contains eighteen items. The subject is required to locate and outline in pencil a simple figure in a complex design. The test was developed for group use and for ages ten to adult. It is hand scored from a key furnished by the publishers.

Groups I, II, III, and IV. Groups designated by the investigator from reading achievement test scores. This allowed the investigator to identify the composites of the independent variables that show the maximum differences among group means of composite scores and the minimum overlap in the distribution of these scores (Thorndike, 1978). Group I, zero to the twenty-fifth percentile; Group II, the twenty-sixth percentile to the fiftieth percentile; Group III, the fifty-first percentile to the seventy-fifth percentile; Group IV, the seventy-sixth to the one hundredth percentile.

Race. Designated black or non-black in the study.

Reading Achivement. Assessment of reading comprehension measured by the California Achievement Tests, Form C, Level 16 (CTB/ McGraw-Hill, 1981).

Reading Comprehension. "...[S]tudents' understanding, recall, and integration of information stated in or inferable from specific text passages. (Tierney and Cunningham, 1984: 610)." Measured by the California

Achievement Tests, Form C, Level 16 (Monterey, CA: CTB/ McGraw-Hill).

Rod and Frame Test (RFT). Forerunner of the Embedded Figures Test and the Group Embedded Figures Test. It required the subject, seated in a darkened room, to adjust a luminous rod to a vertical position within a tilted luminous frame. The aim was to identify differences of individuals in their perceptions of space orientation so that their personality differences could be investigated (LaVoie, 1984).

Short Form Test of Academic Aptitude (SFTAA). A revised form of the California Short Form Test of Mental Maturity. The test contains four sections (Vocabulary, Analogies, Sequencies, and Memory). The scores from the four areas yield composites of language and nonlanguage aptitudes. It can be used from grades 1.5-12. The test was standardized on the same norms as the California Achievement Tests (Aiken, 1979). The Kuder-Richardson - 20 reliability coeficients range from .65 to .91 for Vocabulary, Analogies, Sequencies, and Memory, from .84 to .93 for Language and Nonlanguage, and from .90 to .96 for Total (Shoemaker, 1972).

Socioeconomic Status (SES). A person's rank in relation to certain demographic factors used as indicator to assess "life chances" in contrast to prestige ratings. There are many approaches and no single generally accepted

socioeconomic status classification scheme in use by social scientists. Most of the scales and indices included occupation as part of the measure, but other factors such as income, housing, and education as well as other variables were also included. A basic assumption underlying the selection of items used for measuring socioeconomic status was that the status of the family was indicated by the status of the income earners (Nam and Powers, 1983). The factors used as indicators of and influences on life chance in the present study included; (1) home ownership, (2) if the parents live in the home, (3) number of years of schooling of the parents, and (4) occupation of parents.

The first procedure in the development of the study was to conduct an extensive review of the literature. The review was undertaken to establish the theoretical bachground for the study and to investigate the research related to field dependence-independence and reading achievement. This follows in Chapter Two.

CHAPTER TWO

Review of the Literature

In this chapter the investigator reviewed the field dependent-independent cognitive style with developments in the study of reading and how those developments converged through expansions in psychology and education to form the background for the present investigation. The theoretical framework underlying the study was based in several related disciplines: (1) the early influences of investigations from experimental psychology and psychometrics; (2) the organization of thinking and problem solving rooted in Gestalt psychology which influenced Witkin (1977) in his studies of field dependence-independence; and (3) information processing theories from cognitive psychology expressed in recently developed models of reading comprehension. Specifically, the review examined the pervasive role of individual differences; how individual differences have been studied in the past, field dependence-independence as a means of identifying individual differences in certain information processing chacteristics; and research on field dependence-independence and reading

that suggested the problem of the study.

Early Experimental Psychologists and Individual Differences

According to Glaser (1983: xi) the study of "individual differences in cognition is as old as the beginnings of scientific psychology and ... as new as modern cognitive psychology." He pointed out that although mental processes as individual differences were acknowledged as fundamental they were not analyzed separately by the early experimental psychologists. Those investigators were interested in discovering general laws of nature which could be applied to everyone rather than differences in individuals (Glaser, 1977; Tyler, 1965). Their work provided the foundation leading to the mental testing movement.

Individual differences in mental processes were recognized as early as 1816 by Friedrich Bessel, an astronomer. While examining a history of the Greenwich Astronomical Laboratory, he uncovered a report of the dismissal of a young assistant who reported the time of transit of stars across a line in a telescope to be one second after that reported by his mentor. This led to Bessel's investigation of reaction times of fellow astronomers and the discovery that differences of individuals in the time they reacted to a visual stimulus did exist. The work was important because it indicated that at least one mental characteristic could be measured (Tyler, 1965).

Sir Francis Galton's work on determining the characteristics of geniuses was reported in 1869. Its problems of measurement led to his development of tests of mental abilities. He established the Anthropomorphic Laboratory in London and used the tests in investigations from 1884 to 1890 causing Carroll (1965) to credit him with the invention of the mental test. The idea of differences in heredity posed by Francis Galton and the development of correlation in statistics created by Galton and systematized by Karl Pearson were then available for use in the investigations of others that followed. Although Galton conceptualized correlation and regression he applied it only to the studies of inherited traits, but not in the analysis of mental test results. Carroll (1978: 6) stated that no important information concerning individual differences came from this work on mental tests except that such differences tended "to be distributed according to the Gaussian law of error."

Wilham Wundt, a philosopher-physiologist who called himself a psychologist, was the first to use the term "experimental psychology". He worked to advance psychology as a science and began a laboratory at Leipzig in 1879 where many students came to study elements of the mind by introspection. Although he was interested in child development and the higher mental processes among other topics, he thought they could not be studied experimentally

(Hearst, 1979). He was not interested in individual differences and either ignored them or treated them as error (Anastasi, 1965).

Several of Wundt's students became leaders in the field of experimental psychology. Among them was his self-appointed assistant James McKeen Cattell, who was interested in and studied individual differences. Cattell's interest led to his investigations of basic reading processes and work on mental tests and measurement. On his way back to the United States he stopped for a time at Galton's laboratory in London and on his return to this country incorporated the notion of standard tests into his ideas of mental processes. He introduced the term "mental test" in his writings in 1890 (Venezky, 1984). Also, he worked to establish laboratories for experimental paychology and was involved in the mental testing movement. "The newly established science of experimental psychology and the newer testing movement merged in Cattell's work" according to Anastasi (1968: 8).

The Testing Movement and Individual Differences

Glaser (1977) and others (Good and Stipek, 1983) explained that providing for individual differences in classroom instruction has been a continuing concern for educators since the beginning of the twentieth century. As school attendance increased so did the demand for means to measure individual differences (Tyler, 1965). Two early

investigators, Hermann Ebbinghaus and Alfred Binet, were commissioned to work on school problems.

Ebbinghaus (1897; cited in Tyler, 1965) investigated memory using nonsense syllables with himself as the only subject. He also worked on a school problem at the request of school officials in Breslau (Tyler, 1965). The problem was to determine the time of day that children were least efficient. He constructed three tests: rapid addition and multiplication, memory for digits, and a completion type. The tests were administered to the children before each period. The completion test was similar to the cloze test used today in that it required the child to fill in blanks deleted from a sentence or paragraph. The child was then required to decide on a word as a best fit for the blank from the context of the passage. The completion test discriminated better than the other tests among the poor, good, and average students. The fatigue problem was forgotten. From this study he deduced that the completion test pointed to the importance of a "combining function" in mental ability (Watson, 1963: 289).

Alfred Binet and his associates worked through many approaches in order to measure intelligence. This led to the conviction that intelligence could be measured best through "direct though crude measurement of complex intellectual functions (Anastasi, 1968: 10)." The opportunity to apply those ideas came through the request of

the Minister of Public Instruction who appointed a committee to study the problem of mentally retarded children in the Paris schools. In work for the French government to identify those children who could profit from schooling, Theodore Simon and Binet developed a scale for measuring intelligence in 1905. The scale was revised by Terman at Stanford in 1916 and became known as the Stanford-Binet test, the first standardized test of individual intelligence.

As Anastasi (1968) stated, the Binet tests and all revisions are individual tests. Group tests came about as the need became apparent for ways to classify men when the country became involved in World War I. A committee appointed by the American Psychological Association and directed by Robert M. Yerkes developed the first group intelligence tests. Those tests, Army Alpha and Army Beta, were based upon group tests donated by Arthur S. Otis who was Terman's student at Stanford (Anastasi, 1968). In World War II, more specialized tests were developed to meet the demand for tests as predictors of differences in the aptitude of people such as pilots and navigators needed for special jobs. The tests indicated that intelligence could be considered multidimensional rather than unidimensional as was thought earlier. After World War I the tests were released for everyone to use.

Although E. L. Thorndike wrote the first textbook on

educational measurement in 1904, it was not until after World War I that testing groups in education was begun (Goslin, 1963). Through statistical methods, test theory, and factor analysis (Spearman 1927; Thurstone, 1938: and Guilford, 1967, 1982) attempts were made to "define and organize" the information that was gathered. Individual difference factors measured through standardized tests (Glaser, 1983) were investigated. The pratical outcome of their work was the development of multiple aptitude batteries.

Large school surveys were undertaken and some interest was directed toward individual differences, but the main application of the tests in the schools was for dividing classes into homogeneous groups. This practice continued despite the indicators and arguments that individual differences were so specific that it is impossible to achieve true homogeneous grouping (Carroll, 1982).

Traditionally, individual differences considered in school practice were related to intelligence and aptitude. Those tests predicted outcomes in education. They were not designed to: (1) "...determine the different way in which different students learn best, (2) measure the basic processes that underlie various learning, (3) nor assess prerequisite performance capabilities required for learning a new task", according to Glaser (1977: 310).

Two developments during the 1940s and 1950s occurred

which influenced the construction of mental tests: (1) factor analysis and (2) growth in statistical theory of mental tests. Factor analysis showed that intelligence is multifaceted while statistical theory development allowed "new ways of constructing mental tests and studying their measurement characteristics (Carroll, 1982: 59)." Even though progress was made in mental test theory related to test scores, little progress has occurred in identifying those underlying characteristics that the scores measure. Glaser (1977: 310) pointed out that the psychometricians made a great impact on education in that "the major activity in educational psychology revolved around measurement and psychometric practice." Early investigators either ignored individual differences or were not concerned with individual differences related to learning and cognitive processes. Those developments led to the construction of learning theories not related to individual differences.

In educational pratice, Sternberg (1984) stated that since the development of the Binet tests there has been a strong link between the testing movement and education. He pointed out that the testing now used in the schools cannot yield the information that educators need to make the most informed decisions for instructional practice. The tests (mental measurement and achievement tests) do not provide information necessary for a program that emphasizes learning processes. He suggested that a combination of

the psychometric approach, some Piagetian ideas (not directly related to this study), along with an information processing approach should be used together since each emphasizes different aspects, all of which are needed for adaptive instruction.

Carroll (1982) stated that the latest theories concerned with mental testing were derived from information processing theory from cognitive psychology. Mental tasks including those found on mental tests of ability were thought to involve mental processes as depicted in information processing models (Carroll, 1982) and related investigations conducted by E. Hunt, Frost, and Lunneborg (1973) and Sternberg (1977). E. Hunt, Frost, and Lunneborg (1973, cited in Carroll, 1982: 76) thought that individuals differed in "speed, probability of transfer between different memory stores, and capacity of memory stores" which they considered were involved in the performance of any mental task, including mental tests. Sternberg (1982: 226) worked to "decompose performance on tasks into elementary information-processing components, and then to show the interrelation among the components used to solve various tasks requiring intelligent performance". According to Carroll (1982), the importance of the above work was that much more exact information could be obtained concerning cognitive abilities measured by standardized mental tests.

Cognitive Psychology and Information Processing

Cognitive paychology was generally defined as the study of human higher mental processes (memory, perception, learning, thinking, reasoning, language, and understanding) through analysis by scientific methods (Lachman, Lachman, and Butterfield, 1979; Mayer, 1981). Cognitive psychology had its roots in the work of the early experimental psychologists who studied the mind through self analysis (Leahey, 1981) and the Gestaltist who were interested in perceptual organization. Since the 1960s, some modern cognitive psychologists used information processing models to describe how the mind functions. Theoretical information processing models of how humans receive, act on, store, and retrieve information from their mental framework was described as similar to the way information is processed through a computer program (Mayer, 1981; Wagner and Sternberg, 1984).

Through models the developers expressed the idea that everyone has an information processing system (IPS) composed of parts through which information flows toward some response or output. The parts are short term sensory store (STSS), short term memory (STM), and long term memory (LTM).

Short term sensory store, STSS (also labeled sensory register, sensory buffer) was the point where information entered the system through one of the senses. It was

thought that STSS accommodated each of the senses, although few investigations were attempted with any except the auditory and visual senses. The greater part of the research involved the visual sense. In STSS, the incoming information was held briefly exactly as presented, but faded within a half second unless attended.

Short term memory (STM) was the storage area for information attended on from the short term sensory store (STSS), held for a short time (thirty seconds), and limited to seven items which would decay unless rehersed. STM was designated by some investigators as the store for all that one could be aware of at one time. Working memory (WM) was attached to STM by some developers. Also called intermediate memory, it was described as the store where conscious mental operations were performed. If the information held in STM or WM were acted on, it was then transferred to long term memory (LTM).

Long term memory (LTM), the third storage structure, had unlimited capacity. The information there did not decay, but parts might be lost because retrieval paths could be blocked by new information entering the system (Mayer, 1981).

Those storage components of the information processing system were designated memory structures to distinguish them from another component called memory processes (Klatzky, 1980; Matlin, 1983; Mayer, 1981). Memory

processes (control processes) were the processes used by the system to act on information held in the structures (stores). The memory processes constructed by Mayer, (1981) were not all inclusive (See Klatzky, 1980; Lachman, Lachman, and Butterfield, 1979). They are listed below:

> Attention. Transfering information from STSS to STM.
>
> Rehersal. Keeping information active in consciousness in STM ... .
>
> Chunking. Techniques for clustering information in STM.
>
> Operations in WM. Manipulating information in working memory.
>
> Encoding. Transferring information from STM to LTM.
>
> Searching LTM. Finding a target in LTM (Mayer, 1981: 25).

The structures and processes described in information processing models were depicted in flow diagrams developed by different theorists. The three structures (storage areas) were represented as boxes with one structure per box. The flow and direction of the control processes were symbolized by arrows. The following diagram (Figure I) was based on those developed by Klatzky (1980), Lachman, Lachman, and Butterfield (1979), Matlin (1983), and Mayer (1981).

The Expansion of Cognitive Psychology

As previously noted, cognitive psychology had its roots in the early work of the structuralists. Due to the

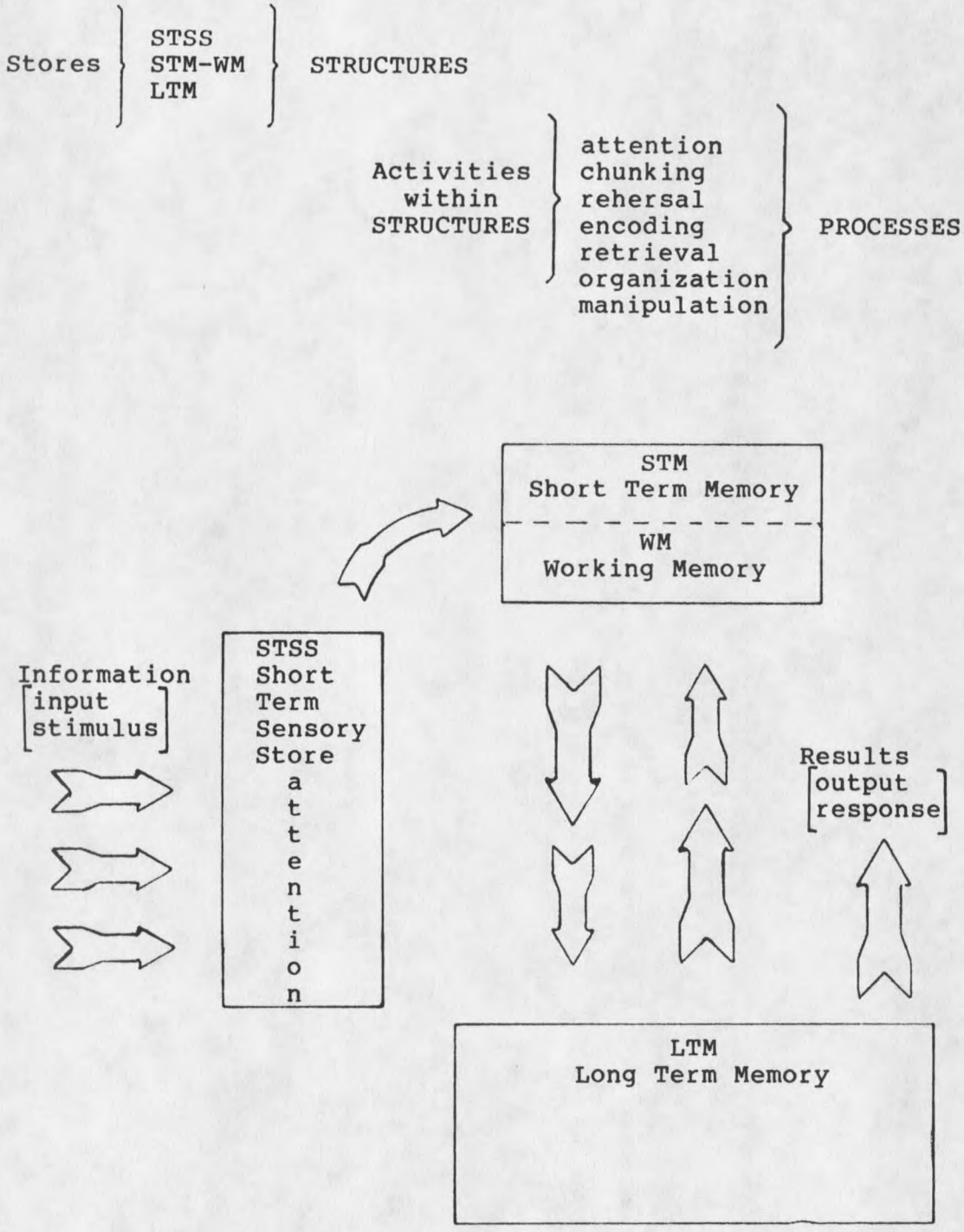

Figure I. Model of a human information processing system based on those developed by Klatzky (1980, 1984); Lachman, Lachman, and Butterfield (1979); Matlin (1983); and Mayer (1981)

reaction of the behaviorists against structuralism under the lesdership of John Watson in the United States, behaviorism became dominant in psychology from the 1920s to the 1950s. In contrast to the structuralists, the behaviorists contended that since mental processes could not be observed directly they could not be studied scientifically. At about the same time, in Europe, another reaction to the structualist developed from the Gestalt group. Gestaltists did study mental processes but did not have available to them the rigorous methods of analysis that they needed.

Important occurrences that had an impact on the development of cognitive psychology during and since the 1950s included : (1) The use of computers by psychologist (Newell, Shaw, and Simon, 1958) to examine problems in human behavior through computer analogies. That resulted in renewed interest in the study of mental processes since those processes could then be specified on a computer program; (2) the work of Noam Chomsky (1957) in linguistics where he examined language from a cognitive perspective; and (3) the developmental studies of Jean Piaget who focused on the cognitive processes that describe developmental changes in children (Mayer, 1981).

Traditional psychologists also presented new ideas. Bruner, Goodnow, and Austin (1956) in their work on strategies involved in learning concepts offered a cognitive interpretation. Miller (1956) in his article, "The Magic

Number Seven, Plus or Minus Two" encouraged the development of an information processing model for the study of cognitive processes. Miller, Galanter, and Pribram (1960) authored a book where the human was viewed as an information processor instead of just a responder to stimuli. These writers provided an alternative to the S-R behaviorists (Mayer, 1981).

In 1967, Neisser's book Cognitive Psychology appeared, in which he posed an information processing model of mental processes. The book was important because it showed that mental processes could be studied from a cognitive psychological base. It provided new analytic procedures that could be adapted for cognitive research in psychology (Mayer, 1981).

Information Processing and Individual Differences

Developers of information processing approaches assumed a general information processing system (IPS) for all people. They thought that individuals might differ in the structures and processes associated with the system. The structures and processes of the system were part of the IPS, but differences could occur among individuals in the size of each memory store and the character of the process of the system. Examples of the differences include variations in retrieval speed in long term memory (LTM), storage capacity in short term memory (STM), or attention in short term sensory store (STSS), which result in the

transfer of more information to short term memory (STM) before it fades.

Snow and Lohman (1984) concluded from their Aptitude Treatment Interaction (ATI) studies that not only qualitative differences could occur as mentioned above but also sequence and route variations might occur within individuals. The most important parts of the cognitive system were labeled assembly and control processes. These processes were designated higher order processes. They involved organization, reorganization, and monitoring processes of the dynamic cognitive system that caused it to adapt or learn within a task. It was thought that the assembly and control processes would be important as sources of ability-learning correlations in education (Snow and Lohman, 1984).

Knowledge was used, as well as processes, in the organization that was required for the individual to perform a task. Different tasks required different organizations. Individuals differed in how they assembled and controlled the processes that were necessary. Less successful participants demonstrated some degree of mismatching in the organizing components they assembled. The implication for instruction for individual differences along those organizing components was alternative teaching. Since the "able students prefer to exercise their own particular organization of abilities (Snow and Lohman, 1984: 351)."

instructional attention needed by the less successful learner would be detrimental to the successful one. If the instructional environment was not structured to accommodate those differences the students would not be able to perform cognitively in using their own personal assembly functions. In order to structure the environment to accommodate those differences, the planners of the environments needed means to measure cognitive processes (Snow and Lohman, 1984).

Measurement

Lyman (1978) stated that there are three types of tests in general use in schools today: intelligence tests, aptitude tests, and achievement tests. Intelligence tests (sometimes called mental maturity tests, mental ability, or scholastic appitude tests) have been used mostly to predict school achievement. Aptitude tests, also used for prediction, depended partly on achievement since reading was required to complete them. Achievement tests measured the amount of knowledge one had acquired. Anastasi (1983: 8) explained that those tests could be used as "predictors in the sense of assessing relevent prerequisites but not in the sense of future stability." She further stated that the tests were "descriptive" of an attribute of behavior and should be used only to "assess the current status" of individuals. None of the tests measured the underlying cognitive processes of individuals.

Another approach to measurement was that of Jean Piaget on the description of the development of children's thought processes assessed through specific tasks. The Piaget tasks were designed to assess "the development of specific concepts or cognitive schemata rather than broad abilities (Anastasi, 1983: 12-13)." Recently, the tasks were organized into standardized scales in experimental form. Although the Piaget tasks were more difficult and required more time to administer, they provided different information from that acquired from intelligence, aptitude, and achievement tests.

Cognitive psychologists applied information processing concepts to determine the processes underlying problem solving and to explore what intelligence tests measure. Investigators used puzzles, chess, word problems from algebra, problems in logic, and the spelling of English words (Simon and Hayes, 1976; cited in Anastasi, 1983) to determine individual differences in methods of problem solving.

In exploring what intelligence tests measured, researchers investigated separate areas. Carroll (1976) classified cognitive processes and structures related to factors identified by factor analysis from intelligence tests. E. Hunt and associates (E. Hunt, 1976; E. Hunt, Frost, and Lunneberg, 1973) used factor analysis to examine relationships between information processing laboratory

tasks they devised and scores on psychometric tests. Simon and Hayes (1976) used simulations of human problem solving related to number series completion tests and the Raven Progressive Matrices. Klahr (1976) developed simulation models to explain intellectual development as Piaget described in the transition of individuals from one developmental stage to another.

Sternberg (1982) proposed a framework for theory and research on problem solving and reasoning based on psychological constructs (components) and analyzed through an information processing approach. In the framework components were classified into three levels of generality with five kinds of functioning. The framework could be ... "applied to diagnostic and prescriptive problems in educational theory and practice..." according to Sternberg (1982: 234).

In light of the research reported above, Anastasi (1983) commented that the investigations should lead to a better understanding of what intelligence tests measure. This in turn should help to identify each person's weaknesses and strengths so that programs could be designed to meet individual needs.

Cognitive Styles

Cognitive styles, another parameter of individual differences, were designated by Messick (1984) as information processing constructs. He further classified

cognitive styles as organizing and controlling variables with implications for education. The measurement of individual differences in achievement in the content areas resulted in the description of psychological dimensions in content terms such as numerical ability. However, if emphases were placed on psychological dimensions of how an individual performed a task, the performance was described in terms of cognitive style.

Overview of Cognitive Style

Vernon (1973) speculated that the term cognitive style evolved from three sources. They were (1) "Perception: Approach to Personality" (Blake and Ramsey, 1951); (2) Klein (1954), when he discussed "perceptual attitudes" that represented a "style of organization"; and (3) Gardner (1953) who catagorized behavior. Nine categories from these sources, conceptualized by Messick (1970) were:

1. Field independence-dependence (Witkin, Lewis, Hertzman, Mackover, Meissner, and Wapner, 1954).
2. Reflection-impulsivity (Kagan, Rosman, Day, Albert, and Phillips, 1964).
3. Conceptual differentiation (Gardner, 1953).
4. Scanning (Gardner and Moriarity, 1968).
5. Leveling and sharpening (Gardner, Jackson, and Messick, 1960).
6. Constricted-flexible control (Smith and Klein, 1953).

7. Tolerance for incongruous or unrealistic experiences (Klein and Schlesinger, 1951).

8. Cognitive complexity (Kelly, 1955).

9. Breadth of categorizing (Pettigrew, 1958).

Messick (1976) modified and added to his list for a total of nineteen cognitive styles. Other writers named more and different ways of categorizing cognitive styles (Vernon, 1973; Goldstein and Blackmon, 1978; and Guilford, 1980).

Cognitive Style Defined. Cognitive style was defined by investigators in the following ways:

> 1. ... information processing habits ... characteristic modes of operation which, although not necessarily independent of content, tend to function across a variety of content areas (Messick, 1976: 190).
>
> 2. ... dimensions of individual differences involving the form of cognitive functioning with impressions in a wide array of content areas including perceptual, intellectual, social, interpersonal, and personality defensive processes (Goodenough, 1976: 675).
>
> 3. The mode in which a person organizes and classifies his perception of the environment in order to impose order upon a confusing series of events (Wolman, 1973: 67).
>
> 4. ... superordinate construct which accounts for individual differences in a variety of cognitive, perceptual, and personality variables (Vernon, 1973: 141).
>
> 5. ... individual variation in modes of perceiving, remembering, and thinking or as a distinctive way of apprehending, storing, transforming, and utilizing information (Kogan, 1971: 244).
>
> 6. ... stable individual performances in

> modes of perceptual organization of the external environment (Kagan, Moss, and Sigel, 1963: 74).

Specific Cognitive Styles: Definitions and Common Elements

From the thousands of studies (Vernon,1973; Goldstein and Blackmon, 1978), three prominent approaches to the study of cognitive styles emerged (Kagan and Kogan, 1970; Messick, 1970; Golstein and Blackmon, 1978). They were the investigations of Witkin and his associates (1954, 1962, 1977) on field independence-dependence; Kagan and others (1963) on reflection-impulsivity; and Klein (1954) on cognitive controls. Several constructs were developed from each of these cognitive styles (Kogan, 1971; Goldstein and Blackmon, 1978; Blackmon and Goldstein, 1982). Since each investigator defined styles based on theoretical interest, the constructs are listed, defined, and relationships are noted in the following:

1. Field independence-dependence (Witkin, Lewis, Hertzman, Machover, Meisner, and, Wapner, 1954). This cognitive style refers to the organizing and restructuring processes individuals utilize when solving a task (reading) and to the attention and use given to salient cues. Field dependent individuals tend to rely on others (teachers) for help in organizing or restructuring information. They attend to the most obvious cues but may ignore other important information. Field independent individuals impose structure on unorganized information and use all cues

that are relevant, both salient cues and not so obvious cues.

Field dependence-independence in this study was measured by how an individual extracted an embedded figure from a complex, confusing field on the Group Embedded Figures Test (Goodenough and Witkin, 1979).

2. Reflection-impulsivity were terms used by Kagan, Rosman, Day, Albert, Phillips (1964) to refer to the time and accuracy involved when a subject had been shown a picture and asked to choose a like picture from several that closely resembled the one shown. The reflective subject took more time and was more accurate in his selections. The impulsive subject tended to respond quickly and with errors.

3. Conceptual differentiation (Gardner, 1953), also labeled equivalence range, described how individuals functioned on sorting tasks. What individuals were willing to "accept as similar or identical" in free sorting tasks (Gardner, 1953: 229) were described. An individual high in conceptual differentiation and narrow in equivalence range used many categories in a free sorting task (Goldstein and Blackmon, 1978).

4. Scanning (Gardner and Moriarity, 1968). The investigations concerning scanning were made to examine the intensity of attention to a task (Kogan, 1971) in the "extent to which an individual checks the judgments he makes

(Goldstein and Blackmon, 1978: 468)."

5. Leveling and sharpening (Gardner, Jackson, and Messick, 1960). Those elements were used to refer to the degree of assimilation between events already perceived and stored in memory and a new event. Levelers had a high degree of assimilation (Goldstein and Blackmon, 1978).

6. Constricted and flexible control (Smith and Klein, 1953). Those styles were used to identify differences of individuals in how they responded to distracting stimuli (Goldstein and Blackmon, 1978).

7. Tolerance within individuals for incongruous or unrealistic experiences (Klein and Schlesinger, 1951) concerned individual differences in the willingness to accept perceptions which varied with conventional experiences (Kogan, 1971).

8. Cognitive complexity (Kelly, 1955) was defined as an information processing construct. The number of constructs a subject used in organizing or representing his environment was an index of his cognitive complexity. The more dimensions he used the greater his cognitive complexity.

9. Breadth of categorizing was the outgrowth of the work of Bruner, Goodenow, and Austin (1956) on thinking, in which strategies of concept attainment were explained in terms of "preferred modes of risk regulation". Pettigrew (1958) developed a paper-pencil questionnaire for assessing

category width (the C-W Scale) where the subject decided which of two types of errors he minimized. The risk of including an event when it did not belong was favored by a broad categorizer. The risk of omitting from the category something that belonged was preferred by the narrow categorizer (Kogan, 1971).

Common characteristics were noted among approaches to cognitive style even when definitions differed (Brody, 1972). Individual differences in styles of thinking were a starting point instead of emphasis on other personality factors (motivation, emotion, or biological processes). How an individual thought rather than what (content) he thought was investigated. Cognitive styles were commonly related to other personality characteristics of individuals, yet style characteristics were considered independent of situational influences (Goldstein and Blackmon, 1978).

Related Concepts

Other investigators who used related constructs were Tolman, cognitive maps; Bartlett and Piaget, schemata; and Lewin, differentiation and hierarchical organization (Goldstein and Blackmon, 1978). The present review was limited to those styles identified as constructs related to how individuals structure thought or process information.

Other Cognitive Styles

Other investigators who made contributions to the field were:

1. Pettigrew (1958) who was influenced by the work of Bruner and his associates (Bruner, Goodnow, and Austin, 1956) who studied consistencies within individuals in which they consider events likely to occur. Pettigrew developed a test of the phenomenon category width, the C-W Scale to discriminate between risk takers and non-risk takers. The subject in a task must decide which type of error to minimize. The broad categorizer preferred an inclusion error, that is, the possibility that elements in a category may not belong in it. The narrow categorizer, on the other hand, risked an exclusion error, an error in which elements omitted from the category should be included (Kogan, 1971).

Another concept investigated by Gardner (1953), termed equivalence range, subsequently relabeled conceptual differentiation, was considered an alternative form of category width. The constructs dealt with sorting tasks. Individuals varied in the number of groupings they formed when asked to sort objects into the most appropriate groups. Kogan (1971) indicated that inaccurate sorters occurred more frequently in less intelligent more poorly adjusted children.

2. Harvey, Hunt, and Schroder (1961) investigated integrative complexity, a cognitive style in which man was