May 1983

A Comparison of Left and Right Brain Hemisphere Processing and Brain Related Sex Differences in Kindergarten Children

Margaret K. Hickerson

East Tennessee State University

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East Tennessee State University

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A COMPARISON OF LEFT AND RIGHT BRAIN HEMISPHERE PROCESSING AND BRAIN RELATED SEX DIFFERENCES IN KINDERGARTEN CHILDREN

A Dissertation

Presented to
the Faculty of the Department of Supervision and Administration
East Tennessee State University

In Partial Fulfillment of the Requirements for the Degree Doctor of Education

by
M. Kay Hickerson
May, 1983
APPROVAL

This is to certify that the Advanced Graduate Committee of

M. KAY HICKERSON

met on the

24th day of March, 1983.

The committee read and examined her dissertation, supervised her defense of it in an oral examination, and decided to recommend that her study be submitted to the Graduate Council and the Dean of the School of Graduate Studies in partial fulfillment of the requirements for the degree Doctor of Education.

Chairman, Advanced Graduate Committee

Signed on behalf of the Graduate Council

Signed on behalf of the School of Graduate Studies
Abstract

A COMPARISON OF LEFT AND RIGHT BRAIN HEMISPHERE PROCESSING AND BRAIN RELATED SEX DIFFERENCES IN KINDERGARTEN CHILDREN

by

M. Kay Hickerson

The purpose of the study was to (1) compare the performance on left and right hemisphere processing tasks of male and female kindergarten students from three instructional approaches, and (2) to determine the effectiveness of an educational application: the use of "hands-on" inquiry-oriented science activities designed to engage the right hemisphere in improving left and right hemisphere processing.

Subjects included 79 students enrolled in intact kindergarten classes representative of three instructional approaches: (1) the Traditional-Conventional Instructional Approach, (2) the Montessori Approach, and (3) the Open Activity-Centered Instructional Approach.

The students were randomly assigned for treatment to experimental and control groups. To the experimental group student teachers presented lessons developed from the Curriculum Guide accompanying Lavatelli's American Science and Engineering Program Kit. The control group participated in regular classroom lessons.

The students were pretested and posttested on the same instruments. Two subtests were indicative of left brain hemisphere processing: the SRA Primary Mental Abilities Verbal Meaning subtest and the WISC-R Digit Span subtest. Two subtests were indicative of right brain hemisphere processing: the SRA Primary Mental Abilities Spatial Relations subtest and the WISC-R Block Design subtest.

The following conclusions were drawn from the findings:

1. Although there was no statistically significant difference, females from all three instructional approaches scored consistently higher on left hemisphere tasks than males from those same instructional approaches.

2. Despite a lack of statistically significant differences, males from all three instructional approaches scored consistently higher on right hemisphere tasks than females from those same instructional approaches.

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3. Although the only significant difference was found in the Montessori class, experimental groups from all three instructional approaches scored consistently higher on right brain hemisphere tasks than the control groups from those same instructional approaches.

4. The students in the Montessori class scored significantly higher on the right brain posttest scores than the students in either the Open Activity-Centered approach or the Traditional-Conventional approach.
Institutional Review Board

This is to certify that the following study has been filed and approved by the Institutional Review Board of East Tennessee State University.

Title of Grant or Project  A Comparison of Left and Right Brain Hemisphere Processing and Brain Related Sex Differences in Kindergarten Children

Principal Investigator  M. Kay Hickerson

Department  Supervision and Administration

Date Submitted  October 9, 1981

Principal Investigator  [Signature]

Institutional Review Board Approval, Chairman  [Signature]
ACKNOWLEDGEMENTS

Many individuals made this study possible. In appreciation, particular thanks to the members of my committee: to my chairman, Dr. Gem Kate Greninger and to Dr. Howard Bowers, Dr. Hester Clark, and Dr. William Evernden. A special thanks to Dr. Robert Shepard for his encouragement and willingness to listen to problems encountered.

I am grateful to Dr. Phil Wishon for his initial encouragement and availability to discuss the study at any and all times.

Dr. Thomas Woolley aided much in this endeavor. A deep sense of appreciation and gratitude is extended him for his valuable direction and expertise with the statistical procedures for the research.

I am grateful to Dr. Vaughn Chambers for the "germ of an idea" developed in the research and to William Porter for his encouragement in the initial stages of its formulation.

I would also like to thank my daughter, DeAnn, my son, Kevin, and friends who through the years expressed confidence in my abilities and displayed faithful support of my efforts.
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Chapter 1

INTRODUCTION

Educators down through history have been intrigued and confounded by how children learn. Current brain research indicates that a grasp of the neurological processes that take place as the child learns is basic to understanding the learning process. Exactly how the brain works has been a mystery for thousands of years. Recently, however, there have been dramatic breakthroughs in the field of brain functioning (Kraft & Languis, 1977).

Current research has determined that the human brain consists of two distinct organs rather than one; the left and right hemisphere (Bogen, 1975; Gazzaniga, 1974; Sperry, 1964). Each has its own distinct memory, learning style, and mode for processing information (Bogen, 1975; Gazzaniga, 1974; Sperry, 1975). The left hemisphere specializes in sequential, linear, and analytical processing and is well adapted to learning and remembering verbal information. It is associated with reading, writing, speaking, understanding the spoken word, and calculations. The right hemisphere processes information holistically, and focuses on simultaneous, spatial, and intuitive operations, remembering in images. It is associated with visuo-spatial tasks such as visual pattern identification and imagery (Wittrock, 1978).

In most schools today, there is a major emphasis on linear, sequential, verbal learning (Grady & Luecke, 1978; McCarthy, 1981). The entire school curriculum is virtually geared to reward left hemisphere modality
(Galin & Ornstein, 1975; Kraft & Languis, 1977). Joseph E. Bogen (1975), a pioneer in the field of split-brain research, commented:

An elementary school program narrowly restricted to reading, writing and arithmetic will educate mainly one hemisphere leaving half of an individual's potential (the right modality) unschooled. . . . This means the whole student body is being educated lopsidedly. (p. 164)

Further compounding the educational dilemma is the predominance of studies indicating brain related sex differences (Goleman, 1978). Diane McGuinness, a research associate at the Neuropsychology Laboratory at Stanford University, maintains that schools discriminate against boys. Boys learn best about their environment, she states, by manipulation and action, by "hands-on" activities. Yet, in the early years, schools concentrate on reading and writing, skills that favor girls. By age 5 or 6, students are required to attend to one task and remain in their seats for long periods of time. They must learn mainly through auditory channels and use fine motor systems in writing and drawing. They are expected to "behave like girls." Boys who insist on acting like boys are then labeled hyperactive. Some authorities estimate hyperactivity to be nine times more prevalent among boys than girls (McGuinness, 1979).

Richard M. Restak (1979), a neurologist and author of The Brain: The Last Frontier, maintains that schooling and testing discriminate against both boys and girls in different ways. Boys suffer in classrooms suited to the ways girls think. Later, girls are put at a disadvantage taking scholarship and college entry tests that are geared for male performance.

Developing school curricula that utilize learning modes of both the left and right hemisphere, (involving both linear and holistic modes of
processing), would optimize student achievement. Exposing children to more activities that engage the right hemisphere, in addition to activities that engage the left hemisphere, provides for a more balanced development (Grady & Luecke, 1978). The exploration in this area of brain functioning is just beginning.

The Problem

Statement of the Problem

The problem of the study was to compare left and right brain hemisphere processing scores of selected male and female students representing three instructional styles.

Statement of the Subproblems

Subproblems of this study were designed to answer the following questions:

1. Does a difference exist in right and left brain hemisphere processing between male and female students from classes using the Traditional-Conventional Instructional Approach?

2. Does a difference exist in right and left brain hemisphere processing between male and female students from classes using the Montessori Instructional Approach?

3. Does a difference exist in right and left brain hemisphere processing between male and female students from classes using the Open Activity-Centered Instructional Approach?

4. Would instructing children using strategies to engage right brain processing have an effect on right brain abilities?
Purpose of the Study

The purpose of the study was to (1) compare the performance on left and right hemisphere processing tasks of male and female kindergarten students from three instructional approaches, and (2) determine the effectiveness of an educational application: the use of "hands-on" inquiry-oriented science activities designed to engage the right hemisphere in improving left and right hemisphere processing.

Significance of the Study

Researchers and curriculum planners have concentrated on the educational effect of such things as pupil-teacher interaction, the classroom environment, or materials used. Modern brain research now indicates a need to design learning experiences and teaching methods that are compatible with differential brain hemisphere information processing (Hart, 1978; Kraft & Languis, 1977).

Research in hemispheric brain functioning has a solid basis in the fields of medicine and the academic sciences, a review of which will be reported in Chapter 2. The evidence provided in many of these studies has led some individuals to make excessive claims to quick and easy prescriptions for many educational ills. Caution should be used in evaluating overly simplified cures. Care should be exercised to make educational applications based on documented research (Kraft & Languis, 1977).

Much of the research done in the field of brain hemisphere research has been done with older children and adults (Berlin & Languis, 1980) and it has been established that brain related sex differences do exist.
at adolescence (Maccoby & Jacklin, 1974). Males tend to be superior in visuo-spatial abilities and experience greater right hemisphere lateralization than females (McGuinness, 1979; Maccoby & Jacklin, 1974). Females tend to show superior performance on verbal skills at approximately age 11 (Maccoby & Jacklin, 1974). Are these differences present in younger children? Do kindergarten females learn and experience their world differently than their male counterparts? Do certain instructional styles enhance hemispheric information processing more than others among young children? Would directed educational intervention provide an ability to increase both the left and right brain hemisphere processing for both males and females at the kindergarten level? The findings of this study may help provide answers to these questions. They can lead to increased instructional effectiveness and student achievement by further providing for the individual needs of both males and females.

Definitions of Terms

Definitions of selected terms appropriate for the study include:

Cerebral Hemisphere

Cerebral hemisphere is the outermost portion of the forebrain, consisting essentially of what is called the telencephalon (cerebral cortex, corpus callosum, basal ganglia, and limbic system). Because the various parts of the telencephalon, which together comprise an appreciable portion of the forebrain, are each found clearly separated from one another on both left and right sides of the brain, each half (left and right) of the telencephalon is called a cerebral hemisphere (Languis, Sanders, & Tipps, 1980).
Cognitive Style

Cognitive style is the relatively stable way individuals perceive, conceptualize, and organize information (McGuinness, 1978).

Contralateral

Contralateral refers to opposite or crossed sides. As an example, auditory connections between the right ear and left hemisphere and left ear and right hemisphere are contralateral connections (Languis et al., 1980).

Corpus Callosum

The corpus callosum is a massive commissure connecting the right and left cerebral hemispheres. Axons leading from neurons in half of the cerebral cortex (e.g., right) always terminate in the corresponding area of the other hemisphere (e.g., left). The corpus callosum thus allows the two halves of the cerebral cortex to communicate directly with one another (Languis et al., 1980).

Dominance

Although some researchers make a clear distinction between dominance and laterality, for this study they will be used interchangeably. (See laterality.)

Electroencephalogram (EEG)

An electroencephalogram is the pattern of electrical activity that may be recorded from the cerebral cortex using electrodes placed on the surface of the scalp (Languis et al., 1980).
Holistic

With reference to cognitive functions, holistic refers to the simultaneous processing of a configuration of information, rather than the sequential processing of its separate parts (Languis et al., 1980).

Intact Classrooms

For the purposes of this study intact classrooms were comprised of those children previously grouped in a particular classroom with an assigned teacher.

Ipsilateral

Ipsilateral indicates same-sided or uncrossed; for example, the anatomical connections between the cerebellum and motor pathways are such that each hemisphere of the cerebellum is related to motor activity on the ipsilateral (same side) of the body (Languis et al., 1980).

Inquiry-Oriented Science Program

For the purposes of this study, the inquiry-oriented science program was The American Science and Engineering Science Program Kit with accompanying Teacher's Guide developed by C. S. Lavatelli; a Piaget-based science curriculum designed to develop a child's interest in learning and resultant inquiries. The strategies employed are for the purpose of engaging the right brain processing (Appendix A).

Lateralization (Hemispheric)

Lateralization is the differentiation of the two cerebral hemispheres with respect to function (Languis et al., 1980).
**Left Hemisphere Processing**

Left hemisphere processing is the functioning of the left cerebral hemisphere in response to stimuli. In the majority of right handed people the left hemisphere operates as an analytic specialist, and tends to be more specialized in verbal functioning and sequential analysis (Wittrock, 1978).

**Montessori Instructional Approach**

The Montessori Instructional Approach is the teaching style developed by Maria Montessori, emphasizing a structured, sequential method of learning. Tactile and other materials, specially designed for sequential learning are utilized. Flexibility, experimentation, and experiencing one's own environment are vital components of this approach. Time and provisions are made for each child to work independently, at the child's own pace.

**Open Activity-Centered Instructional Approach**

The term Open Activity-Centered Instructional Approach refers to the teaching style that emphasizes discovery, moving among various learning centers, manipulating materials and interaction with peers and teacher. Independence and individualism are encouraged strongly. There is a blending of group activity and independent work. This approach is not as structured and sequential as the Montessori Approach or as group and comparison oriented as the Traditional-Conventional Approach.
Right Hemisphere Processing

Right hemisphere processing is the functioning of the right cerebral hemisphere in response to stimuli. In the majority of right handed people the right hemisphere processes information as a whole, simultaneously and synthetically, with a focus upon visuo-spatial components, remembering in pictures or images rather than words (Wittrock, 1978).

Traditional-Conventional Instructional Approach

For the purposes of this study, the Traditional-Conventional Instructional Approach is the teaching style adopted by many public school systems wherein the emphasis is placed on learning by repetition and recall. Uniform standards are established in the form of mastery skills and grade levels. The classrooms are organized and controlled by an authority figure. The students spend the majority of class time at assigned desks, completing assignments, listening to lectures or observing demonstrations; the classic approach to education, attending to basic skills and preparing a student to effectively master the next grade (Hart, 1978).

Tri-Cities

Tri-Cities refers to the geographical area located in the Appalachian Region of the United States, specifically the northeastern Tennessee cities of Bristol, Johnson City, and Kingsport.

Visuo-Spatial (Visual Spatial)

Visuo-spatial means to mentally move, turn, twist, or rotate an object or objects and then to recognize a new appearance or position
after the prescribed manipulation has been performed (Wheatley, 1979); to perceive spatial patterns accurately and to compare them with each other (Harris, 1976).

Hypotheses

Hypothesis 1

The mean pretest scores on the WISC-R Digit Span Test (left hemisphere task) for female students from classes using the Traditional-Conventional Instructional Approach will be significantly greater than the scores of the male students in these same classes.

Hypothesis 2

The mean pretest scores on the WISC-R Digit Span Test (left hemisphere task) for female students from classes using the Montessori Instructional Approach will be significantly greater than the scores of the male students in these same classes.

Hypothesis 3

The mean pretest scores on the WISC-R Digit Span Test (left hemisphere task) for female students from classes using the Open Activity-Centered Instructional Approach will be significantly greater than the scores of the male students in these same classes.

Hypothesis 4

The mean pretest scores on the PMA Verbal Meaning Test (left hemisphere task) for female students from classes using the Traditional-Conventional Instructional Approach will be significantly greater than
the scores of the male students in these same classes.

**Hypothesis 5**

The mean pretest scores on the PMA Verbal Meaning Test (left hemisphere task) for female students from classes using the Montessori Instructional Approach will be significantly greater than the scores of male students in the same classes.

**Hypothesis 6**

The mean pretest scores on the PMA Verbal Meaning Test (left hemisphere task) for female students from classes using the Open Activity-Centered Instructional Approach will be significantly greater than the scores of the male students in these same classes.

**Hypothesis 7**

The mean pretest scores on the WISC-R Block Design Test (right hemisphere task) for male students from classes using the Traditional-Conventional Instructional Approach will be significantly greater than the scores of the female students from these same classes.

**Hypothesis 8**

The mean pretest scores on the WISC-R Block Design Test (right hemisphere task) for male students from classes using the Montessori Instructional Approach will be significantly greater than the scores of the female students from these same classes.

**Hypothesis 9**

The mean pretest scores on the WISC-R Block Design Test (right
hemisphere task) for male students from classes using the Open Activity-Centered Approach will be significantly greater than the scores of the female students from these same classes.

**Hypothesis 10**

The mean pretest scores on the PMA Spatial Relations Test (right hemisphere task) for male students from classes using the Traditional-Conventional Instructional Approach will be significantly greater than the scores of the female students from these same classes.

**Hypothesis 11**

The mean pretest scores on the PMA Spatial Relations Test (right hemisphere task) for male students from classes using the Montessori Instructional Approach will be significantly greater than the scores of the female students from these same classes.

**Hypothesis 12**

The mean pretest scores on the PMA Spatial Relations Test (right hemisphere task) for male students from classes using the Open Activity-Centered Approach will be significantly greater than the scores of the female students from these same classes.

**Hypothesis 13**

Mean pretest scores for students in the Open Activity-Centered Instructional Approach will be significantly greater on the WISC-R Block Design Test (right hemisphere task) than the scores of the students in the Montessori Instructional Approach.
Hypothesis 14

Mean pretest scores for students in the Open Activity-Centered Instructional Approach will be significantly greater on the WISC-R Block Design Test (right hemisphere task) than the scores of the students in the Traditional-Conventional Instructional Approach.

Hypothesis 15

Mean pretest scores for students in the Montessori Instructional Approach will be significantly greater on the WISC-R Block Design Test (right hemisphere task) than the scores of the students in the Traditional-Conventional Instructional Approach.

Hypothesis 16

Mean pretest scores for students in the Open Activity-Centered Instructional Approach will be significantly greater on the PMA Spatial Relations Test (right hemisphere task) than the scores of the students in the Montessori Instructional Approach.

Hypothesis 17

Mean pretest scores for students in the Open Activity-Centered Instructional Approach will be significantly greater on the PMA Spatial Relations Test (right hemisphere task) than the scores of the students in the Traditional-Conventional Instructional Approach.

Hypothesis 18

Mean pretest scores for students in the Montessori Instructional Approach will be significantly greater on the PMA Spatial Relations Test (right hemisphere task) than the scores of the students in the
Hypothesis 19

The posttest mean for females in the experimental group will be significantly greater on the WISC-R Block Design Test (right hemisphere task) than for females in the control group where classes were taught using the Traditional-Conventional Instructional Approach.

Hypothesis 20

The posttest mean for females in the experimental group will be significantly greater on the WISC-R Block Design Test (right hemisphere task) than for females in the control group where classes are taught using the Montessori Instructional Approach.

Hypothesis 21

The posttest mean for females in the experimental group will be significantly greater on the WISC-R Block Design Test (right hemisphere task) than for females in the control group where classes are taught using the Open Activity-Centered Instructional Approach.

Hypothesis 22

The posttest mean for males in the experimental group will be significantly greater on the WISC-R Block Design Test (right hemisphere task) than for males in the control group where classes are taught using the Traditional-Conventional Instructional Approach.

Hypothesis 23

The posttest mean for males in the experimental group will be
significantly greater on the WISC-R Block Design Test (right hemisphere task) than for males in the control group where classes are taught using the Montessori Instructional Approach.

**Hypothesis 24**

The posttest mean for males in the experimental group will be significantly greater on the WISC-R Block Design Test (right hemisphere task) than for males in the control group where classes are taught using the Open Activity-Centered Instructional Approach.

**Hypothesis 25**

The posttest mean for females in the experimental group will be significantly greater on the PMA Spatial Relations Test (right hemisphere task) than for females in the control group where classes are taught using the Traditional-Conventional Instructional Approach.

**Hypothesis 26**

The posttest mean for females in the experimental group will be significantly greater on the PMA Spatial Relations Test (right hemisphere task) than for females in the control group where classes are taught using the Montessori Instructional Approach.

**Hypothesis 27**

The posttest mean for females in the experimental group will be significantly greater on the PMA Spatial Relations Test (right hemisphere task) than for females in the control group where classes are taught using the Open Activity-Centered Instructional Approach.
Hypothesis 28

The posttest mean for males in the experimental group will be significantly greater on the PMA Spatial Relations Test (right hemisphere task) than for males in the control group where classes are taught using the Traditional-Conventional Instructional Approach.

Hypothesis 29

The posttest mean for males in the experimental group will be significantly greater on the PMA Spatial Relations Test (right hemisphere task) than for males in the control group where classes are taught using the Montessori Instructional Approach.

Hypothesis 30

The posttest mean for males in the experimental group will be significantly greater on the PMA Spatial Relations Test (right hemisphere task) than for males in the control group where classes are taught using the Open Activity-Centered Instructional Approach.

Limitations of the Study

The following were limitations of the study:

1. The study was limited to students from selected classes in the Tri-Cities area in East Tennessee as indicated below:
   a. The Traditional-Conventional Instructional Approach,
   b. The Montessori Instructional Approach,
   c. The Open Activity-Centered Instructional Approach.

2. The amount of time for the treatment was limited to approximately 1-1/2 hours per week for a 5-week period in October and November, 1981.
3. The testing period extended from October to December, 1981.

4. The number of students participating in the study was 42 females and 37 males for a total of 79.

5. The participating students were from five intact kindergarten classrooms.

Assumptions

The following assumptions were made:

1. The study was not contaminated by the use of activities within the regular classroom similar to those used in the treatment program.

2. Instructional sessions assured that student teachers presenting the treatment were adequate to insure consistency, uniformity, and accuracy in delivery of right brain activities.

3. The only untoward difference between the experimental and the control groups was the selected treatment strategies.

4. Classes chosen to participate in the study were representative of the three instructional approaches.

5. Students selected would be representative of the total population.

6. Instruments selected for the study were appropriate.

7. A need existed for this type study.

8. Student teachers were reliable in presenting the assigned treatment.

9. The statistical procedures employed would be valid for treatment of data.
Procedures

The procedures followed in conducting this study were:

1. An intensive review of the relevant literature was conducted.

2. A sample was selected which consisted of kindergarten children enrolled in five intact classrooms from city and county schools in the Tri-Cities area in Upper East Tennessee where selected instructional styles were used.

3. Approval was secured from the school principals and teachers and from East Tennessee State University Institutional Review Board.

4. Informed Consent forms were signed by the parents/guardians of each participant.

5. Specific methods employed in carrying out the experiment included:
   a. The members of each class were randomly assigned for treatment as an experimental or control group.
   b. The children were pretested at their respective schools using the four chosen subtests: the WISC-R Block Design Test and Digit Span Test, and the PMA Verbal Meaning Test and Spatial Relations Test.
   c. Student teachers assigned to deliver the treatment attended three training sessions instructing them in the use of Lavatelli's American Science and Engineering Science Program Kit.
   d. The 15 one-half hour lessons were presented three times a week for a total of 5 weeks. Lavatelli's Curriculum Guide
was used as a guide for each session.

e. Immediately following the treatment sessions with the experimental group, the control group was presented with a traditional classroom lesson.

f. At the conclusion of the treatment period the children were posttested using the same four subtests.

6. The analysis of variance, three-way analysis of covariance, t-test, and Newman-Keuls procedure were employed for analyzing the data using the .05 level of significance.

7. The results were reported, the data summarized, the conclusions formulated, and the recommendations suggested.

**Organization of the Study**

The study was organized into five chapters.

Chapter 1 contains the introduction, statement of the problem, statement of the subproblems, purpose of the study, significance of the study, definitions of terms, hypotheses, limitations, assumptions, procedures of the study and organization of the study.

Chapter 2 contains the review of the relevant literature.

Chapter 3 contains the procedures and methodology used in the study.

The analysis of the data and the findings are presented in Chapter 4.

Presented in Chapter 5 are the summary, findings, implications, conclusions and recommendations.
Chapter 2

REVIEW OF THE RELEVANT LITERATURE

Introduction

This chapter contains a survey of literature pertaining to the major issues of this study. The review examines evidence related to hemispheric lateralization and brain related sex differences. The research studies included were concerned with asymmetries in hemispheric functioning, first learned from clinical situations and later from the normal, healthy brain. Recent studies have dealt with the educational aspects of this hemispheric functioning. Books, periodicals, government documents, and dissertations relevant to the study were searched.

History of Hemispheric Specialization

Although frequently thought of as a single structure, the brain is actually divided into halves. The two parts, or hemispheres, are tightly packed together inside the skull and are linked together by a thick band of nerve fibers, the corpus callosum, which serves as a channel of communication between them (Springer & Deutsch, 1981). Since each cerebral hemisphere appears to be the mirror-image of the other, there is nothing in the outward appearance that hints at the profound functional differences within. What is known of these differences has come from studies of how the two hemispheres respond separately (Restak, 1979). Originally, this was learned from abnormal conditions or under

Broca's Area

The hemispheric brain model began in 1846 with a Frenchman, Paul Broca's work with stroke and brain damaged patients. In 1861 Broca published the first of a series of papers on language and the brain. He was among the first to point out that damage to a specific portion of the left hemisphere results in a disturbance of language output. The portion he identified, a language center, is now called "Broca's area." "Broca's area" is responsible for the conversion of thoughts into smoothly articulated sounds (Restak, 1979). The lesion-produced language disorder was called "aphasia."

In 1865 Broca made a second major contribution to the study of language and the brain. He reported that damage to specific areas of the left half of the brain led to disorder of spoken language but that destruction of corresponding areas in the right side of the brain left language abilities intact (Geschwind, 1972). Broca may be properly credited with being the first person to bring to the attention of the medical community as a whole the asymmetry of the human brain with regard to speech. In the century since his report his observation has been amply confirmed (Bogen, 1977; Sperry, 1968; Sperry, Gazzaniga, & Bogen, 1969). Only rarely does damage to the right hemisphere of the brain lead to language disorder. It has been suggested that approximately 97 out of 100 people with permanent language disorders caused by
brain lesions will have damage to the left side (Geschwind, 1972).

Wernicke's Area

Further support for the early scientific demonstration of hemispheric specialization came 10 years after Broca's first publication when a German neurologist, Carl Wernicke, discovered a second rather different speech center. Wernicke described damage at a site in the left hemisphere outside Broca's area that results in a language disorder differing from Broca's aphasia. A lesion in Wernicke's area can produce a severe loss of understanding. A patient with destruction of Wernicke's area speaks with perfect articulation but makes no sense (Geschwind, 1972). Perhaps the most important contribution made by Wernicke was his model of how the language areas in the brain are connected. He made the natural assumption that Broca's area and Wernicke's area must be connected. We now know that his assumption is an accurate one. When a word is heard, the output from the primary auditory area is received by Wernicke's area. If the word is to be spoken, the pattern is transmitted from Wernicke's area to Broca's area, where the articulation originates (Geschwind, 1972). By the 1870's both Broca and Wernicke had become convinced of the importance of the left hemisphere in speech.

Dejerine-Corpus Callosum

At about the same time that findings by Broca and Wernicke were being published, a French neurologist, Joseph Jules Dejerine, suggested a role for the corpus callosum, the thick band of nerve fibers connecting the right and left hemispheres. This role concerns the manner in which visual impressions are conveyed from the eyes to the brain.
The eyes can be thought of as divided vertically into two equal halves. The optic fibers from the outer sides of each eye do not cross but go directly to the same side of the brain, while fibers from the inner (nasal) side cross over just behind the eyeballs and proceed to the opposite side of the brain. Each eye thus contributes equally to the visual image in both eyes (Restak, 1979). This precludes loss of sight to either "visual field" by destruction of one eye. A similar crossing-over exists between the function of movement and sensation. Once the stimulus reaches one hemisphere, it is immediately transferred to the other across the corpus callosum. If the two hemispheres are prevented from "talking" to each other across the corpus callosum, the hemispheres become functionally isolated, a phenomenon referred to as a "split brain." Unfortunately, DeJerine's demonstration of the importance of the corpus callosum was forgotten, and for the next 60 years brain scientists considered it little more than a fancy "tethering system" to hold the two hemispheres together (Restak, 1979).

**Evidence of Hemispheric Specialization**

A recent synthesis of existing evidence on the functioning of the human brain, together with new findings, indicates that the two hemispheres process stimuli differently (Bogen, 1975; Science Digest, 1982; Wheatly, Mitchell, Frankland, & Kraft, 1978; Wittrock, 1978). For most right-handed persons, the left hemisphere treats stimuli serially, one at a time, whereas the right hemisphere processes stimuli many at a time as a gestalt. This functional difference renders each hemisphere superior in performing certain types of tasks: the left hemisphere is better at
such tasks as reading, speaking, analytical reasoning, and arithmetic, and the right hemisphere is better at spatial tasks, recognizing faces and music (Geschwind, 1972; Grady, 1979; Gray, 1980; McGuinness, 1979). Evidence for this theory of hemispheric specialization has come from many diverse investigations from anatomical to behavioral. This evidence is presented briefly in the following paragraphs.

**Lesion Studies**

Functional differences in the left and right hemispheres were first noted in observing persons who had suffered brain injury to one hemisphere (Ettlinger, Warrington, & Zangwill, 1957; Geschwind, 1970; Luria, 1966; Milner, 1971). Right hemisphere lesions resulted in loss of spatial ability, whereas left hemisphere lesions resulted in loss of speech and reasoning ability (Bogen, 1969a, 1969b; Bogen & Bogen, 1969).

**Anatomical Evidence**

Definite differences are seen when relative shape and size of the hemisphere of a human brain are examined. For example, in examining 100 adult and 100 infant brains, Wada, Clark, and Hamon (1975) found anatomical evidence for left hemisphere speech. Geschwind (1974), Geschwind and Levitsky (1968), and Witelson and Pallie (1973) reported convincing evidence to support specialization of the hemisphere, with left hemisphere linguistic processing and right hemisphere spatial processing.

**Split-brain Research**

The impetus for the recent research in lateralization of cerebral
functioning was provided by the work of Sperry (1964), Bogen and Gazzaniga (1965), and Levy, Trevarthen, and Sperry (1972) with patients whose two cerebral hemispheres had been disconnected surgically as treatment for epilepsy. In the absence of an intact corpus callosum, remarkable and unexpected behavior was noted for these "split-brain" persons. With each hemisphere operating in comparative isolation, Sperry and other psychobiologists were able to devise tests aimed at tapping the individual capabilities of the hemisphere. Through these carefully designed studies Roger Sperry (1964), one of the California Institute of Technology researchers who pioneered much of this work, was able to show that the right hemisphere could perform spatial tasks (draw a figure, recognize faces) but had virtually no language capability. The left hemisphere controlled speech, calculation, and reasoning but could not perform simple spatial tasks. The importance of split-brain discoveries might have been limited if work had not also been continued with people having an intact corpus callosum. Critics aptly suggested that conclusions about normal brain function can never come from the study of diseased brains (Restak, 1979; Springer & Deutsch, 1981).

**Dichotic Listening**

By presenting balanced sounds to each ear simultaneously it is possible to determine ear superiority for different types of tasks. Sounds presented to the left ear are processed by the right hemisphere (Geldard, 1972). Such dichotic listening studies have consistently found a right ear advantage (REA) for linguistic stimuli and left ear advantage for nonlinguistic stimuli (Ingram, 1975; Kimura, 1967; Knox & Kimura,
1970; Shankweiler & Studdert-Kennedy, 1967; Springer & Gazzaniga, 1975). For example, Knox and Kimura (1970) found a left ear advantage for verbal sounds in a sample of 5 to 8-year-olds. Doreen Kimura (1973), working at the Montreal Neurological Institute, suggested that the right hemisphere advantage was a reflection of left brain dominance or left hemisphere specialization for language, a hypothesis that has been confirmed many times since Kimura's initial study (Krashen, 1975; Shankweiler et al., 1970). In most right handers Kimura (1967) found the left hemisphere better than the right hemisphere at tasks involving auditorily presented words, nonsense syllables, backward speech, visually repeated letters and words and skilled movements and gesticulations. The right hemisphere was better than the left at auditory tasks involving melodies and non-speech human sounds; at visual tasks involving locating points in two dimensions, stereoscopic depth perception, and at manual tasks involving the determination of locations. Kimura's (1973) results support those of Sperry (1968) and Bogen (1969b, 1977). In 98% of the right handers and in about 2/3 of the left-handers language and speech are analyzed predominantly in the left hemisphere. Spatial patterns and some auditory patterns (such as melodies) are synthesized predominantly in the right hemisphere (Wittrock, 1978).

**Tachistoscopic Studies**

For visual information, a tachistoscope can be used to present a task to only one hemisphere. Each eye has two distinct neural pathways leading to the brain. Images falling on the nasal half of the retina are sensed only by the contralateral hemisphere, whereas images falling
on the outer portion of the retina are sensed only by the ipsilateral hemisphere. That is, the left hemisphere receives signals from the inner portion of the right eye. Each eye contributes equally to the visual image in both eyes. Using a tachistoscope, however, stimuli can be presented to just one hemisphere. Studies using this technique have confirmed the specialization of the cerebral hemispheres; the right hemisphere is superior for processing spatial tasks and the left hemisphere superior for linguistic tasks (Hines, 1975; Kimura, 1967; Levy, Trevarthen, & Sperry, 1972; Marcel, Katz, & Smith, 1974; McGlone & Davidson, 1973; Yeni-Hemshian, Isenberg, & Goldberg, 1975).

These findings lend support to the idea that visual-field differences in normal subjects reflect brain asymmetries. This suggests that differences between the left brain and right brain found in clinical and split-brain subjects have reality for the normal brain as well, and that these differences can actually be studied in normal subjects (Springer & Deutsch, 1981).

**Wada Test - Sodium Amytol**

With sodium amytol, a single hemisphere can be anesthetized, leaving the other alert. The Wada test, like direct electrical stimulation, has been very useful in determining which hemisphere controls speech and language. Studies using this technique provide strong evidence for left hemisphere control of speech (Bogen & Gordon, 1971; Branch, Milner, & Rasmussen, 1964; Wada & Rasmussen, 1960).

**Handedness Studies**

The measurement of handedness is complicated. The hand used in
writing is one important element of handedness, but other uses of the hands are also relevant. To index multiple uses of the hands, paper and pencil questionnaires, such as the Edinburg Handedness Inventory (Oldfield, 1971) are often used in studies of brain processes (Wittrock, 1978).

Studies provide support for theories which suggest that right and left-handers perceive the world in significantly different ways (Briggs & Nebes, 1976; Levy & Reid, 1976; McClone & Davidson, 1973; Nebes, 1976). While over 98% of right-handed people use their right hemisphere for spatial-temporal tasks and their left hemisphere for language, the situation in left-handers is reversed about 35% of the time (Krashen, 1977; Levy & Reid, 1976; Restak, 1979; Wittrock, 1978). This third may have right-hemisphere language or some degree of diffuse representation (Branch, Milner, & Rasmussen, 1964). Levy and Reid (1976) maintain that hand posture may serve as an outward sign for brain lateralization. Stated simply, the inverted (or hooked) hand position is a biological marker indicating that the hemisphere for language specialization is on the same side as the writing hand.

Popular stereotypes about cognitive deficits of left-handers find no substantial support in the research literature (Wittrock, 1978). Despite the attention afforded handedness, the findings are inconclusive (Kinsbourne & Hiscock, 1978). There are numerous claims that deviation from firmly established right-handedness is more common among poor readers than among controls (Critchley, 1970; Vernon, 1971). There are also numerous findings that are contradictory to these claims (Critchley, 1970; Lyle, 1969; Rutter, Tizard, & Whitmore, 1970; Vernon, 1971;
Many clinicians and researchers have focused their attention on the consistency of handedness, footedness and eyedness (mixed dominance or crossed dominance), rather than on handedness alone (Barlow, 1963; Hicks & Kinsbourne, 1976; Orton, 1937; Porac & Coren, 1976).

The implications of these studies of handedness are that the level of cognitive abilities does not differ according to handedness. The organizations of the cognitive process, however, and perhaps the strategies of learning do sometimes differ between right and left-handedness (Wittrock, 1978).

Lateral Eye Movement Studies

An individual generally looks directly at a speaker when asked a question but will look away while answering. Day (1964), a clinical psychologist, suggested that the direction of these lateral eye movements (LEMS) might be associated with certain personality characteristics. Later, Parl Baken (1969), of Simon Fraser University, proposed that eye movements are related to hemispheric asymmetry as well. His hypothesis was based on the fact that eye movements to one side are controlled by centers in the frontal lobe of the contralateral hemisphere. He suggested that cognitive activity occurring primarily in one hemisphere would trigger eye movements to the opposite side, so that eye movements could be viewed as an index of the relative activity of the two hemispheres in an individual.

Later investigations exploring LEMS as an index of hemispheric activity began to consider the role played by the type of question used
to elicit eye movement (Kinsbourne, 1972, 1974; Kocel, 1972; Schwartz, Davidson, & Maer, 1975). When verbal analysis was required, indicating left hemisphere involvement, the subjects looked to the right. When an analysis of spatial relationships was required, activating the right hemisphere the subjects looked to the left. Gary Schwartz and his colleagues at Yale conducted a study dealing with lateral eye movements in response to emotional questions. His findings support greater right hemisphere involvement in processing emotional information (Schwartz et al., 1975).

Reviews of work in the area of lateral eye movement have found no support for using horizontal eye movements to index hemispheric processes. They maintain the evidence linking LEMs to hemispheric asymmetry is indirect and weak (Ehrlichman & Weinberger, 1979; Ehrlichman, Weiner, & Baker, 1974).

Factors in the experimental situation may account for these confusing results. The presence or absence of another person during the questioning may affect the pattern of eye movement (Gur, Gur, & Harris, 1975). Wittrock (1978) cautions that eye movement measures should be used by educational researchers only when gathering data from a large number of people. For use with individual students, he contends, the eye movement index of cognitive processes presents serious problems of reliability and validity.

Unfortunately, we have no eye-movement data on split-brain patients engaged in various tasks, nor do we have any information about eye movement in the presence of direct electrical stimulation. In the absence of independent verification that eye movements are related to differential
hemispheric activity, it would be wise to interpret results of LEMs studies cautiously (Springer & Deutsch, 1981).

**Dichaptic Studies**

Sandra Witelson (1976), a psychologist with the Department of Psychiatry at McMaster University in Ontario, Canada, used the sense of touch in dichaptic tests. When right-handed children reached into a curtained box and explored irregular shapes with fingers of each hand, the left hand was more accurate at identifying shapes. Thus, the spatial strength of the right hemisphere was demonstrated in normal people. The experiment shows a tendency for each hemisphere to be better at certain tasks presented in certain ways consistent with split-brain findings.

**Electroencephalography**

Among the many methods available to study hemispheric processing, electroencephalography (EEG) seems particularly useful. It is possible using EEG's, to monitor hemispheric activity while a person is engaged in a task. A high proportion of the alpha band component in the signal indicates little brain activity, or a hemisphere "at rest" (Christie, Delafield, Lucas, Linwood, & Gale, 1972; Giannitroparri, 1966; Glass, 1968; Glass & Kwialkowski, 1970; Smyk & Darway, 1972).

The technique employed to study hemispheric specialization differs markedly from the standard EEG methods used for medical purposes. In studying hemispheric specialization EEG's are recorded while the subject is actively engaged in a cognitive task. Although this is a relatively new technology in the study of hemispheric specialization, there is much work being done in this area (Butler & Glass, 1974; Dilling, Wheatley, &
Mitchell, 1976; Doyle, Ornstein, & Galin, 1974; Duman & Morgan, 1975; Galin & Ellis, 1975; Galin & Ornstein, 1972, 1975; Morgan, MacDonald, & Hilgard, 1974; Morgan, McDonald, & MacDonald, 1971). EEG studies show that while a subject is doing a logical, verbal or mental arithmetic task the left hemisphere (but not the right) is active (Butler & Glass, 1974; Galin & Ornstein, 1972, 1975). These EEG techniques have also been used to isolate right hemisphere activity for spatial tasks (Doyle, Ornstein, & Galin, 1974; Galin & Ellis, 1975; Galin & Ornstein, 1975).

Although performance data are quite useful in inferring lateralization, the results are strengthened when confirmed by direct measure of brain activity (Wheatley et al., 1978).

**Summary of Hemispheric Specialization**

Notions about the role of the two cerebral hemispheres have ranged from the idea that the whole brain is involved in every function, to the belief that the left half is the dominant part, to the current idea that both hemispheres contribute to behavior in important ways through their specialized capabilities. Clinical evidence, despite its limitations, has yielded a sizeable body of information about the left brain and the right brain. Damage to one hemisphere leads to disabilities different from those arising from damage to the other hemisphere. These differences strongly suggest that each hemisphere contributes certain specialized functions to overall human behavior.

Recent work with split-brain patients has revealed that each hemisphere is capable of handling many kinds of tasks but often differs from the other in both approach and efficiency. Reviewing hemispheric
difference by studying the behavior of normal subjects in testing adds further evidence by measuring directly observable behavior. Overall, the results matched data that emerged from the brain-damaged and split-brain studies.

**Left Hemisphere Functioning**

Recent research has shown that the two hemispheres are specialized for different modes of thought (Wheatley & Wheatley, 1979). It has become popular for educators to refer to "right brain" or "left brain" thinking in many contexts. A survey of the history and evidences behind the current view of hemispheric specialization provides insights for improved evaluation of teaching effectiveness. In right handers, the left cerebral hemisphere (which controls the dominant right arm, hand, leg, foot and eye) is the center where linguistic expressions and logical thought processes originate (Gray, 1980; Krashan, 1977). It specializes in verbal functioning such as speaking and reading as well as sequential analysis; it is best able to store or retrieve information in a part-by-part coded form such as words (Languis, Sanders, & Tipps, 1980; Wheatley & Wheatley, 1979). The left hemisphere processes stimuli serially and excels in language tasks, computation, and logical analysis with attention to detail (Wheatley & Wheatley, 1979).

People who are left mode dominant are rational, analytical, systematic and sequential thinkers. They solve problems by looking at the parts rather than the whole. They may demonstrate verbal proficiency, but may be awkward and have difficulty generating images (McCarthy, 1981; Telzrow, 1981). Krashan (1977) states, however, that there is evidence
that a great deal of nonverbal processing occurs in the left hemisphere. Most of these nonverbal left hemisphere functions appear to be time-related and having to do with temporal-order judgments (judging which of two stimuli comes first).

Gazzaniga's (1979) research suggests that all language and all spatial functions are not strictly and exclusively lateralized to the respective left and right hemisphere. Psychologist, Robert Ornstein, (1977) believes that we naturally alternate between our left and right thinking modes. He suggests that the two modes complement one another without being able to readily substitute for one another. Esther Gray (1980), a research associate at Kansas State University, describes it this way:

These functions complement and temper one another. As an example of these two styles of thinking, we might imagine that when one sees a familiar face in the grocery story his left hemisphere could be stimulated to think:

Public library reference librarian since fall 1977.
Name: Milton Smith. Knows how to locate information on consumer problems.
Meanwhile his right hemisphere is stimulated to think wordless, less-orderly thoughts which are also an essential part of his split-second reaction to Milton Smith:
Friendly face . . . quiet behavior . . . I trust this person . . . (pictures public library) . . . (pictures route to reference desk) . . . (pictures feel of microfilm in his hand) . . . (remembers image of stove on the screen of microfilm-reading machine) . . .

In the healthy normal brain these impulses are combined instinctively without conscious effort. We have been so unaware of possessing these two styles of thinking that prior to the revelations of recent research the distinction between them sounded like science fiction. (p. 127)

Kraft and Languls (1977), researchers from Ohio State University, stressed that each child has an individual functioning pattern which researchers liken in distinctiveness to an individual's fingerprint.
Not all children process information with the left or right hemisphere in precisely the same manner but each develops a unique style.

**Right Hemisphere Functioning**

Since the 1950's there has been an enormous change in our concept of the role the right cerebral hemisphere plays in higher mental activities. Attention prior to this time has focused primarily on the left hemisphere. It seemed logical that the hemisphere in which the comprehension and production of language took place should be the more highly developed and thus be in ultimate control over the rest of the brain. The left was therefore called the "major," "dominant," or "leading" hemisphere (Nebes, 1977). The nature of the right hemisphere was not understood.

Recently, creative brain research has revealed new knowledge about the organization and functioning of the right hemisphere (Bogen, 1969; Sperry, 1964). Many studies have resulted from this beginning. It has been found that the right cerebral hemisphere is the center where intuitive, holistic thinking as well as spatial conceptualizing originates (Gray, 1980). It processes stimuli all at once rather than sequentially. The right hemisphere "thinks" in images and excels in tasks that are nonverbal in nature and less familiar. Testing has shown it to be superior to the left for spatial tasks (Harris, 1975; Nebes, 1977; Wheatley, 1977).

The right hemisphere not only has the capacity to remember more material for longer times, but does not tire out as quickly as the left hemisphere (Dimond & Beaumont, 1974). It has also been demonstrated
that the verbal memory system of the left hemisphere can be enhanced by actively eliciting the right hemisphere's imaginal memory (Seamon, 1974). The right hemisphere processes stimuli in parallel, many at a time and is superior in comparing complex geometric shapes, interpreting graphic material, and recognizing faces (Wheatley & Wheatley, 1979). Nebes (1977) suggests that the right cerebral hemisphere makes an important contribution to human performance, having functions complementary to those of the left hemisphere. The right side of the brain processes information differently from the left, relying more on imagery than on language, and being more synthetic, holistic than analytic and sequential in handling data. Considering the results on hemispheric specialization it seems natural to many researchers in related fields that the "scientific and technical aspects of our civilization are products of the left hemisphere, while the mystical and humanistic aspects are products of the right" (Nebes, 1977, p. 104).

The right hemisphere comprehends but cannot produce speech (Wittrock, 1978). Grayson Wheatley (1977) states:

Words are not the only medium for knowing, although a study of our educational practices would belie this. An often used adage is "You don't know it if you cannot explain it." Our efforts to explain a waterfall, a pyramid, or a spiral fall short without using our hands to create a visual image. (p. 37)

People who are right hemisphere dominant may have delayed language development or may demonstrate reading and spelling problems but have intact, even superior, visuo-spatial skills (Telzrow, 1981). They see in patterns. They solve problems by.looking at the whole picture and asking new questions. Their thinking is more random, and they seem to
arrive at accurate conclusions in the absence of logical justification (McCarthy, 1981).

The right hemisphere is considered the stronghold of aesthetics. Art and music appreciation may be largely dominated by the right hemisphere. Right hemisphere processes typically emerge in such curricular areas as industrial arts, art and music. These areas have long been perceived by the majority of educators, as well as the public, as the "frills" in our educational system (Telzrow, 1981).

**Right Hemisphere—Not the "Minor Hemisphere"**

Right hemisphere development is as important for high-level problem solving and creative thinking as is language skills (Bogen & Bogen, 1969). It has been suggested that intuition may be a "basic," an essential in education (Gray, 1980). If it is, then the thinking ability in our culture will suffer if we do not nurture intuition in our children. Gray maintains that it is necessary to explore means for the exercise of the right hemisphere thinking mode in education. McCarthy (1981) maintains that schools tend to ignore the intuitive, holistic world of hunches and patterns, the thinking that is beyond logic.

**Brain Related Sex Differences**

Although our understanding of the differences between the sexes is far from complete, there are sufficient data to allow us to begin to piece together some of the puzzle. McGuinness (1979) contends that boys and girls appear to learn about the environment differently and have qualitatively different patterns of behavior, which are in turn strongly
influenced by the social setting. She cautions, however, that we must avoid the tendency to ascribe all differences to environment or biology. Both, she says, are wrong. Biology initiates and sets limits and within these limits culture plays an enormous role. Restak (1979) supports these contentions, maintaining that many differences believed to exist are based on stereotypes. He believes that many behavioral differences between males and females are based on differences in brain functioning that are biologically inherent and unlikely to be modified by cultural factors alone.

Basic sensory differences between the sexes do exist and can be detected at early ages. It is conceivable that these differences may contribute to other more complex central processes (McGuinness & Pribram, 1978). Sex differences in sensory capacity and response characteristics provide some of the most important evidence on the development of perceptual differences. The relationship between sex differences and hemispheric specialization need no longer be so bewildering. A flood of data, as will be discussed, has shown beyond doubt that such a relationship exists. Still, the origin of the relationship on any one physiological basis has remained, up till now, a mystery (McGuinness, 1979).

**Sensory Capacities**

The following paragraphs present a brief summary of perceptual asymmetry studies.

**Taste**

Apart from finding that females tend to prefer greater concentrations of sugar or saccharin to males (Maccoby & Jacklin, 1974), the only
available information on taste differences and sensitivities between the sexes comes from a well-controlled study by Bailey and Nichols (1888). No statistics were performed on the data, but the trend was clearly present, with females more sensitive (McGuinness & Pribram, 1978).

**Smell**

Nichols and Bailey (1886) again provide evidence on sex differences in sensitivity to smell. Here the trend is reversed, with males considerably more sensitive.

**Touch**

The trend favoring females in tactile threshold in the neonate is convincingly demonstrated in children and continues into adulthood where the evidence shows overwhelming sensitivity in the fingers and hands of females (Axelrod, 1959; Ippolitov, 1972; Jastrow, 1892; Weinstein & Sersen, 1961).

**Audition**

In the auditory mode, studies on threshold for sound have consistently demonstrated superior hearing for high frequencies in females from childhood onward (Corso, 1959; Eagles, Wishik, Doefler, Melnick, & Levine, 1963; Hull, Mielke, Timmons, & Willeford, 1971; McGuinness, 1972). Corso's findings are particularly relevant, as he could find no evidence that sex differences were in any way attributable to specific environmental factors. Females are intolerant of loud levels of sound both in childhood (Elliott, 1971), and adulthood (Corah & Boffa, 1970; McGuinness, 1972). Findings suggest that by the level of
85 db., females will hear the volume of any sound as twice as loud as males.

**Vision**

In the instance of visual modality the male is more efficient in conditions of light and females more sensitive in the dark (Burg, 1966; Burg & Hulbert, 1961; McGuinness, 1976; Roberts, 1964).

In summary, the evidence on sensory capacity shows that females are more sensitive to all modalities at threshold with the exception of smell, and that they possess a certain advantage in some aspects of tactile and auditory processing. Men have superior visual acuity and greater sensitivity to light.

**Special Abilities in Females**

Females aged 1-5 years are proficient in linguistic skills (Maccoby & Jacklin, 1974). The most notable distinction between the sexes at this early age is the use of speech by females for specifically communicative purposes (Smith & Connolly, 1972). This early advantage tends to fade during middle childhood. Females retain a marginal advantage in overall language ability such as fluency, comprehension, verbal reasoning and flexibility in handling verbal symbols. They perform outstandingly well in tests of reading skills. It is well known that remedial reading classes contain significantly higher proportions of males (Maccoby & Jacklin, 1974; McGuinness, 1979; Ounsted & Taylor, 1972).

Goodenough (1957) has found that sensitivity to persons, or increased social awareness, occurs in girls at 2-4 years. Oetzel (1967) lists 21
studies in which females were reported to have a significantly greater interest in people and social matters than males. Girls appear to learn about their world through communication. They ask questions as often as they act or perform. The stability of their environment comes largely through social and linguistic channels (McGuinness, 1979). Girls respond with interest when a new child is introduced into their group while boys at first ignore new children. Girls monitor their activities in speech, almost continuously offering advice and information or seeking help.

Girls can sing in tune at an earlier age, read sooner, and learn foreign languages more easily than boys (Restak, 1979). Females tend to have diffused language and spatial ability, with some representation in both hemispheres (Kraft & Languis, 1977; Restak, 1979). They speak sooner, with greater fluency and grammatical accuracy. Speech defects are almost non-existent (Restak, 1979). Females show superior memory ability; remembering verbal, visual and social information (Fairweather & Hutt, 1972).

Levy (1971) proposed the most straightforward theory that females are left hemisphere dominant and males are right hemisphere dominant. Buffery and Gray (1972) suggest that males are more bilateral and females more left hemisphere dominant. Harris (1976) interprets the data as indicating that the female is more bilateral for language and the male more asymmetric. For these three theories they cite identical anatomical evidence. Latest findings show the brain to be far more complicated than we ever believed, too complex to be adequately explained by simplistic theories. As more researchers are attempting to explore hemispheric differences by studying the behavior of normal subjects in
special testing situations we are being provided with more clues and answers to deal with this and other such dichotomies.

**Special Abilities in Males**

The superiority of males in visuo-spatial ability is well documented (Buffery & Gray, 1972; Garai & Scheinfeld, 1968; Guilford, 1967; Harris, 1976; Hutt, 1972; Maccoby & Jacklin, 1974; Tyler, 1965). Only one girl in 20 exceeded the male average on tests of spatial ability (Bennett & Cruickshank, 1942). There is some controversy as to when this advantage is evident. Maccoby and Jacklin (1974) contend that young children do not exhibit the differences to any large extent and the advantage for males does not occur until mid-childhood or later (Garai & Scheinfeld, 1968; Gazzaniga, 1974; Witkin, Dyk, Paterson, Goodenough, & Karp, 1962). Restak (1979) and McGuinness (1979) however suggest that the superiority is apparent during the first years of school or even at birth.

Boys perform poorly on dexterity tasks but excel at tasks calling for total body coordination. They learn by manipulating their environment and are primarily visual as opposed to verbal (McGuinness, 1979; Restak, 1979). Males respond to objects more than people, are generally active and more impulsive and curious. There is some evidence that the characteristic of curiosity in boys (but not in girls) leads to success in certain types of problem-solving tasks (Greenberger, O'Conner, & Sorensen, 1971). There is a superior mathematical ability for males that appears in the early teens (Benbow & Stanley, 1980; Maccoby & Jacklin, 1974).

Boys learn by watching and doing. A verbal command fades rapidly
from attention. Boys cannot sit still. They are distractible; they
"test the properties of objects" (McGuinness, 1979). Some authorities
estimate hyperactivity to be nine times more prevalent among boys than
girls (McGuinness, 1979; Miles, 1981).

Brain related sex differences do exist. Identifying sex differences
does not reveal anything about the origin of the differences. The
nature-nurture question arises and both biological and environmental
factors play a role in individual development.

**Development of Hemispheric Specialization:**
A Time Frame

How, and at what point do the basic differences between the left
and right brain found in adults fit into this picture of physical and
functional change in childhood? Do these asymmetries emerge over time
as the child develops, or are they present at birth or even possibly
before? Eric Lenneberg (1967), a psychologist at Cornell University,
reviewed a variety of evidence and concluded that lateralization of
function in the brain develops over time but is complete by puberty. A
neurologist named L. S. Basser (1962) hypothesized that lateralization
is completed by age 5, rather than by puberty. Reviewing Basser's work,
Kinsbourne (1975, 1978) maintains that lateralization is complete at
birth. Many dichotic listening studies have sought to determine the
earliest age at which the right-ear advantage may be found (Kimura, 1967;
Knox & Kimura, 1970; Nagafuchi, 1970). The standard test has been used
with children as young as 3, and a right ear advantage found (Nagafuchi,
1970). One study producing a REA used infants 50 days old (Entus, 1977).

Research investigating the time course of cerebral hemispheric
specialization and the factors that affect it is difficult. Our measures of laterality are far from perfect. Does failing to find differences between the hemispheres mean such differences do not exist? Can we be sure that we have not simply failed to set up conditions that would allow us to detect true differences (Springer & Deutsch, 1981)? There are no simple answers.

There is reason to postulate that the right brain system is the dominant mode of thinking and learning in the very young child, particularly in the first 2 years of life (Harris, 1975; Kraft & Languis, 1977). Harris (1975) presents a convincing argument for this right brain dominance in the very young, citing research support that (1) the visual cortex of the right hemisphere matures faster than the left, (2) high fevers which produce greater brain damage in the most active hemisphere cause more right hemisphere damage in infants before age 2, and (3) newborns tend to lie in a position which will enable most of the incoming sensory information to be processed by the right hemisphere. He concludes that the cognitive development of the right hemisphere precedes that of the left. This is evidenced by the early ability to recognize and discriminate between faces. He states that much of early learning is visuo-spatial and supports the notion that the right hemisphere is the "learning hemisphere" in early prelinguistic life (Kershner, 1977; Marcel & Rajan, 1975).

Gazzaniga (1974) and Galin (1976), neurosurgeons at California Institute of Technology, suggest that because the connecting corpus callosum fiber system slowly matures throughout infancy and childhood the young child may be a "functional split-brain" developing each
thinking system independently. They maintain that infants tend to be right brained, based partially on the evidence that 80% of newborn infants position their heads with the left ear up, channeling information to the right hemisphere (Wheatley, 1977).

A great deal more has been said about the "left brain" and "right brain" than could be reviewed in this chapter. There has been ample evidence presented, however, to support a basic hemispheric specialization theory. No attempt has been made to deal with the "how" and "why" of this specialization. Whether sex differences can be explained by genetically determined structural differences or hormonal development or attentional biases or these factors being acted upon by one's environment is not a question dealt with in this paper. That must be left to another time and another place.

**Educational Implications**

When a child's strengths and talents lie in a propensity for visual-spatial relations, and he or she is being forced into a curriculum that emphasizes the verbal articulatory modes of solving a conceptual problem, this child will encounter enormous frustration and difficulty which may well result in hostility toward the teacher and worse, toward the learning process itself (Gazzaniga, 1975).

In the early school years, according to McGuinness (1979), research associate at the Neuropsychology Laboratory at Stanford University, children concentrate on reading and writing, skills that largely favor girls. As a result, boys "fill remedial classes, don't learn to spell, and are classified as dyslexic or learning disabled four times as often
as girls" (p. 82). Studies have shown (McGuinness, 1979) that most hyperactive children are not unusually active. Instead they are distractible, and because their activity is inappropriate in the classroom, they become disruptive.

Observing children in a particular classroom, some learners who have great difficulty in spatial tasks do extremely well both in academic performance and classroom leadership in "hands-on" science inquiry lessons. Others, who excel in verbal learning are totally confused by this open-ended approach. Learning science concepts often relates to problem solving. Hands-on experiences and inquiry learning in science consistently seem to involve the imagery process (Languis, Sanders, & Tipps, 1980). Young children show substantial gains in verbal fluency, language complexity, and logic when they engage in activity-based, inquiry-oriented science programs.

Active manipulation of the physical world implies creating an environment favorable for the establishment of motoric representations. Rowe's study involving inner-city children showed 200% to 500% more student-initiated, content-relevant speech during science lessons than during language arts lessons (Rowe, 1978).

As tests are developed which will diagnose an individual with respect to the origin of specific mental skills, it is possible we will find that many people may be spatially bright while they are verbally dull, or spatially dull and verbally bright. We will find that some have a better short-term memory system, some a faster processing. Expanding on this theme, Gazzaniga (1975) explains:
If the teacher were to be made aware that a child is specialized in visual-spatial skills, both the discouragement and the subsequent hostility that is often present might be avoided if the child is allowed to use his special talents. Conversely, the child with high verbal skills may quite frequently be unable to visualize the spatial aspect of an assigned task. Far better results could be obtained if he is not forced into academic areas for which he is not naturally equipped. (p. 94)

**Summary**

Readings and studies cited in the review of the literature provided a framework of reference for comparison of research data. In this overview of left and right brain processing, an attempt has been made to separate what is reasonably established as fact from what is purely speculative. No attempt has been made to supply explanations, however, for seemingly inconsistent findings or for the "how" and "why" of brain specialization. Studying the left brain and right brain is but one approach to brain research. This study is an effort to convey, in part, the fruitfulness of this approach.

The review of the literature included hemispheric specialization, brain related sex differences, hemispheric specialization development and the resultant educational implications.
Chapter 3

METHODS AND PROCEDURES

The purpose of this study was to compare left and right brain hemisphere processing scores of selected male and female students representing three instructional styles.

Method

Population and Sample

Participants for the study were chosen from kindergarten classrooms representative of three different instructional approaches: (1) the Traditional-Conventional Instructional Approach; (2) the Montessori Instructional Approach; (3) the Open Activity-Centered Instructional Approach. Students were enrolled in kindergarten classes in the Tri-Cities area for the 1981-1982 school year in the city and county public schools, representative of the Traditional-Conventional approach; a Montessori school, representative of the Montessori approach; and the Child Study Center, a university-related preschool at East Tennessee State University, representative of the Open Activity-Centered approach.

Intact classes from each of the above-mentioned categories were randomly selected from city and county schools in the Tri-Cities area in Upper East Tennessee as follows:

Group 1 - 63 students (34 females, 29 males)
Group 2 - 8 students (4 females, 4 males)
Group 3 - 8 students (4 females, 4 males)
Group 1 employed the Traditional-Conventional Instructional approach to teaching. Group 2 was taught by the Montessori approach and Group 3 used the Open Activity-Centered approach to teaching.

Each building principal was contacted for permission to conduct the testing and treatment in the respective schools. Permission was also obtained from the teacher of each of the classes.

Names of the male students in the selected classes were alphabetized and assigned consecutive numbers. Using a table of random numbers, one-half of the students were chosen for the experimental group, the other half being assigned to the control group. Names of the female students were also alphabetized and assigned consecutive numbers. Using a table of random numbers, half the females were assigned to an experimental group, the other half to a control group. The process was repeated for each class used in the study. Students previously identified as candidates for special education classes were excluded from the study.

The resulting assignments were as follows:

Group 1E - 32 students (17 females, 15 males)
Group 1C - 31 students (17 females, 14 males)
Group 2E - 4 students (2 females, 2 males)
Group 2C - 4 students (2 females, 2 males)
Group 3E - 4 students (2 females, 2 males)
Group 3C - 4 students (2 females, 2 males)
Description of the Students and Instructional Approach

Traditional-Conventional Instructional Approach. The Traditional-Conventional Instructional Approach was described in this study as that which requires the students to remain in assigned seats much of the day. The students in these classes attended a full day, 8:30 a.m. to 2:30 p.m. All classes were a part of a public educational system.

Students were instructed mainly by lecture and demonstration. They indicated willingness to participate in class discussion by raising their hands and being called on to do so. Recall, memorization, reading, and writing were stressed. Preparing a student for first grade (or for the next grade) was an important goal. Teaching a child to count, write and perform basic primary skills was emphasized.

Progress was based on comparison and in competition with the other students. The environment was manipulated in such a way as to enable students to compete more effectively with other children in academic pursuits. Students were grouped according to age and grade level. There were uniform standards and expectations for students (Von Haden & King, 1971).

Montessori Instructional Approach. Students were enrolled in a private Montessori school. The school building housed kindergarten through second grade. Students attended kindergarten for the full day, 8:30 a.m. to 2:15 p.m. The teacher was formally trained in the Montessori method. The class was small (10) and students were children of professional parents. Tuition was required to attend this school.
The Montessori approach was based on encouraging each child to cultivate the natural desire to learn. Discovery and experience were key words. Sensory motor learning was stressed. Tactile and other materials specially designed for sequential learning were provided. Tables and chairs in the classroom were movable, allowing for flexibility in arrangement. Children often sat on the floor.

The entire program of learning was purposefully structured, allowing the child to handle and manipulate objects learned about from the environment. Activity was encouraged and planned for, such as carrying, pouring, walking, speaking, interacting, and the constant use of the hands.

Students were not necessarily being prepared for the future, but for living today. The teacher was more an observer and director than an authoritarian leader. Each child's work was evaluated on its own merit rather than being compared with the work of others. Students worked independently as opposed to working in group activities and were allowed to progress at their own pace (Von Haden & King, 1971; Wolf, 1968).

Open Activity-Centered Instructional Approach. Students in this class were mainly from university-related families and attended a full day, 8:00 a.m. to 1:30 p.m. The class was housed on the first floor of the Warf-Pickel Hall on the campus of East Tennessee State University.

As the name implies, activity was the emphasis in this instructional approach. Although the children experimented and explored, the sequence of activities was not as rigidly planned and structured as in the Montessori method of instruction. Field trips, visiting speakers, and outside activities were built into the program.
This open approach was flexible with more programming, activities, and interaction of pupil-pupil and pupil-teacher than in the Traditional or Montessori approach. The room was arranged into various interest centers and learning areas. The children had a great degree of freedom to move and function among these areas. Methods of reporting pupil progress were individual rather than based on comparison among students (Von Haden & King, 1971).

**Instrumentation**

The SRA Primary Mental Abilities subtests administered to the subjects in the study were from the revised edition published in 1962. The revision of the Primary Mental Abilities tests was designed to provide multifactored as well as general intelligence indices for all grade levels from kindergarten through twelfth grade (SRA Technical Report, 1965). The revised battery contains five subtests, two of which were administered to the subjects in the study, the Verbal Meaning test and the Spatial Relations Test.

The Verbal Meaning Test is a pencil and paper test involving the ability to understand ideas expressed in words. The K-1 test is a picture vocabulary test. This test is indicative of left hemisphere functioning (Berlin & Languis, 1980; Galin & Ornstein, 1975; Gazzaniga, 1975).

The Spatial Relations Test is a group paper and pencil test which involves the ability to visualize how parts of figures or objects fit together, what their relationships are, and what they look like when rotated in space. The kindergarten test has two parts, identifying the
missing part of a figure and completing a drawing of a model figure. The test is indicative of right hemisphere functioning (Berlin & Languis, 1980; McGlone & Davidson, 1973; Nebes, 1977).

Reliability data were obtained through cooperation of a public school system in North Carolina. The results of the test-retest studies are given in Table 1.

Table 1
Reliability Data Based on Test-Retest Studies on the PMA Spatial Relations and Verbal Meaning Test K-1

<table>
<thead>
<tr>
<th>Subtest</th>
<th>( r_{11} )</th>
<th>( SE_{M} )</th>
<th>( r_{11} )</th>
<th>( SE_{M} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Verbal meaning</td>
<td>.82</td>
<td>6.8</td>
<td>.77</td>
<td>5.8</td>
</tr>
<tr>
<td>Spatial relations</td>
<td>.69</td>
<td>7.3</td>
<td>.72</td>
<td>8.4</td>
</tr>
</tbody>
</table>


The Wechsler Intelligence Scale for Children - Revised (WISC-R) has been designed and organized as a test of general intelligence. It is used in this study, however, as an indication of left or right brain hemisphere processing. The WISC-R consists of 12 subtests, two of which (the Block Design and the Digit Span Test) were administered individually to the subjects in the study.

The Digit Span Test requires the subjects to repeat strings of digits heard, some forward and some backward. The research of Black

The Block Design Test requires the subject to duplicate a design shown by an experimental model using blocks with different colors on their different sides. This test has been related to right hemispheric functioning (Berlin & Languis, 1980; Warrington, James, & Black, 1974; Nebes, 1977; Sperry, 1964; Warrington & James, 1967).

**Procedures**

The Informed Consent Form (Appendix C) was sent to the parents or guardians of every subject. Each form was signed by parent or guardian and investigator. A short personal data sheet (Appendix D) was completed by the parents/guardians of each child.

**Pretest**

The four subtests, two from the WISC-R, the Block Design and the Digit Span test; and two from the SRA Primary Mental Abilities Test, the Verbal Meaning and the Spatial Relations tests were administered to the subjects in the sample. The Verbal Meaning Test and the Spatial Relations Test, being pencil and paper tests, were administered to small groups of six or seven subjects. The Digit Span Test and the Block Design Test were given individually. The pretest was administered to all the children participating in the study the week prior to the treatment phase. These pretest scores were used for the purpose of gathering baseline data. The test results were recorded.
Treatment

Student teachers majoring in Early Childhood Education were trained in the use of teaching strategies associated with an inquiry-oriented science program, using C. S. Lavatelli's (1970) Early Childhood Curriculum as the basis. This open type, inquiry-oriented treatment program, designed to engage right hemisphere processing, was presented to the experimental group one-half hour three times weekly for 5 weeks.

This Piaget-based curriculum, developed as a part of the American Science and Engineering Program, was organized around three main themes: classification, number, space and measurement; and seriation (arranging things in a certain order). The emphasis, however, was placed on the way in which the material was presented rather than the content of the material. The type response required was more important than the accuracy of the response. Tasks and methodology requiring right hemisphere processing were stressed. These lessons consisted of activities designed to engage right brain hemisphere processing such as divergent questioning, hands-on activity, discovery, increased waiting time for response to questions, imagining, manipulation of objects and little or no writing or recall work (see Appendix A). Student teachers were encouraged to ask questions and increase waiting time for student response. The children were led to solve problems by acting and reacting physically and mentally with the data presented and by shuffling the facts about in their minds. They were asked to imagine and visualize rather than using pictures or workbooks. Open discussion and a spirit of free inquiry were encouraged. Small group work was incorporated into each session. Detailed written instructions and Lavatelli's Curriculum
Guide were given to each student teacher. Appropriate activities were included for each session (see Appendix A).

The control groups received traditional classroom lessons designed to control for the Hawthorne effect, which might have been present. Behavioral objectives, appropriate activities and the teaching style to be used were included for each lesson taught. These lessons were presented by the same student teachers who presented the treatment. Written assignments in mathematics, handwriting or alphabet work were utilized in the control groups. An attempt was made to incorporate both tasks and methods and did not directly require right brain hemispheric processing on the part of the student. The tasks were primarily paper-work that called for memorization, handwriting projects, and phonics drills accompanied by verbal instruction.

Posttest

Upon completion of the 15 one-half hour sessions of instruction, the experimental and control groups were posttested, using the same four subtests, approximately 6 weeks after the beginning of the first treatment session.

Data Analysis

The collection and analysis of data in the study were for the purpose of determining differences, if any, between kindergarten males and females in hemispheric functioning, using three selected instructional styles. A second purpose was to evaluate the effectiveness of right brain teaching strategies on the kindergarten students' ability to employ right brain hemispheric functioning.
For statistical purposes, the null form of each of the hypotheses was tested. The statistical techniques used to analyze and interpret the data were the analysis of variance (ANOVA), the three-way analysis of covariance (ANCOVA), t-test for independent samples, and the Newman-Keuls procedure.

The three-way analysis of covariance was used to determine the difference in posttest means, controlling for differences between pretest means. W. James Popham and Kenneth A. Sirotnik (1973) asserted that the analysis of covariance was an extremely valuable statistical measure because it "compensated for initial differences between groups" while allowing the researcher to test for mean difference between two or more groups. The level of significance used in the study was 0.05. Data were processed through the East Tennessee State University Computer Center.

Hypotheses $H_1$ through $H_{18}$ were based on pretest scores and were made in support of the existing literature as well as to provide necessary baseline data.

**Personnel Required**

Personnel required for the study consisted of four senior undergraduate student teachers majoring in Early Childhood Education and the investigator who conducted the orientation and planned meetings with the student teachers. They were instructed in the use and purpose of the Lavatelli Science Kit as well as in the method of conducting sessions to engage right hemisphere processing. The pretest and posttest for the study were administered by the investigator. Student teachers presented
the 15 one-half hour treatment sessions to the experimental groups and the lessons to the control groups.

**Setting**

Each kindergarten classroom used provided the space necessary for testing and for presenting lessons. All the testing (group and individual) was administered in an unused classroom. The treatment for the experimental group and the lessons for the control groups were presented at an individual learning center or in an unused classroom.

**Equipment**

Desks and chairs were furnished in each classroom used. Testing materials were duplicated by special permission of Science Research Associates (Appendix E). The necessary paper for duplication, scoring forms, and Lavatelli kit materials were provided by the investigator. Materials used in the lessons for the control group were those materials present in the classroom or supplemented by the investigator.

**Summary**

Chapter 3 included population and sample, data analysis techniques, description of students and instructional styles, instrumentation, procedures, personnel required, setting and equipment.
Chapter 4

PRESENTATION AND ANALYSIS OF DATA

Presentation of Data

Participants for the study were chosen from intact kindergarten classrooms representative of three different instructional approaches: (1) Traditional-Conventional Instructional Approach, (2) Montessori Instructional Approach, (3) Open Activity-Centered Instructional Approach. Students were divided according to sex and then randomly assigned to the experimental and control groups.

Four subtests were administered to each student for the purpose of determining left and right brain hemisphere functioning. Two subtests were indicative of left hemisphere functioning; the Verbal Meaning subtest from the SRA Primary Mental Abilities Test, and the Digit Span subtest from the WISC-R test. Two subtests were indicative of right hemisphere functioning; the Spatial Relations subtest from the SRA Primary Mental Abilities Test and the Block Design subtest from the WISC-R test.

A series of lessons was taught for an instructional period of 15 one-half hour sessions to both experimental and control groups. The lessons for the experimental group consisted of activities designed to elicit right brain functioning. The control group received lessons consisting of regular classroom work that required recall and work with letters and numbers, primarily left brain activities. Six weeks later,
upon the completion of these lessons, the four subtests were re-administered. Data were processed at the Office of Computer Services at East Tennessee State University.

Pretest means for the left hemisphere tasks (PMA Verbal Meaning test and WISC-R Digit Span test) for all males and females in the three instructional approaches are shown in Table 2. The females had a mean of 2.065 points greater than the males on the Verbal Meaning test. There was a 1.660 difference in the means on the Digit Span in favor of females.

### Table 2

Pretest Means for Left Hemisphere Tasks (PMA Verbal Meaning Test and WISC-R Digit Span Test) by Sex

<table>
<thead>
<tr>
<th>Sex</th>
<th>Verbal Meaning</th>
<th></th>
<th></th>
<th>Digit Span</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Means</td>
<td>SD</td>
<td>Variance</td>
<td>Means</td>
<td>SD</td>
<td>Variance</td>
</tr>
<tr>
<td>M</td>
<td>28.649</td>
<td>7.700</td>
<td>59.290</td>
<td>4.054</td>
<td>2.687</td>
<td>7.219</td>
</tr>
<tr>
<td>F</td>
<td>30.714</td>
<td>8.220</td>
<td>67.575</td>
<td>5.714</td>
<td>2.521</td>
<td>6.355</td>
</tr>
</tbody>
</table>

Note. Total n = 79

Pretest means for the WISC-R Block Design test and the PMA Spatial Relations test, which are right hemisphere tasks, are shown by sex in Table 3. On these right hemisphere tasks the means for all males were less than 1 point greater than the means for all females in the three instructional approaches: .613 on the Block Design and .679 on the Spatial Relations test.

Although these differences were not great enough to be statistically significant, the differences were in the direction of the hypotheses.
That is, females scored higher than males on left hemisphere tasks and males scored higher than females on right hemisphere tasks.

### Table 3

<table>
<thead>
<tr>
<th>Sex</th>
<th>Block Design</th>
<th>Spatial Relations</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Means SD Variance</td>
<td>Means SD Variance</td>
</tr>
<tr>
<td>M n=37</td>
<td>5.108 4.033 16.266</td>
<td>10.703 4.352 18.937</td>
</tr>
<tr>
<td>F n=42</td>
<td>4.595 3.343 11.174</td>
<td>10.024 4.876 23.780</td>
</tr>
</tbody>
</table>

Note. Total n = 79

**Testing of Hypotheses**

The hypotheses presented in Chapter 1 are given here in the null form. The data were computer analyzed using the Statistical Package for the Social Sciences (SPSS), Release 9 and the Statistical Analysis System (SAS). The analysis of variance (ANOVA), the three-way analysis of covariance (ANCOVA), the t-test for independent samples and the Newman-Keuls procedure were used to determine statistical significance. The level of significance for rejection of the null hypotheses was set at p < .05 using a two-tailed test.

\[ H_{01} \]

There will be no significant difference in the pretest means on the WISC-R Digit Span test (left hemisphere task) between male and female
students from classes using the Traditional-Conventional Instructional Approach.

The means for males and females in all three instructional approaches—Traditional-Conventional, Montessori and Open Activity-Centered—were utilized in order to provide a thorough analysis of the data. To incorporate all these scores the analysis of variance was employed. The results, shown in Table 4, yielded an F ratio of 8.718, significant at .05 level, indicating a significant difference between the means. Table 4 was used as the basis for further analysis of hypotheses 1 through 3, since each of these hypotheses dealt with the Digit Span test.

Table 4

Summary of the Analysis of Variance of Pretest Scores by Sex for Students from Three Instructional Approaches Using the WISC-R Digit Span Test

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>SS</th>
<th>DF</th>
<th>MS</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex</td>
<td>56.947</td>
<td>1</td>
<td>56.947</td>
<td>8.718a</td>
</tr>
</tbody>
</table>

Note. Analysis of variance: Total n = 79.

a p < .05

Continued analysis of the data using the t-test for independent samples, shown in Table 5, showed a mean difference of 2.042 between males and females in the Traditional-Conventional Instructional Approach and a t value of 3.500. With 61 degrees of freedom, the t-score was significant at the .05 level. Therefore, the investigator rejected
the null hypothesis and accepted the research hypothesis that there was a significant difference.

Table 5

An Analysis of Pretest Means by Sex for Students from the Traditional-Conventional Instructional Approach Using the WISC-R Digit Span Test

<table>
<thead>
<tr>
<th>N</th>
<th>Sex</th>
<th>Mean</th>
<th>Variance</th>
<th>Standard Deviation</th>
<th>Mean Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>29</td>
<td>Male</td>
<td>3.517</td>
<td>3.973</td>
<td>1.993</td>
<td>2.042</td>
</tr>
<tr>
<td>34</td>
<td>Female</td>
<td>5.559</td>
<td>6.618</td>
<td>2.572</td>
<td></td>
</tr>
</tbody>
</table>

\( t = 3.500 \quad df = 61 \quad p < .001 \)

\( H_0^2 \)

There will be no significant difference in the pretest means on the WISC-R Digit Span test (left hemisphere task) between male and female students from classes using the Montessori Instructional Approach.

The t-test was applied to the means of male and female students in classes from the Montessori Instructional Approach and, as shown in Table 6, there was no significant difference between the sexes. There was a mean difference of .500 with six degrees of freedom and a t value of .217, not significant at the .05 level. Consequently, the investigator failed to reject the null hypothesis.
Table 6
An Analysis of Pretest Means by Sex for Students From a Montessori Instructional Approach Using the WISC-R Digit Span Test

<table>
<thead>
<tr>
<th>N</th>
<th>Sex</th>
<th>Mean</th>
<th>Variance</th>
<th>Standard Deviation</th>
<th>Mean Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>Male</td>
<td>5.750</td>
<td>18.250</td>
<td>4.272</td>
<td>.500</td>
</tr>
<tr>
<td>4</td>
<td>Female</td>
<td>6.250</td>
<td>2.917</td>
<td>1.708</td>
<td></td>
</tr>
</tbody>
</table>

\[ t = .217 \quad df = 6 \quad p > .05 \]

\[ H_{0}^{3} \]

There will be no significant difference in the pretest means on the WISC-R Digit Span test (left hemisphere task) between male and female students from classes using the Open Activity-Centered Instructional Approach.

Applying the t-test for independent samples to the means of male and female students in the Open Activity-Centered class, as shown in Table 7, yielded a mean difference of .250. With six degrees of freedom, the t value of .095 was not significant at .05 level. These results indicated that no significant difference existed between the sexes. Hypothesis 3 was not rejected.

\[ H_{0}^{4} \]

There will be no significant difference in the pretest means on the PMA Verbal Meaning test (left hemisphere task) between male and female students from classes using the Traditional-Conventional Approach.
Table 7
An Analysis of Pretest Means by Sex for Students from an Open Activity-Centered Instructional Approach Using the WISC-R Digit Span Test

<table>
<thead>
<tr>
<th>N</th>
<th>Sex</th>
<th>Mean</th>
<th>Variance</th>
<th>Standard Deviation</th>
<th>Mean Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>Male</td>
<td>6.250</td>
<td>18.250</td>
<td>5.272</td>
<td>.250</td>
</tr>
<tr>
<td>4</td>
<td>Female</td>
<td>6.500</td>
<td>9.667</td>
<td>3.109</td>
<td></td>
</tr>
</tbody>
</table>

_t = .095_  
_dfs = 6_  
_p > .05_

The means for males and females in all three instructional approaches were incorporated into the analysis of variance to discover whether there was any significant difference between the means on the Verbal Meaning test. The results, illustrated in Table 8, showed an F ratio of 1.697 which was not significant at .05 level. Since that F ratio (1.697) indicated no significant difference between the sexes across all instructional approaches it was concluded that there was no significant difference between the means of males and females in the Traditional-Conventional classes. There was no need for further analysis of the data. Consequently, the investigator failed to reject the null hypothesis. Table 8 was used as the basis for the analysis of hypotheses 4, 5, and 6.

\[ H_{O5} \]

There will be no significant difference in the pretest means on the FMA Verbal Meaning test (left hemisphere task) between male and female students from classes using the Montessori Instructional Approach.
Table 8

Summary of the Analysis of Variance of Pretest Scores by Sex for Students from Three Instructional Approaches Using the PMA Verbal Meaning Test

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>SS</th>
<th>DF</th>
<th>MS</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex</td>
<td>99.089</td>
<td>1</td>
<td>99.089</td>
<td>1.697a</td>
</tr>
</tbody>
</table>

Note. Analysis of variance: total n = 79.

a p > .05

As presented in Table 8, the F ratio was 1.697 which was not significant at the .05 level, indicating that no significant difference existed between the sexes in the Montessori class on the Verbal Meaning test. These results negated the need for further testing. As a result, the null hypothesis was not rejected.

\[ H_0 \]

There will be no significant difference in the pretest means on the PMA Verbal Meaning test (left hemisphere task) between male and female students from classes using the Open Activity-Centered Instructional Approach.

Again, referring to Table 8, the F ratio of 1.697 did not equal or exceed the critical F value. This F ratio (1.697) indicated that no significant difference existed between the means of the sexes in the Open Activity-Centered classes on the Verbal Meaning test. As a result, no further test was needed. The investigator failed to reject the null hypothesis.
There will be no significant difference in the pretest means on the WISC-R Block Design test (right hemisphere task) between male and female students from classes using the Traditional-Conventional Instructional Approach.

To facilitate the analyses of the data, the means for the sexes of all three instructional approaches were used in an analysis of variance. Table 9 shows the results of the analyzed data concerning the pretest means for the sexes across all three instructional approaches using the WISC-R Block Design test. As indicated by the analysis of variance summarized in Table 9, there was no significant difference between the means of male and female students across all instructional approaches. Table 9 was used as a basis for the analysis of hypotheses 7, 8 and 9.

Table 9
Summary of the Analysis of Variance of Pretest Scores by Sex for Students from Three Instructional Approaches Using the WISC-R Block Design Test

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>SS</th>
<th>DF</th>
<th>MS</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex</td>
<td>3.035</td>
<td>1</td>
<td>3.035</td>
<td>.335a</td>
</tr>
</tbody>
</table>

Note. Analysis of variance: total n = 79.

a p > .05
The obtained F ratio (Table 9) of .335 did not equal or exceed the critical F value needed, indicating no significant difference between the means of males and females in the Traditional-Conventional classes on the WISC-R Block Design test. Thus, further analysis was unnecessary and the investigator failed to reject the null hypothesis.

\[ H_0 \]

There will be no significant difference in the pretest means on the WISC-R Block Design test (right hemisphere task) between male and female students from classes using the Montessori Instructional Approach.

Analysis of the pretest means between the sexes of all three instructional approaches on the Block Design test, shown in Table 9, yielded an F ratio of .335. This ratio was not significant at .05 level, indicating no significant difference between the mean scores of male and female students in the Montessori class. Further testing, therefore, was unnecessary; consequently, the investigator failed to reject the null hypothesis.

\[ H_0 \]

There will be no significant difference in the pretest means on the WISC-R Block Design test (right hemisphere task) between male and female students from classes using the Open Activity-Centered Instructional Approach.

As shown by the analysis of variance summarized in Table 9, there was no significant difference between the means of male and female students across all three instructional approaches. The obtained F ratio
(.335) indicated no significant difference between the means of males and females in the Open Activity-Centered classes on the WISC-R Block Design test. Therefore, the null hypothesis was not rejected.

\[ H_{0.10} \]

There will be no significant difference in the pretest means on the PMA Spatial Relations test (right hemisphere task) between male and female students from classes using the Traditional-Conventional Instructional Approach.

The pretest means for males and females from the three instructional approaches were used in the statistical analysis of the Spatial Relations test scores. Table 10 incorporates the data provided by the analysis of variance. Information contained in Table 10 was used as a basis for the analysis of hypotheses 10, 11 and 12 since each of the three hypotheses dealt with the results of the Spatial Relations test.

Table 10

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>SS</th>
<th>DF</th>
<th>MS</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex</td>
<td>5.585</td>
<td>1</td>
<td>5.585</td>
<td>.343a</td>
</tr>
</tbody>
</table>

Note. Analysis of variance: total n = 79.

\[ ^a \] p > .05
The results of the analysis (Table 10) showed an F ratio of .343 which is not significant at .05 level. No significant difference was indicated between the means for males and females on the Spatial Relations test. Thus, further tests were unnecessary and the investigator failed to reject the null hypothesis.

**H₀₁₁**

There will be no significant difference in the pretest means on the PMA Spatial Relations test (right hemisphere task) between male and female students from classes using the Montessori Instructional Approach.

As shown in Table 10, analyzing the data using the pretest means for the sexes in the three instructional approaches provided an F ratio of .343. This ratio did not equal or exceed the critical F value, thus indicating there was no significant difference between the means of male and female students in the Montessori class on the Spatial Relations test. No further analysis of the data was necessary. Hypothesis 11 was not rejected.

**H₀₁₂**

There will be no significant difference in the pretest means of the PMA Spatial Relations test (right hemisphere task) between male and female students from classes using the Open Activity-Centered Instructional Approach.

The analysis of the Spatial Relations pretest means of males and females, as shown in Table 10, indicates an F ratio of .343 which is not significant at .05 level. Since no significant difference existed between
pretest means of males and females in the Montessori class, it was not necessary for further analysis. Therefore, the investigator failed to reject the null hypothesis.

\[ H_0 \]

The pretest mean for students in the Open Activity-Centered Instructional Approach will not be significantly different on the WISC-R Block Design test (right hemisphere task) from the pretest mean of the students in the Montessori Instructional Approach.

Continuing analysis of data across all three instructional approaches the analysis of variance, summarized in Table 11, showed a significant difference between the means of the instructional approaches on the Block Design test. Tables 11 and 12 were used as the bases for analysis of hypotheses 13, 14, and 15, since each hypothesis dealt with the WISC-R Block Design test by instructional approach. The achieved F ratio was 18.157 which was significant at the .05 level.

Table 11

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>SS</th>
<th>DF</th>
<th>MS</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Instructional Approach</td>
<td>329.124</td>
<td>2</td>
<td>164.562</td>
<td>18.157a</td>
</tr>
</tbody>
</table>

Note. Analysis of variance: total n = 79.

\[ ^a \] p < .05
Table 12
An Analysis of Pretest Means by Instructional Approach Using the Block Design Test

<table>
<thead>
<tr>
<th>Sex</th>
<th>Montessori</th>
<th>Open Activity</th>
<th>Traditional</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$\overline{X}$</td>
<td>$N$</td>
<td>$\overline{X}$</td>
</tr>
<tr>
<td>Male</td>
<td>12.250</td>
<td>4</td>
<td>5.000</td>
</tr>
<tr>
<td>Female</td>
<td>8.500</td>
<td>4</td>
<td>8.500</td>
</tr>
<tr>
<td>Total</td>
<td>20.750</td>
<td>8</td>
<td>13.500</td>
</tr>
<tr>
<td>Mean</td>
<td>10.375</td>
<td>6.750</td>
<td>3.887</td>
</tr>
</tbody>
</table>

The means in Table 12 were later used for the Newman-Keuls procedure. The results of this procedure, presented in Table 13, indicated the mean for students from the Open Activity-Centered class (6.750) was significantly lower than the mean of students from the Montessori class (10.375). Thus, the investigator rejected the null hypothesis and accepted the research hypothesis that there was a significant difference between pretest and posttest means.

$H_{0}^{14}$

The pretest mean for students in classes from the Open Activity-Centered Instructional Approach will not be significantly different on the WISC-R Block Design test (right hemisphere task) from the pretest mean of the students in the Traditional-Conventional Instructional Approach.
Table 13

Summary of Differences Between All Pairs of Means from Three Instructional Approaches Using the WISC-R Block Design Test

<table>
<thead>
<tr>
<th>Ordered Means</th>
<th>Traditional</th>
<th>Open Activity</th>
<th>Montessori</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.889</td>
<td>6.750</td>
<td>10.375</td>
<td></td>
</tr>
<tr>
<td>3.889</td>
<td>2.861&lt;sup&gt;a&lt;/sup&gt;</td>
<td>6.486&lt;sup&gt;a&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td>6.750</td>
<td></td>
<td>3.625&lt;sup&gt;a&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td>10.375</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<sup>a</sup> p < .05

Using the Newman-Keuls test of multiple comparisons, results presented in Table 13 showed a significant difference in the means. The mean of students in the Open Activity-Centered Instructional Approach (6.750) was significantly greater on the Block Design test than the mean of the students from the Traditional-Conventional classes (3.889). Thus, null hypothesis 14 was rejected and the research hypothesis was accepted.

H<sub>0</sub><sub>15</sub>

The pretest mean for students in classes from the Montessori Instructional Approach will not be significantly different on the WISC-R Block Design test (right hemisphere task) from the pretest mean for students in the classes from the Traditional-Conventional Instructional Approach.
Using the means in Table 12, the Newman-Keuls procedure was applied. The results of the test, shown in Table 13, indicated a significant difference in the means. The mean of the students in the Montessori class (10.375) was significantly greater on the Block Design test than the mean of the students in the Traditional-Conventional classes (3.889). Hypothesis 15 was rejected.

H₀₁₆

The pretest mean for students in the Open Activity-Centered Instructional Approach will not be significantly different on the PMA Spatial Relations test (right hemisphere task) from the pretest mean for students in the Montessori Instructional Approach.

The scores of students from the three instructional approaches were utilized in the analysis of variance conducted with the Spatial Relations test. Table 14 indicates a significant difference in the means between the instructional approaches. The F ratio was 13.332, which exceeded the critical value of F. From the means presented in Table 15, the Newman-Keuls test of multiple comparisons was calculated. The analysis of variance summarized in Table 14, the means in Table 15 and the Newman-Keuls procedure shown in Table 16 were used as the bases for the analysis of hypotheses 16, 17 and 18. Each of these hypotheses dealt with the Spatial Relations test across all three instructional approaches.

The results of the Newman-Keuls, presented in Table 16, showed no significant difference between the students in the Open Activity-Centered class (13.625) and the mean of the students in the Montessori class (16.125) on the Spatial Relations test. Based on these findings hypothesis 16 was not rejected.
Table 14

Summary of the Analysis of Variance of Pretest Scores by Instructional Approach for Students from Three Instructional Approaches Using the PMA Spatial Relations Test

<table>
<thead>
<tr>
<th>Source of Variance</th>
<th>SS</th>
<th>DF</th>
<th>MS</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Instructional Approach</td>
<td>433.826</td>
<td>2</td>
<td>216.913</td>
<td>13.332^a</td>
</tr>
</tbody>
</table>

Note. Analysis of variance: total n = 79.
^a p < .05

Table 15

Pretest Mean for Students from Three Instructional Approaches Using the Spatial Relations Test

<table>
<thead>
<tr>
<th>Sex</th>
<th>Montessori</th>
<th>Open Activity</th>
<th>Traditional</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>X</td>
<td>N</td>
<td>X</td>
</tr>
<tr>
<td>Male</td>
<td>16.000</td>
<td>4</td>
<td>12.000</td>
</tr>
<tr>
<td>Female</td>
<td>16.250</td>
<td>4</td>
<td>15.250</td>
</tr>
<tr>
<td>Total</td>
<td>32.250</td>
<td>8</td>
<td>27.250</td>
</tr>
<tr>
<td>Mean</td>
<td>16.125</td>
<td>13.625</td>
<td>9.190</td>
</tr>
</tbody>
</table>
Table 16

Summary of Differences Between All Pairs of Means (Newman-Keuls) for Three Instructional Approaches Using the PMA Spatial Relations Test

<table>
<thead>
<tr>
<th>Ordered Means</th>
<th>Traditional</th>
<th>Open Activity</th>
<th>Montessori</th>
</tr>
</thead>
<tbody>
<tr>
<td>9.190</td>
<td>13.625</td>
<td>16.125</td>
<td></td>
</tr>
<tr>
<td>4.435&lt;sup&gt;a&lt;/sup&gt;</td>
<td>6.935&lt;sup&gt;a&lt;/sup&gt;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.500</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6.935&lt;sup&gt;a&lt;/sup&gt;</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<sup>a</sup> p < .05

**H.017**

The pretest mean for students in the Open Activity-Centered Instructional Approach will not be significantly different on the PMA Spatial Relations test (right hemisphere task) from the mean for students in the Traditional-Conventional Instructional Approach.

Using the pretest means in Table 15, the Newman-Keuls test of multiple comparisons was performed. The results of this procedure, presented in Table 16, showed the mean of the students in the Open Activity-Centered class (13.625) to be significantly greater than the mean of students in the Traditional-Conventional classes (9.190). Thus, hypothesis 17 was rejected.

**H.018**

The pretest mean for students in classes from the Montessori Instructional Approach will not be significantly different on the PMA...
Spatial Relations test (right hemisphere task) from the pretest mean for students in the Traditional-Conventional Instructional Approach.

Again, using the pretest means in Table 15 the Newman-Keuls was calculated. The summarized results of this procedure for the Spatial Relations test are found in Table 16. The mean of the Montessori students (16.125) was significantly greater than the mean of students from the Traditional-Conventional classes (9.190). Therefore, hypothesis 18 was rejected.

H$_{0}^{19}$

The posttest mean for females in the experimental group will not be significantly different on the WISC-R Block Design test (right hemisphere task) from the posttest mean for females in the control group from classes using the Traditional-Conventional Instructional Approach.

In order to allow and adjust for any pre-existing differences between the intact classes, and to incorporate data from the treatment groups and all three instructional approaches the three-way analysis of covariance was chosen as the appropriate statistical procedure. The pretest served as the covariate. The results of the analysis are shown in Table 17, and was used as the bases for the analysis of hypotheses 19 through 24.

As Table 17 shows, the F ratio of 13.800 is statistically significant at .05 level. This F ratio (13.800) indicated a significant difference between the means of the treatment groups on the WISC-R Block Design test.

Using the adjusted means in Table 18 the Newman-Keuls procedure was utilized and the results, shown in Table 19, revealed no significant
difference between the mean of the experimental group (7.138) and the
mean of the control group (5.879) on the Block Design test for females
in the Traditional-Conventional Instructional Approach. Based on these
results hypothesis 19 failed to be rejected.

Table 17

Summary of the Analysis of Covariance of Pretests and
Posttests by Treatment Group Using the WISC-R
Block Design Test

<table>
<thead>
<tr>
<th>Source of Variance</th>
<th>SS</th>
<th>DF</th>
<th>MS</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatment Group</td>
<td>133.190</td>
<td>1</td>
<td>133.190</td>
<td>13.800(^a)</td>
</tr>
</tbody>
</table>

*Note. Analysis of covariance: total n = 79.*

\(^a\) \(p < .05\)

Table 18

Adjusted Posttest Means for Females in Experimental
and Control Groups from Three Instructional
Approaches Using the WISC-R
Block Design Test

<table>
<thead>
<tr>
<th>Montessori</th>
<th>Open Activity</th>
<th>Traditional</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experimental</td>
<td>Control</td>
<td>Experimental</td>
</tr>
<tr>
<td>17.506</td>
<td>7.752</td>
<td>9.441</td>
</tr>
</tbody>
</table>
Table 19
Summary of Differences Between All Pairs of Adjusted Posttest Means for Females in Experimental and Control Groups from Three Instructional Approaches Using the WISC-R Block Design Test

<table>
<thead>
<tr>
<th>Ordered Means</th>
<th>OA Control</th>
<th>TC Control</th>
<th>TC Exp.</th>
<th>M Control</th>
<th>M Exp.</th>
<th>M Exp.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3.817</td>
<td>5.879</td>
<td>7.138</td>
<td>7.752</td>
<td>9.441</td>
<td>17.506</td>
</tr>
<tr>
<td>3.817</td>
<td>2.063</td>
<td>3.323</td>
<td>3.931</td>
<td>5.622</td>
<td>13.694a</td>
<td></td>
</tr>
<tr>
<td>5.879</td>
<td>1.262</td>
<td>1.874</td>
<td>3.564</td>
<td>11.633a</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7.138</td>
<td>.610</td>
<td>2.302</td>
<td>10.376a</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7.752</td>
<td>1.965</td>
<td>9.764a</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9.441</td>
<td></td>
<td>8.072</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>17.506</td>
<td></td>
<td>0.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note. OA = Open Activity; TC = Traditional-Conventional; M = Montessori

\(^a\) p < .05

\(H_{020}\)

The posttest mean for females in the experimental group will not be significantly different on the WISC-R Block Design test (right hemisphere task) from the posttest mean for females in the control group from classes using the Montessori Instructional Approach.

Referring to the adjusted posttest means (Table 18) from which the Newman-Keuls procedure was performed, the results, recorded in Table 19 showed a significant difference in the means. The posttest mean of
females in the experimental group (17.506) was significantly greater on the Block Design test than the mean of females in the control group (7.752) for classes using the Montessori approach. The investigator rejected the null hypothesis and accepted the research hypothesis.

The posttest mean for females in the experimental group will not be significantly different on the WISC-R Block Design test (right hemisphere task) from the posttest mean for females in the control group from classes using the Open Activity-Centered Instructional Approach.

Again, referring to the Newman-Keuls table of ordered means, Table 19, it is shown there was no significant difference between the mean of the experimental group (9.441) and the mean of the control group (3.817) for females in the Open Activity-Center class. Consequently, the investigator failed to reject the null hypotheses.

The posttest mean for males in the experimental group will not be significantly different on the WISC-R Block Design test (right hemisphere task) from the posttest mean for males in the control group from classes using the Traditional-Conventional Instructional Approach.

The adjusted posttest means for all the teaching approaches are presented in Table 20, followed by the Newman-Keuls procedure (Table 21) on the WISC-R Block Design test. An analysis of the data, presented in Table 21, indicated that a mean of 7.847 for the experimental group and a mean of 5.359 for the males in the control group resulted in no
significant difference for males in the Traditional-Convention classes on the Block Design test. Based on these findings hypothesis 22 failed to be rejected.

Table 20

<table>
<thead>
<tr>
<th>Montessori</th>
<th>Open Activity</th>
<th>Traditional</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experimental</td>
<td>Control</td>
<td>Experimental</td>
</tr>
<tr>
<td>11.817</td>
<td>8.009</td>
<td>9.252</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 21

<table>
<thead>
<tr>
<th>Ordered Means</th>
<th>TC Control</th>
<th>TC Exp.</th>
<th>M Control</th>
<th>OA Control</th>
<th>OA Exp.</th>
<th>M Exp.</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.359</td>
<td>7.847</td>
<td>8.009</td>
<td>8.377</td>
<td>9.252</td>
<td>11.817</td>
<td></td>
</tr>
<tr>
<td>7.847</td>
<td>2.488</td>
<td>2.649</td>
<td>3.017</td>
<td>3.893</td>
<td>6.458</td>
<td></td>
</tr>
<tr>
<td>8.009</td>
<td>.161</td>
<td>.529</td>
<td>1.405</td>
<td>3.970</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8.377</td>
<td>.368</td>
<td>1.243</td>
<td>3.808</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9.252</td>
<td>.875</td>
<td>3.440</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11.817</td>
<td>2.564</td>
<td>0.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The posttest mean for males in the experimental group will not be significantly different on the WISC-R Block Design test (right hemisphere task) than the posttest mean for males in the control group from classes using the Montessori Instructional Approach.

Using the adjusted posttest means for males in the Montessori class (Table 20) the Newman-Keuls procedure for multiple comparisons was applied to the Block Design test. The results of this test are presented in Table 21.

As indicated in Table 21 the mean of 11.817 for the experimental group and the mean of 8.009 for the control group were not significantly different for males in the Montessori class on the Block Design test. Therefore, null hypothesis 23 failed to be rejected.

The posttest mean for males in the experimental group will not be significantly different on the WISC-R Block Design test (right hemisphere task) from the posttest mean for males in the control group from classes using the Open Activity-Centered Instructional Approach.

Continued analysis utilized the adjusted posttest means for males in the experimental and control group on the WISC-R Block Design as shown in Table 20. Using these means the Newman-Keuls test of multiple comparisons was computed. As presented in Table 21 the mean for Open Activity-Centered male experimental group (9.252) was not significantly different from the mean of the control group (8.377). Therefore, hypothesis 24 failed to be rejected.
The posttest mean for females in the experimental group will not be significantly different on the PMA Spatial Relations test (right hemisphere task) than the posttest means for females in the control group from classes using the Traditional-Conventional Instructional Approach.

The adjusted posttest means for the treatment groups from all three instructional approaches were analyzed by a three-way analysis of covariance with the pretest serving as the covariate. As presented in Table 22, the obtained F ratio of 14.292 was significant at the .05 level. Table 22 was used as the basis for further analysis with hypotheses 25 through 30. The adjusted means from Table 23 were used for the Newman-Keuls procedure. The posttest mean of 14.252 for the Traditional-Conventional females in the experimental group and the mean of 9.941 for the control group as indicated by the Newman-Keuls procedure (Table 24) were not significantly different. It was concluded, therefore, that there was no significant difference between the means of the females in the experimental group and the females in the control group in the Traditional-Conventional classes on the Spatial Relations test. Thus, hypothesis 25 was not rejected.

The posttest mean for females in the experimental group will not be significantly different on the PMA Spatial Relations test (right hemisphere task) than the posttest means for females in the control group from classes using the Montessori Approach.

H_0.25

The posttest mean for females in the experimental group will not be significantly different on the PMA Spatial Relations test (right hemisphere task) than the posttest means for females in the control group from classes using the Traditional-Conventional Instructional Approach.

The adjusted posttest means for the treatment groups from all three instructional approaches were analyzed by a three-way analysis of covariance with the pretest serving as the covariate. As presented in Table 22, the obtained F ratio of 14.292 was significant at the .05 level. Table 22 was used as the basis for further analysis with hypotheses 25 through 30. The adjusted means from Table 23 were used for the Newman-Keuls procedure. The posttest mean of 14.252 for the Traditional-Conventional females in the experimental group and the mean of 9.941 for the control group as indicated by the Newman-Keuls procedure (Table 24) were not significantly different. It was concluded, therefore, that there was no significant difference between the means of the females in the experimental group and the females in the control group in the Traditional-Conventional classes on the Spatial Relations test. Thus, hypothesis 25 was not rejected.

H_0.26

The posttest mean for females in the experimental group will not be significantly different on the PMA Spatial Relations test (right hemisphere task) than the posttest means for females in the control group from classes using the Montessori Approach.
Table 22

Summary of the Analysis of Covariance of Posttest with Pretest by Treatment Group Using the PMA Spatial Relations Test

<table>
<thead>
<tr>
<th>Source of Variance</th>
<th>SS</th>
<th>DF</th>
<th>MS</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatment Group</td>
<td>88.788</td>
<td>1</td>
<td>88.788</td>
<td>14.292^a</td>
</tr>
</tbody>
</table>

Note. Analysis of covariance: total n = 79.

^a p < .05

Table 23

Adjusted Posttest Means for Females in the Experimental and Control Groups from Three Instructional Approaches Using the PMA Spatial Relations Test

<table>
<thead>
<tr>
<th>Montessori</th>
<th></th>
<th>Open Activity</th>
<th></th>
<th>Traditional</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td></td>
<td></td>
<td></td>
<td>Control</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 24

Summary of Differences Between All Pairs of Adjusted Posttest Means for Females by Treatment Group from Three Instructional Approaches Using the PMA Spatial Relations Test

<table>
<thead>
<tr>
<th>Ordered Means</th>
<th>OA Control</th>
<th>M Control</th>
<th>TC Control</th>
<th>OA Exp.</th>
<th>Exp.</th>
<th>TC Exp.</th>
<th>M Exp.</th>
</tr>
</thead>
<tbody>
<tr>
<td>9.198</td>
<td>.321</td>
<td>.752</td>
<td>2.093</td>
<td>5.063</td>
<td>5.135</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9.515</td>
<td>.434</td>
<td>1.775</td>
<td>4.749</td>
<td>4.812</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9.941</td>
<td>1.342</td>
<td>4.318</td>
<td>4.380</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11.286</td>
<td></td>
<td>2.973</td>
<td>3.040</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14.252</td>
<td></td>
<td></td>
<td>3.111</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14.321</td>
<td></td>
<td></td>
<td>0.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The data shown in Table 24 indicated the mean for the females in the experimental group (14.321) and the mean for the control group (9.515) are not significantly different on the Spatial Relations test for students in the Montessori class. Hypothesis 26 was not rejected.

H₀:27

The posttest mean for females in the experimental group will not be significantly different on the PMA Spatial Relations test (right hemisphere task) from the posttest mean for females in the control group from classes using the Open Activity-Centered Instructional Approach.

The Newman-Keuls table of ordered means, shown in Table 24, indicated no significant difference between the mean of the experimental
group (11.286) and the mean of the control group (9.198). Therefore, it was concluded that females in the experimental group did not score significantly different on the Spatial Relations test than did the females in the control group. Hypothesis 27 failed to be rejected by the investigator.

\[ H_{028} \]

The posttest mean for males in the experimental group will not be significantly different on the PMA Spatial Relations test (right hemisphere task) from the posttest mean for males in the control group from classes using the Traditional-Conventional Instructional Approach.

Utilizing the adjusted posttest means from Table 25 a Newman-Keuls procedure was conducted. A summary of the Newman-Keuls is presented in Table 26. The mean for males in the experimental group from the Traditional-Conventional Instructional Approach (14.682) was not significantly different from the mean achieved by the males in the control group (12.200) from the same instructional approach on the Spatial Relations test. Based on these findings the investigator failed to reject the null hypothesis.

<table>
<thead>
<tr>
<th>Table 25</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adjusted Posttest Means for Males by Treatment Groups from Three Instructional Approaches Using the PMA Spatial Relations Test</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Montessori</th>
<th>Open Activity</th>
<th>Traditional</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experimental</td>
<td>Control</td>
<td>Experimental</td>
</tr>
</tbody>
</table>
### Table 26

Summary of Differences Between All Pairs of Adjusted Posttest Means for Males by Treatment Group from Three Instructional Approaches Using the PMA Spatial Relations Test

<table>
<thead>
<tr>
<th>Ordered Means</th>
<th>OA Control</th>
<th>TC Control</th>
<th>M Control</th>
<th>OA Exp.</th>
<th>TC Exp.</th>
<th>M Exp.</th>
</tr>
</thead>
<tbody>
<tr>
<td>10.057</td>
<td>2.154</td>
<td>2.508</td>
<td>2.681</td>
<td>4.630</td>
<td>5.646a</td>
<td></td>
</tr>
<tr>
<td>12.200</td>
<td>.352</td>
<td>.533</td>
<td>2.184</td>
<td>3.495</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12.553</td>
<td>.187</td>
<td>2.138</td>
<td>3.149</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12.734</td>
<td>1.950</td>
<td>2.961</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14.682</td>
<td>.</td>
<td>1.012</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15.691</td>
<td>.</td>
<td>0.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

^a p < .05

H₀²⁹

The posttest mean for males in the experimental group will not be significantly different on the PMA Spatial Relations test (right hemisphere task) from the posttest mean for males in the control group from classes using the Montessori Instructional Approach.

The adjusted means (Table 25) were used to compute a Newman-Keuls test for multiple comparisons. The results of this test are shown in Table 26. The mean of the males in the Montessori experimental group (15.691) was not significantly different than the mean of the males in the control group (12.553) on the Spatial Relations test. Thus, null hypothesis 29 was not accepted.
The posttest mean for males in the experimental group will not be significantly different on the PMA Spatial Relations test (right hemisphere task) from the posttest means for males in the control group from classes using the Open Activity-Centered Instructional Approach.

As can be seen in Table 26, the mean of the males in the experimental group (12.734) was not significantly different from the mean of the males in the control group (10.057) from the Open Activity class on the Spatial Relations test. Therefore, the investigator failed to reject the null hypothesis.

**Statistical Power Analyses, Post Hoc, of Test Conducted**

For the analysis of variance, the power of the F test for differences between treatment groups would be:

\[
\text{Power of } F (\alpha = .05, n = 4, k = 2)^a
\]

<table>
<thead>
<tr>
<th>Effect Size</th>
<th>Small</th>
<th>Medium</th>
<th>Large (^b)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>.06</td>
<td>.09</td>
<td>.16</td>
</tr>
</tbody>
</table>

*Note. From Cohen, Statistical Power Analysis for the Behavior Sciences, 1977.*

*\(^a\) Where \(n = \) harmonic mean of cell size; \(k = \) number of treatment groups = 2.*

*\(^b\) Range of effect sizes based upon Cohen's recommendations.*
Given that recommended Power = .80 is the minimum acceptable value (as defined by Cohen, 1977), the statistical power of the posttest analyses was extremely low. Therefore, even though there may in fact be a difference between the control and experimental groups for any or all of the given instructional styles, there was only a 16% chance (for a large effect size) of detecting such differences, primarily due to small sample sizes.

Larger sample sizes would thus enhance the opportunity for greater validity in findings as well as inhibit the chance of making a Type I or Type II statistical error when testing hypotheses.

Summary

Chapter 4 included the presentation and analysis of data. The presentation of data provided information compiled for each sex, treatment group, and instructional approach. The data and statistical analysis of results were discussed and illustrated in tables.

As a result of the findings, the investigator failed to reject null hypotheses 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 16, 19, 21, 22, 23, 24, 25, 26, 27, 28, 29 and 30. The following null hypotheses were rejected: 1, 13, 14, 15, 17, 18 and 20.
Chapter 5

SUMMARY, FINDINGS, CONCLUSIONS, IMPLICATIONS AND RECOMMENDATIONS

This chapter contains the summary, presentation of the findings of the study, and implications and conclusions drawn from the analysis of the data. Recommendations based on the findings of the study were included in the final section.

Summary

Problem

The problem of this study was to compare left and right hemisphere processing scores of selected male and female students representing three instructional styles.

Subproblems were designed to answer the following questions:

1. Does a difference exist in right and left hemisphere processing between male and female students from classes using the Traditional-Conventional Instructional Approach?

2. Does a difference exist in right and left brain hemisphere processing between male and female students from classes using the Open Activity-Centered Instructional Approach?

3. Does a difference exist in right and left brain hemisphere processing between male and female students from classes using the Montessori Instructional Approach?

4. Would instructing children using strategies to engage right
Procedure

In the Fall of 1981, 79 students from intact kindergarten classrooms, representing three different instructional styles were randomly assigned to experimental and control groups. Four subtests were administered as a pretest. Two of these subtests indicate right brain hemisphere functioning; the WISC-R Block Design test and the PMA Spatial Relations test. Two subtests indicate left brain hemisphere functioning; the WISC-R Digit Span test and the PMA Verbal Meaning test.

Fifteen 30-minute sessions of activities designed to elicit right brain functioning were provided the experimental group. The control group received regular lessons of 15 thirty-minute sessions. At the completion of these sessions the same four subtests were re-administered as a posttest.

Findings

The data were analyzed and 30 null hypotheses were tested for significance at the .05 level. The following findings were developed from the results of data analysis and interpretation. The findings were reported as they pertained to each of the hypotheses.

Null hypotheses 1, 13, 14, 15, 17, 18 and 20 were rejected. The rejection of hypothesis 1 indicated that there was a significant difference in the pretest means on the WISC-R Digit Span (left hemisphere task) between male and female students in the Traditional-Conventional classes. Female students scored significantly higher.

The rejection of hypotheses 13, 14, 15, 17 and 18 indicated that there was a significant difference in pretest means of right hemisphere
tasks (WISC-R Block Design test and PMA Spatial Relations test) across all three instructional approaches as follows:

$H_0^{13}$. The pretest mean of students from the Montessori Approach was significantly greater on the WISC-R Block Design test (right hemisphere task) than the mean of students from the Open Activity-Centered Approach.

$H_0^{14}$. The pretest mean of students from the Open Activity-Centered Approach was significantly greater on the WISC-R Block Design test (right hemisphere task) than the mean of the students from the Traditional-Conventional Approach.

$H_0^{15}$. The pretest mean of students from the Montessori Approach was significantly greater on the WISC-R Block Design test (right hemisphere task) than the mean of students from the Traditional-Conventional Approach.

$H_0^{17}$. The pretest mean of students from the Open Activity-Centered Approach was significantly greater on the PMA Spatial Relations test (right hemisphere task) than the mean of students from the Traditional-Conventional Approach.

$H_0^{18}$. The pretest mean of students from the Montessori Approach was significantly greater on the PMA Spatial Relations test (right hemisphere task) than the mean of students from the Traditional-Conventional Approach. The rejection of hypothesis 20 indicated that the posttest mean of females in the experimental group was significantly greater than the posttest mean of females in the control group in the Montessori class.

Null hypotheses 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 16, 19, 21, 22, 23, 24, 25, 26, 27, 28, 29 and 30 were not rejected. The findings for
hypotheses 2 through 12 indicated that there was no significant difference on pretest means between the sexes as follows:

$H_0^2$. There was no significant difference in pretest means on the WISC-R Digit Span test (left hemisphere task) between male and female students in the Montessori class.

$H_0^3$. There was no significant difference in pretest means on the WISC-R Digit Span test (left hemisphere task) between male and female students in the Open Activity-Centered class.

$H_0^4$. There was no significant difference in pretest means on the PMA Verbal Meaning (left hemisphere task) between male and female students in the Traditional-Conventional class.

$H_0^5$. There was no significant difference in pretest means on the PMA Verbal Meaning test (left hemisphere task) between male and female students in the Montessori class.

$H_0^6$. There was no significant difference in pretest means on the PMA Verbal Meaning test (left hemisphere task) between male and female students in the Open Activity-Centered class.

$H_0^7$. There was no significant difference in pretest means on the WISC-R Block Design test (right hemisphere task) between male and female students in the Traditional-Conventional classes.

$H_0^8$. There was no significant difference in pretest means on the WISC-R Block Design test (right hemisphere task) between male and female students in the Montessori class.

$H_0^9$. There was no significant difference in pretest means on the WISC-R Block Design test (right hemisphere task) between male and female students in the Open Activity-Centered class.
H₀.₁₀. There was no significant difference in pretest means on the PMA Spatial Relations test (right hemisphere task) between male and female students in the Traditional-Conventional classes.

H₀.₁₁. There was no significant difference in pretest means on the PMA Spatial Relations test (right hemisphere task) between male and female students in the Montessori class.

H₀.₁₂. There was no significant difference on the PMA Spatial Relations test (right hemisphere task) between male and female students in the Open Activity-Centered class.

The findings indicated that for hypothesis 16 there was no significant difference between instructional approaches as follows:

H₀.₁₆. The pretest mean of students from the Open Activity-Centered class was not significantly different on the PMA Spatial Relations test (right hemisphere task) than the pretest mean of students from the Montessori class.

The findings for hypotheses 19 and 21 through 30 indicated no significant difference between the experimental and control posttest means among the three instructional approaches on right hemisphere tasks as follows:

H₀.₁₉ and 2₁. There was no significant difference between posttest means of females in the experimental and control groups on the WISC-R Block Design test in the Traditional-Conventional or Open Activity classes.

H₀.₂₂ through 2₄. There was no significant difference between posttest means of males in the experimental and control groups on the WISC-R Block Design test (right hemisphere task) among all three
instructional approaches.

H_0^25 through 27. There was no significant difference between post-test means of females in the experimental and control groups on the PMA Spatial Relations test (right hemisphere task) across all three instructional approaches.

H_0^28 through 30. There was no significant difference between post-test means of males in the experimental and control groups on the PMA Spatial Relations test (right hemisphere task) among all three instructional approaches: Montessori, Open Activity-Centered, and Traditional-Conventional.

Conclusions

The following conclusions were drawn from the results of the study:

1. The study failed to yield a significantly greater mean score for females than males on left hemisphere tasks (WISC-R Digit Span test and PMA Verbal Meaning test).

2. The mean score for males was not significantly greater than the mean score of the females on right hemisphere tasks (WISC-R Block Design test and PMA Spatial Relations test).

3. The students from the Montessori Instructional Approach scored significantly greater on the right hemisphere tasks than the students from the Open Activity-Centered group or the Traditional-Conventional group.

4. The students from the Traditional-Conventional Instructional Approach scored significantly lower than students in either the Montessori or Open Activity-Centered Instructional Approach on right hemisphere
tasks.

5. The study failed to show significant differences between experimental and control groups due to treatment consisting of primarily right hemisphere activities.

6. Females scored consistently higher on left hemisphere tasks than males from all three instructional approaches.

7. Males scored consistently higher on right hemisphere tasks than females from all three instructional approaches.

8. Experimental groups from all three instructional approaches scored consistently higher on right hemisphere tasks than the control groups from those same instructional approaches.

The findings presented vary from the work of McGuinness (1979) and Restak (1979) as well as others reported in Chapter 2. The results of the study showed no significant brain related sex differences in 5 and 6 year olds. The findings seemed to bear out Maccoby and Jacklin's (1974) contention that young children do not exhibit brain specialization sex differences to any large extent at so early an age.

Implications

1. There seemed to be a possibility that the small n in two of the instructional groups did not allow for a powerful statistical analysis. Therefore, the chance of finding a significant difference was minimized.

2. There was a possibility that the short duration of the treatment and/or the size of the sample were not sufficient to produce marked right brain functioning improvement.
3. The indication that no significant differences between the means of the sexes were found by the computation of data collected in the study does not mean that scores on left brain tasks did not favor females and scores on right brain tasks did not favor males (Tables 2 and 3). The trend here should not be taken lightly but should serve as a means for follow-up study.

Recommendations

Based on the findings of the study it is recommended that:

1. Additional studies be conducted using larger samples to determine whether brain related sex differences exist among 5 and 6 year olds.

2. Additional studies be conducted incorporating treatment sessions over longer durations of time to determine whether selected right brain activities were effective in increasing ability of right brain functioning.

3. Replication of the study be made in larger as well as other geographical areas in order to increase the ability to generalize the results and determine the validity of the findings.

4. Additional study be given to the validation of experimental treatment both in reference to the small n in two of the instructional approaches and unequal cells.

5. Studies be conducted with middle and upper elementary school children to determine whether right brain activities will increase the ability to utilize both right and left brain.

6. An effort be made to develop curricula incorporating both left and right brain methods of teaching and learning.
7. Tests be redesigned to assure that both sexes have equal opportunity to achieve.
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BIBLIOGRAPHY


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APPENDIX A

GENERAL INSTRUCTIONS FROM LAVATELLI'S
EARLY CHILDHOOD CURRICULUM
SAMPLE LESSON
1. Each set of materials should be used in small groups, with no more than six children in a group and as few as three where children are seriously disadvantaged.

2. Conduct the small group sessions at a table screened off from the rest of the playroom, or in a separate room, if possible.

3. Instructions for the use of each set are written in two different ways. In one, the basic teaching procedure is summarized so the experienced teacher can quickly grasp the principles and adapt them as she sees fit. In the other, directions are written specifically enough so that a teaching aide can follow them. In both cases, however, group sessions should be carried on in a spirit of free inquiry, without pressure, and with enough time allowed for exploration of the materials and discussion of them.

4. The length of group sessions depends upon the attention span of the children. The sessions may be as short as 10 minutes to being with, gradually increasing in duration as the children learn to attend.

5. The logical processes for each set of materials in the kit are analyzed in detail so the teacher and teacher aides will have a clear understanding of what they are doing. With such understanding, they will find innumerable occasions in the course of the day to reinforce the learning developed in the small group sessions.

6. Teachers need to listen carefully to children's explanations of what they are doing, for these responses have tremendous potential for teacher growth in understanding the thinking processes. And with greater insight into children's thought processes, into what "bugs" children in solving problems, teachers can ask the "right" question at the "right" time as children work at other activities throughout the day. Relating child activity during free play to activity during the group sessions serves to reinforce learnings. For example, when the children have been engaged in the "tower" activity (Number, Measurement and Space, Set 7), and the teacher notes in block building that a child is using his body to measure with, she may ask, "What other things can you find in the room to find out how tall your building is? See how many different things you can use."

7. The number of small group sessions devoted to one set depends upon how advanced the child is to start with. However, it is important to keep interest and motivation high. As suggested above, teachers can use the rest of the school day to reinforce what is being taught in the small group sessions, rather than relying on the sessions alone for mastery. Furthermore, the possibility that what the children are learning will generalize and transfer is increased if the children are asked to extend concepts to other materials and situations.
8. Remember that language training is an important feature of the program, and to improve in language, children must talk. Instructions call for the teacher or aide to say, over and over again, "Tell me what you are doing," to model for the child what he is to say, and to have the child repeat what the teacher has modeled. The repetition should be a reasonable approximation of what the teacher has modeled, but the teacher should not insist upon an exact replication.

9. Children are not expected to master all of the activities prepared for any one set of materials before going on to the next. The program is planned with developmental sequence in mind; the last set in each of the three series calls for more advanced mental operations than does the first. But since activities planned for each set begin with the very simple and become progressively more difficult, a particular set can and should be introduced without waiting for mastery of earlier ones, for the first activities in that set will be easier than the last ones in the preceding set. In fact, the great variety of materials and activities is itself an important factor in developing mental operations; it is sometimes the second exposure to a particular concept that clarifies meaning.
SAMPLE LESSON

FLOWERS

Directions for Group Sessions: Summary

1. Distribute equipment and teach the names of flowers (roses and daisies), if necessary.

2. Have the children make up bouquets of different flowers; yellow roses, roses, yellow daisies, daisies, flowers. Make a game out of the activity, having the children give each other specified bunches of flowers.

3. Ask the children to tell what they are doing. Supply language models as necessary.

4. As bouquets are made up and exchanged, have the children compare: daisies and roses; roses and yellow roses; flowers and roses; flowers and daisies ("Are there more flowers or more roses?" "Why? How do you know?") Your questions force the child to go back in his mind to the total class.

5. Have the children combine subclasses of other objects and compare class with subclass. Use beads, for example; the children can make up a large class of yellow beads and a much smaller class of red beads and compare the number of beads with the number of yellow beads.

NOTE: The important point to remember here is to keep numbers in the two subclasses very different; there should be eight or nine times as many items in one subclass (yellow roses) as in the other (red roses). Otherwise, it is possible to do No. 5 on a perceptual level and the teacher will not know if the child is using operations or not.
October 26, 1981

Thank you so much for being willing to be such a vital, necessary part of my study!! I'd like to give you a few pointers in presenting right-brain lessons.

1) Allow each individual child to talk (let him/her "monologue" if he/she wants.)

2) Ask for few convergent questions. Don't look for the one right answer. Don't be concerned with "correctness" or "incorrectness."

3) Let each student play, feel, and manipulate materials

4) When asking questions, increase waiting time for an answer

5) Work in any music, art, dance or nursery rhymes, you feel comfortable with

6) Develop sensory presentations (sound, smell, touch, taste)

7) Include imagination, fantasizing, closing their eyes and "picturing in their heads."

8) Don't hesitate to work with 5 or 6 at a time while the other 5 or 6 observe and then reverse the process.

The way you present the lesson is more important than what you present. If you need supplies from me (from the kit) and can't get hold of me - then substitute one of the supplementary lessons if needs be. We are all (5 classes) sharing one kit!

Your help is very important - I am extremely appreciative! Please read the instructions and discussion in the front of each curriculum guide that I have supplied you with - it is a good guide.

Again, thanks so much,

M. Kay Hickerson

Home Phone - 929-3778
School Phone - 929-4431
APPENDIX B

SAMPLE LESSON FOR CONTROL GROUP
Visual Training

1. Developing rhyming words
   a. Point to pictures, in a left-to-right direction. Say names of pictures with pupils. Lead children to reply that they sound alike and therefore rhyme.
   b. Say name of one picture in each pair of pictures and pupils say name of the picture that rhymes with it.
   c. Say name of a picture in a row of pairs of pictures, ask a pupil to find the picture that rhymes with it.
   d. Pupils collect pictures of rhyming words from magazines to make a cooperative chart.

2. Objects that rhyme
   a. Display articles the names of which rhyme---moon/spoon.
   b. Pupils arrange in pairs.

3. Selecting rhyming words
   a. There is one picture in each row that has a name which does not rhyme with the names of the other pictures in the row.

4. Study of pictures
   a. From a magazine, book or newspaper, clip a few pictures of group activity, preferably a family activity. Ask questions about details.
   b. Note differences and likenesses in two comparable pictures.
   c. Note details in a single picture. "What is missing?"

5. Recognizing capital letters
   a. Some of your names begin with the same sound and same letter. Show on "name cards."
   b. Choose others.
   c. Find letter to match (chart, box of letters).
   d. Make flashcards using picture of seasonal items (Christmas items in December). Have children take turns at making the initial sounds of objects pictured. Write the letters the sounds represent on the chalkboard.
   e. Write the word "cat" on the chalkboard. Have children look through magazines for samples of the letters that make up the word. Have child paste the word at the bottom of a sheet of white paper. Let him draw a cat at the top of his paper. Do the same with other words. Compile.
   f. Paste pictures of chicks, ducks, bunnies, and lambs on an oak tag. Label and display around room. (Pictures chosen may be seasonal.)
   g. Make a set of cards as:
      \[
      \begin{array}{cccc}
      b & h & 1 & b \\
      c & y & c & o \\
      a & c & e & a \\
      \end{array}
      \]
Have children point out the letter that matches the first one on each card. Increase difficulty of comparisons as children grow in ability.

h. Make flashcards for all the letters of the alphabet, both capital and lower-case letters. Have children try to match the capital and lower-case version of each letter. Children may be inspired to paint some letters of their choice.

i. "Alphabet Bingo." Make enough oak tag Bingo cards to go around: 3 squares across and 3 down with a capital letter in each square. Call out letters at random as children cover any of the called letters that appear on their cards with paper scraps. Winner is the first one to cover all the letters in one row.

j. Make it a practice to write your pupils' names in upper left-hand corner of their papers. They will get used to looking at the left first, a habit most helpful later.
APPENDIX C

INFORMED CONSENT FORM
East Tennessee State University
Institutional Review Board

Informed Consent Form

PRINCIPAL INVESTIGATOR: M. Kay Hickerson

TITLE OF PROJECT: A Comparison of Left and Right Brain Hemisphere Processing and Brain Related Sex Differences in Kindergarten Children

1. Indicated below are the (a) purpose of this study, (b) the procedures to be followed, and (c) the approximate duration of this study:

Your child _______________________________ is invited to participate (Full name of the child)

in a study to be designed by M. Kay Hickerson, a doctoral student in the College of Education at East Tennessee State University. The purpose of this study is to present an inquiry-oriented science program and to compare the performance of male and female students who participate in it with those who do not. Participants in the study will be tested and provided regular and special instruction as a part of the school's schedule of instruction. The special instruction will continue approximately six to eight weeks. At the completion of this phase of the study students will again be tested. There are no risks to the student, and should you or your child not wish to participate, there is no jeopardy involved academically or otherwise.

2. Discomforts, inconveniences and/or risks that can be reasonably expected are:

There will be no discomforts, inconveniences, or risks involved in the study. Confidentiality as to the identity of the student subjects will be maintained in accordance with strict research procedure. School records may be consulted for pertinent information regarding the student. The student and/or his or her parents may decline the invitation to participate with no academic or personal jeopardy.

3. I understand the procedures to be used in this study and the possible risks involved. All my questions have been answered. I also understand that while my rights and privacy will be maintained, the Secretary of the Department of Education does have free access to any information obtained in this study should it become necessary and I freely and voluntarily choose to participate. I understand that I may withdraw my child at any time without prejudice to me. I also understand that while East Tennessee State University does not provide compensation for medical treatment other than emergency first aid, for any physical
injury which may occur as a result of my child's participation as a subject in this study, claims arising against ETSU or any of its agents or employees may be submitted to the Tennessee State Board of Claims for disposition to the extent allowable as provided under TCA Section 9-812. Further information concerning this may be obtained from the chairman of the Institutional Review Board.

________________________  ____________________________
Date                      Signature of Student

________________________  ____________________________
Date                      Signature of Parents or Guardian

________________________  ____________________________
Date                      Signature of Investigator

________________________  ____________________________
Date                      Signature of Directing Professor
East Tennessee State University
APPENDIX D

PERSONAL DATA SHEET
INFORMATION FORM

CHILD'S NAME ____________________________________________________________

SCHOOL _________________________________________________________________

SEX       Female ________
           Male ________

BIRTHDATE __________________________________________________________________
          month  day  year

RIGHT HANDED ________
LEFT HANDED ________
APPENDIX E

SRA PERMISSION LETTER
July 21, 1981

M. Kay Hickerson  
East Tennessee State University  
Department of Supervision & Administration  
Box 19000A  
Johnson City, Tennessee 37614

Dear Ms. Hickerson:

Thank you for your letter of June 25 requesting permission to use the "Verbal Meaning" and "Spatial Relations" subtest from the SRA Primary Mental Abilities test for research purposes in your doctoral study.

SRA is willing to and hereby does grant you permission to use the material cited above in your project subject to the following terms and conditions. This permission is for one-time, noncommercial use, for research purposes only and distribution of the test materials is limited to research applications.

This permission does not allow you to include a copy of these test materials or any of the individual test items in your doctoral study -- either permanently filed with, bound to or microfilmed. You may provide a loose copy of these instruments with your study for your faculty review and you may publish the results of your study as long as none of the test items or test materials are included in the publication.

This authorization also grants you permission to reproduce 200 copies of the two subtests cited above; however, the following credit line must appear on each of the duplications along with the entire copyright notice.

"Reproduced with the permission of Science Research Associates, Inc."

Thank you for your request and interest in SRA materials. I wish you well in your project. Should there be anything further I may do for you, please let me know.

Very truly yours,

L. M. Greninger
Associate, Rights & Permissions

cc: Gem Kate Greninger  
Chairman, Doctoral Committee
March 17, 1991

Ms. M. Kay Hickerson
113 Terrace Ct. #6
Johnson City, TN 37601

Dear Kay:

I am responding to your letter of March 13, 1991, concerning your dissertation topic. I believe also that the hemispheric organization of the brain lends itself well to dissertation studies. However, I do not have in mind at the moment any burning questions that I believe are appropriate for dissertation topics. You mention in your letter curriculum development and brain related sex differences. I believe this is a fruitful area of research and one in which I'm interested. I believe a suitable dissertation topic could be developed around these subjects.

If you develop a proposal to which you would like some reaction, I would be happy to do this. In the meantime I have included some material that may be helpful to you.

Sincerely yours,

Michael P. Grady
Associate Professor of Education
March 31, 1981

Ms. M. Kay Hickerson
113 Terrace Ct. #6
Johnson City, TN 37601
U.S.A.

Dear Ms. Hickerson:

Thank you for your letter of March 23rd.

I think there is much that can be done in the field in which you are interested. Studies of hemisphere specialization involve detailed methodology and equipment that you may not have easy access to or supervision in. I am thinking of tests such as dichotic listening, etc. See a chapter of mine for a review of cerebral dominance in children, Witelson, S.P., Early hemisphere specialization and interhemisphere plasticity: An empirical and theoretical review. In Language Development and Neurological Theory, Segalowitz, S. and Gruber, F. (Eds.) Academic Press, 1977, pp 213-287.

As you know some of the work on lateralization in the brain has led to the possibility of sex differences in brain organization which you say interests you. One topic that I think could merit further work is the documentation of whether there are sex differences in basic skills underlying reading activities, etc., manifest at an early age. Such findings could have practical educational as well as theoretical implications.

See books by Maccoby and review articles in psychology journals on sex differences in cognition. See also my enclosed reprint.

You mentioned some articles referencing my work, such as Kappen, Scientific American, Phi Delta Kappan Fastback, etc.). I'd appreciate copies of these if you have them.

Best of luck in your endeavours.

Sincerely,

Sandra F. Witelson, Ph. D.
Professor of Psychiatry (Psychology)
Ms. Kaye Hickerson
Department of Supervision & Administration
Box 19000 A
East Tennessee State University
Johnson City, Tennessee 37614

Dear Ms. Hickerson:

I am writing in response to your letter to Diane McGuinness. At this time she is out of the country and will not be returning until June 5. At that time she will be able to respond to your letter. In the meantime I have enclosed a few articles which I hope will be of interest to you.

Sincerely,

Amy Olson
Research Asst.
M. Kaye Hickerson  
Department of Supervision and Administration  
Box 19000A  
East Tennessee State University  
Johnson City, Tennessee 37614

Dear Ms. Hickerson:

Thank you for your letter. I am not currently involved in any research that bears on brain lateralization or sex differences therein. There is a graduate student here, working both in physiological and developmental psychology, by the name of Beth Martin, who has been using some tests of lateralization and is well informed about which tests are reliable. I am forwarding your letter to her and hope that she will get in touch with you.

As to my own recent work: my recent book "Social Development" (Harcourt Brace Jovanovich, 1980) represents my current thinking on a variety of topics pretty well. There's a paper in the most recent issue of Developmental Psychology (joint with John Martin), and one in the Dec. 1980 issue of Child Development. I hope these papers are helpful to you.

Sincerely,

Eleanor E. Maccoby  
Professor

EDM:AP  
CC: Beth Martin
Kay-

Thank you for your letter and interest in my work. Enclosed are some materials and reports for clarification that may be of assistance to you.

Best wishes on your dissertation. Please give my warmest greetings to Dr. Green. Tell her to contact me if you need further assistance to your work.

Sincerely,

[Signature]

College of Education
June 17, 1981

H. Kaye Hickerson  
East Tennessee State University  
Dept. of Supervision and Administration  
Box 19000 A  
Johnson City, Tennessee 37614

Dear Kaye:

Thanks very much for your letter and your enthusiasm for research in the field of sex-differences. Unfortunately, the laterality studies are so ambiguous at present I don't know what to tell you to do in this regard. I am enclosing a chapter which will put you in the picture with respect to my thinking. Also, you might want to read Jeanette McGione's review on sex differences in laterality in Brain and Behavior Sciences which came out earlier this year. She is more favorable than Phil Bryden, who after reviewing about 100 studies, concluded that nothing could be said about the subject.

I am also sending a paper I am presenting to the Montessori meeting next week. This may interest you because of the importance of the problems to the field of education. I feel there is a major research project in doing follow up work on Montessori children. This should not be difficult, as they must be dotted around in high schools with batteries of achievement tests on file which one could use to compare them to a control population.

If you find anything of relevance in the chapter or the Montessori idea appeals to you, please let me know.

Best wishes,

Diane McQuinness
Eleanor Maccoby has forwarded a copy of her letter to you to my attention. I am enclosing a section from my master's thesis and the bibliography to the thesis which I hope will be of some use to you.

I personally do not believe that cerebral asymmetry research with normals has, as yet, progressed far enough to justify curricular implementations. Research leading to that possible goal is certainly needed. For example, would different methods of instruction differentially affect learning of math skills between sexes? My reading of the literature, as well as my own research, lead me to believe that we do not have enough information at this time to draw this type of conclusion.

The bibliography I have enclosed is quite broad. Some of it is bound to be of little interest to you. I hope that some of the references will be of use.

Sincerely yours,

[Signature]

Elizabeth J. Martin
Ms. M. Kay Hickerson  
Dept. of Supervision & Administration  
E. Tennessee State University  
Campus Box 19,000A  
Johnson City, TN 37614

Dear Ms. Hickerson:

Enclosed please find the materials you requested. If I can be of further assistance please feel free to contact me.

Best wishes in your work.

Sincerely,

Grayson H. Wheatley  
Professor of Mathematics and Education

GHW:bb  
Encl.
Miss Sarah Woods, Principal
King Springs School
King Springs Road
Johnson City, TN 37601

Dear Miss Wood:

I am currently working toward the completion of the requirements for the degree, Doctor of Education, at East Tennessee State University. My research project deals with the left and right brain hemisphere processing of male and female kindergarten students.

With your permission, I wish to work with you and the children in your kindergarten class. The teacher involved would be Virginia Baker. Data collection would be scheduled for the fall, 1981.

Your assistance in the research project would be greatly appreciated. All results of the study will be made available to you should you be interested.

Sincerely,

M. Kay Hickerson
Project Director
Phone: 929-2778
929-4431
Mrs. Virginia Baker  
Kindergarten Teacher  
King Springs School  
King Springs Road  
Johnson City, Tennessee 37601

Dear Mrs. Baker:

I am currently working toward the completion of the requirements for the degree, Doctor of Education, at East Tennessee State University. My research project deals with the left and right brain hemisphere processing of male and female kindergarten students.

With your permission, I wish to work with you and the children enrolled in your kindergarten class. This project has the approval of the Principal of your school. Data collection would be scheduled for the fall, 1981.

Your assistance in the research project would be greatly appreciated. All results of the study will be made available to you should you be interested.

Sincerely,

M. Kay Hickerson  
Project Director  
Phone: 929-2778  
929-4431
Mr. M. Earl Henley, Principal
Jonesboro Elementary
306 Forest Drive
Jonesboro, TN 37659

Dear Mr. Henley:

I am currently working toward the completion of the requirements for the degree, Doctor of Education, at East Tennessee State University. My research project deals with the left and right brain hemisphere processing of male and female kindergarten students.

With your permission, I wish to work with you and the children enrolled in your kindergarten class. The teachers involved would be Debbie Morrison and Sandy Williamson. Data collection would be scheduled for the fall, 1981.

Your assistance in the research project would be greatly appreciated. All results of the study will be made available to you should you be interested.

Sincerely,

M. Kay Hickerson
Project Director
Phone: 929-2778
  929-4431
Dr. Rebecca Isbell, Director  
Child Study Center  
East Tennessee State University  
Johnson City, TN 37614  

Dear Dr. Isbell:

I am currently working toward the completion of the requirements for the degree, Doctor of Education, at East Tennessee State University. My research project deals with the left and right brain hemisphere processing of male and female kindergarten students.

With your permission, I wish to work with you and the children enrolled in your kindergarten class. The teacher involved would be Su Su Mobley. Data collection would be scheduled for the fall, 1981.

Your assistance in the research project would be greatly appreciated. All results of the study will be made available to you should you be interested.

Sincerely,

M. Kay Hickerson  
Project Director  
Phone: 929-2778  
929-4431
Mrs. Debbie Morrison  
Kindergarten Teacher  
Jonesboro Kindergarten  
Old Jonesboro Highway  
Johnson City, Tennessee 37601  

Dear Mrs. Morrison:

I am currently working toward the completion of the requirements for the degree, Doctor of Education, at East Tennessee State University. My research project deals with the left and right brain hemisphere processing of male and female kindergarten students.

With your permission, I wish to work with you and the children enrolled in your kindergarten class. This project has the approval of the Principal of your school. Data collection would be scheduled for the fall, 1981.

Your assistance in the research project would be greatly appreciated. All results of the study will be made available to you should you be interested.

Sincerely,

M. Kay Hickerson  
Project Director  
Phone: 929-2778  
929-4431
Mrs. Sandy Williamson  
Kindergarten Teacher  
Jonesboro Kindergarten  
Old Jonesboro Highway  
Johnson City, Tennessee 37601

Dear Mrs. Williamson:

I am currently working toward the completion of the requirements for the degree, Doctor of Education, at East Tennessee State University. My research project deals with the left and right brain hemisphere processing of male and female kindergarten students.

With your permission, I wish to work with you and the children enrolled in your kindergarten class. This project has the approval of the Principal of your school. Data collection would be scheduled for the fall, 1981.

Your assistance in the research project would be greatly appreciated. All results of the study will be made available to you should you be interested.

Sincerely,

M. Kay Hickerson  
Project Director  
Phone: 929-2778

929-4431
Miss Su Su Hobley  
Kindergarten Teacher  
Child Study Center  
East Tennessee State University  
Johnson City, TN 37614  

Dear Miss Hobley:  

I am currently working toward the completion of the requirements for the degree, Doctor of Education, at East Tennessee State University. My research project deals with the left and right brain hemisphere processing of male and female kindergarten students.

With your permission, I wish to work with you and the children enrolled in your kindergarten class. This project has the approval of the director of your school. Data collection would be scheduled for the fall, 1981.

Your assistance in the research project would be greatly appreciated. All results of the study will be made available to you should you be interested.

Sincerely,

M. Kay Hickerson  
Project Director  
Phone: 929-2778  
         929-4431
VITA

M. KAY HICKERSON

Personal Data: Place of Birth: E. Alton, Illinois
Marital Status: Single

Education:
Public Schools, St. Louis, Missouri.
Harris Teachers College, St. Louis, Missouri; elementary education, Summa Cum Laude, B.A., 1970.
East Tennessee State University, Johnson City, Tennessee; special education, M.A., 1975.
East Tennessee State University, Johnson City, Tennessee; educational supervision, Ed.D., 1983.

Professional Experience:
Teacher, St. Louis Public Schools, St. Louis, Missouri, 1968-1970.
Teacher, John Sevier Middle School, Kingsport, Tennessee, 1975-1981.

Publications:
Hickerson, M. Kay. "The Effect of a Handicapped Child on the Family" in Family Living, text used at East Tennessee State University.

Honors and Awards:
Phi Dappa Phi
Phi Delta Kappa
American Association of University Women
Kappa Delta Pi
Doctoral Fellowship, ETSU