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THE RELATIONSHIP BETWEEN A DEVELOPMENTAL
THEORY OF BRAIN HEMISPHERE LATERALIZATION AND
AGE AND SEX DIFFERENCES IN FIELD
DEPENDENCE-INDEPENDENCE AND VISUO-SPATIAL
MEASURES.

THE OHIO STATE UNIVERSITY, PH.D., 1978

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THE RELATIONSHIP BETWEEN A DEVELOPMENTAL THEORY
OF BRAIN HEMISPHERE LATERALIZATION AND
AGE AND SEX DIFFERENCES IN
FIELD DEPENDENCE-INDEPENDENCE AND VISUO-SPATIAL MEASURES

DISSERTATION

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

By

Donna Freshman Berlin, B. S., M. A.

*****

The Ohio State University
1978

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Adviser
Department of Education
For my husband Larry and daughter Joy
without whose encouragement, understanding, and devotion
this dissertation would not have been possible
and
in loving memory of my sister Jody
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VITA

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CHAPTER I

INTRODUCTION

The study of individual differences, and more particularly those of sex differences, has long pervaded educational research and been pursued in many different directions. Witkin and his associates (1962) focused their attention upon the cognitive construct of field dependence-independence. More recent research has centered upon the organization of the cortex and hemispheric lateralization. The purpose of this study is to investigate a neurological model to explain sex differences in field dependence-independence (FDI) and in visuo-spatial abilities. It is felt that brain laterality best serves this function. In addition, it is hypothesized that this neurological model is of a developmental nature, progressing from a functioning likened to that of a split-brain individual (commissurotomy patient) to that of differing degrees of hemispheric lateralization. Consequently, the problem statement of this study is the relationship between a developmental theory of brain hemispheric lateralization and age and sex differences in field dependence-independence and
visuo-spatial measures.

The complexity of this study and its interrelatedness with different aspects of educational, psychological, and medical research mandates a lengthy review of the literature. It is to medical research that we owe our knowledge of brain hemispheric specialization or lateralization. The names of Bogen, Galin, Gazzaniga, Ornstein, and Sperry are associated with studies of split-brain patients. As the result of commissurotomies on these patients, the corpus callosum is severed and the two hemispheres of the brain are separated and available to individual study. Numerous follow-up studies have revealed that in nearly all right-handed persons the left hemisphere attends to verbal tasks as these are appropriate to its logical, analytical mode of processing. The right hemisphere deals with visuo-spatial stimuli that are suited to its analogical or relational, gestalt-type processing. The significant difference between the hemispheres is their mode of processing experience. The left hemisphere specialization for verbal processes and the right for visuo-spatial functions is very well documented in other types of clinical brain research. Studies dealing with brain damaged patients (lesions and lobectomies) and those involving electroencephalogram (EEG) measures of direct hemispheric involvement have confirmed hemispheric specialization. In addition, it has been suggested that
these two modes of processing are mutually antagonistic (Levy, 1970). Since there are individual differences with regard to one's degree of laterality, less laterialized persons will exhibit an interference effect. If both processes exist within one hemisphere, it is possible that both or one may not function to its full potential. The importance of verbal processes (language) to human development and survival suggests the preservation of verbal processes and the deficit in visuo-spatial abilities where complete lateralization is not present.

Educational and psychological research with normal individuals based upon visual and auditory dichotic presentations and lateral eye movements confirm the left and right hemisphere dichotomy of process. These studies are based upon the contralateral effect of stimuli. Stimuli to the right visual field, right ear, or lateral eye movements to the right indicate left hemisphere processing. Conversely, right hemisphere functioning is elicited by stimuli to the left visual field, left ear, and lateral eye movements to the left. These studies have found that tasks involving words, letters, and digits were processed faster and more accurately by the left hemisphere, while those involving spatial abilities, dot enumeration, depth perception, the slant of a line, faces, music, and nonspeech noises were superior in the right hemisphere.
Since this study is concerned with sex differences and their age of onset in relationship to spatial tests and FDI, which involves visuo-spatial restructuring abilities, the work of Harris (1978) is of particular relevance. He reviewed numerous studies dealing with sex differences in spatial abilities. With tests involving geometry, dot localization, and the recall and detection of shapes (disembedding ability), a male advantage is observed by age twelve and is consistently and routinely observed in adults. In studies which employ the Rod-and-Frame Test, a visual-spatial restructuring measure of FDI, male superiority appears reliable by age ten. In addition, he offers three neurological models based upon hemispheric lateralization to explain these sex differences in spatial abilities. Model 3, greater male hemispheric lateralization and female bilateral representation of language, is thought to be the most viable and represents the view held by the present study. The effect of this model is male superiority in visuo-spatial abilities and female deficiency in these abilities due to the interference of verbal processes in the right hemisphere of the brain. The reader is directed to Chapter II, Literature Review, for a summary of the two alternative neurological models.

The last group of studies to be reviewed deals specifically with field dependence-independence (FDI).
FDI, as defined by Witkin and Goodenough (1977) is the "...tendency to function with greater or less autonomy of external referents, manifested in both cognitive and social domains."¹ The focus of this research is upon the cognitive domain, specifically spatial restructuring abilities as measured by the Rod-and-Frame Test. The Rod-and-Frame Test (RFT) involves disembedding abilities in perception and spatial restructuring in order to determine when a rod is vertical although its surrounding frame is tilted. A detailed discussion of FDI is found in the latter half of this chapter, titled Definition of Terms.

Studied based upon various FDI measures have found it to be a reliable and consistent cognitive construct. Although field independence is related to increasing age (the maximum attainment at approximately age 17), the relative standings at each age are stable. FDI has also been related to sex differences similar to those found for spatial abilities tasks. A male superiority or field independence has been well-documented beyond age ten and consistently observed in adults. This pattern of sex differences manifested in both FDI measures and spatial abilities tests has caused some authors to relate the two. Sherman (1967) and Vaught (1965) suggest that it is the sex differences in spatial ability which account for the same

sex differences in FDI. Various theories based upon sex typing, sex role identification and maternal attitudes, ego strength, a major sex-linked gene, rate of maturation, and hormonal activity have been proposed as a rationale for sex differences in spatial abilities. This author feels, however, that the explanation for sex differences in FDI and spatial abilities, is rooted in the different male and female neurological organization of the brain based upon the degree of hemispheric lateralization.

The major thrust of this research is found in the literature relating FDI to cortical organization. Some authors have related FDI, as measured by various perceptual disembedding tasks including the RFT, to hemispheric dominance or specialization. The majority have noted right hemispheric involvement for these tests as well as for those involving similar ability as applied to visual coordinate systems. However, a small number of studies have related FDI ability to left hemisphere processing. Most of these studies employed only female subjects which could possibly account for their contradictory results. Thus, it seems that a better avenue of relating neurological organization and FDI is by way of the degree of hemispheric lateralization. This would not only explain individual differences in FDI but also sex differences in both FDI and spatial abilities. To this end, studies have shown that field independent subjects display evidence of
greater hemispheric lateralization (e.g. Oltman, Ehrlichman & Cox, 1977; Pizzamiglio & Cecchini, 1971; Waber, 1977; Zoccolatti & Oltman, in press). Other studies, corroborating Model 3, have shown males to exhibit greater lateralization (Kimura, 1969; McGlone & Davidson, 1973). Since males have been consistently found to be more field independent (Witkin, Dyk, Faterson, Goodenough & Karp, 1962; Witkin, Goodenough & Karp, 1967) and superior in spatial abilities (Harris, 1978), it seems reasonable to suggest that this sex difference is founded upon the degree of hemispheric lateralization. Similarly, the tendency for females to be more field dependent and inferior in spatial abilities tasks would reflect less hemispheric lateralization and perhaps a bilateral representation of language.

In conclusion, the need for this study becomes apparent. Current literature investigates brain hemispheric specialization, sex differences in spatial abilities, sex differences in FDI, the relationship between spatial abilities and FDI, and the degree of hemispheric specialization or lateralization in both spatial abilities and FDI. The interrelatedness and total sum of these investigations has stimulated and justified the present research. It is this author's intention to examine sex differences in a FDI measure and in visuo-spatial tests in relationship to the theory of greater male hemispheric lateralization. Age of onset or a developmental perspective will also be examined
by using two different age groups, kindergarten five-to-six year olds and sixth grade eleven-to-twelve year olds.

Hypotheses

1. Sixth grade children will perform significantly superior to kindergarten children on the WISC Digit Span, WISC Block Design, PMA Verbal Meaning, and PMA Spatial Relations Tests.

2. Sixth grade children will be significantly more field independent than kindergarten children as measured by the Rod-and-Frame Test.

3. There will be no significant sex differences for all subjects on the WISC Digit Span, WISC Block Design, PMA Verbal Meaning, PMA Spatial Relations, and Rod-and-Frame Tests.

4. There will be no significant sex differences for kindergarten children on the following measures:

   Left Hemisphere Tasks
   a. WISC Digit Span
   b. PMA Verbal Meaning

   Right Hemisphere Tasks
   c. WISC Block Design
   d. PMA Spatial Relations

   FDI Task
   e. Rod-and Frame
5. Sixth grade female subjects will perform significantly better than sixth grade male subjects on the WISC Digit Span and PMA Verbal Meaning Tests (left hemisphere tasks).

6. Sixth grade male subjects will perform significantly better than sixth grade female subjects on the WISC Block Design and the PMA Spatial Relations Tests (right hemisphere tasks).

7. Sixth grade male subjects will be more field independent than sixth grade female subjects as measured by the Rod-and-Frame Test.

8. For kindergarten male subjects there will be a significant negative correlation between Rod-and-Frame Test scores* and each of the right hemisphere tasks:
   a. WISC Block Design
   b. PMA Spatial Relations

9. For kindergarten female subjects there will be a significant negative correlation between Rod-and-Frame Test scores* and each of the right hemisphere tasks:
   a. WISC Block Design
   b. PMA Spatial Relations

10. For sixth grade male subjects there will be a significant negative correlation between Rod-and-Frame Test scores*

* A low score on the Rod-and-Frame Test indicates field independence; a high score indicates field dependence.
scores* and each of the right hemisphere tasks:

a. WISC Block Design

b. PMA Spatial Relations

11. For sixth grade female subjects there will be a significant negative correlation between Rod-and-Frame Test scores* and each of the left hemisphere tasks:

a. WISC Digit Span

b. PMA Verbal Meaning

**Definition of Terms**

1. Hemispheric Lateralization - refers to the anatomical and functional differences between the two hemispheres (left and right) of the human brain. The functional differences are based upon process differences. The left hemisphere uses a logical, analytical mode of processing suitable to verbal tasks and the right hemisphere uses an analogical, gestalt processing appropriate to visuo-spatial and musical tasks. Individuals may differ in their degree of hemispheric lateralization. Synonymous terms appearing in the literature are hemispheric asymmetry and hemispheric specialization.

*A low score on the Rod-and-Frame Test indicates field independence; a high score indicates field dependence.*
2. Neurological Model 3 - as proposed by Harris (1978) refers to greater hemispheric lateralization for males and bilateral representation of language for females as an explanation for sex differences (male superiority) in spatial abilities. This same model is extended by the present author as a rationale for sex differences in field dependence-independence.

3. Field Dependence-Independence (FDI) - as originally conceived by Witkin and his associates (1962) was thought to be a measure of one's spatial perception. This ability involves the separation of a figure from its embedding ground or context. Traditional measures of field dependence-independence (FDI) are the Body Adjustment Test (BAT), Rod-and-Frame Test (RFT), and the Embedded Figures Test (EFT). In these tests, one's body, a rod, or a geometric design are the figures to be dis-embedded. This cognitive construct was then expanded to include nonperceptual dimensions. The term "psychological differentiation" was developed in order to encompass all aspects of FDI, visuo-spatial, intellectual or cognitive, and social or interpersonal. Psychological differentiation refers to the process of developing toward greater psychological complexity in three areas: 1) segregation of psychological function dealing with controls and defenses; 2) self-nonself segregation of the extent of autonomy of
external referents; and 3) segregation of neuropsychological function as the basis of individual differences.
The second area of psychological differentiation is now referred to as FDI. Field independent people do well in cognitive restructuring tasks particularly in the spatial domain. Field dependent people are superior in interpersonal competencies and relationships. This is a continuous function with individuals exhibiting varying degrees of FDI. In addition, some individuals are fixed with regard to FDI while others are mobile having access to both equally valuable ends of the continuum. Lastly, FDI is referred to as a second order function with individual test scores at the bottom and differentiation at the apex of a pyramid. Other terms found in the literature related to FDI are field articulation, global vs articulated functioning, and field sensitivity.

4. Rod-and-Frame Test (RFT) - is a specific measure of field dependence-independence. It involves disembedding in the perception of an upright and spatial restructuring ability. The subject is required to determine the true vertical of a rod despite the conflicting visual cues of a tilted frame. A low score on the RFT indicates field independence; a high score indicates field dependence. Performance on the RFT has been
related to other spatial restructuring abilities of closure, conservation, representation of horizontal coordinates, and perspectivism. A complete description of this test appears in Chapter III, Procedures.

5. Left Hemisphere Tasks - Two instruments were used to assess left hemispheric functioning. The Digit Span Subtest of the Wechsler Intelligence Scale for Children (WISC) will be used upon the research of Black (1974), Hines and Satz (1974), Newcombe (1974), and Warrington and James (1967). The Primary Mental Abilities (PMA) Verbal Ability Subtest is also indicative of left hemispheric functioning based upon the hemispheric process differences that are consistent in the literature. (Chapter III, Procedures, fully describes each instrument.)

6. Right Hemisphere Tasks - Two instruments were used to assess right hemispheric functioning. The Block Design Subtest of the Wechsler Intelligence Scale for Children (WISC) (Black, 1974; Nebes, 1975; Sperry, 1974; Warrington and James, 1967) and the Primary Mental Abilities (PMA) Spatial Relations Subtest (McGlone & Davidson, 1973) have been linked to right hemispheric functioning in the literature. (See Chapter III, Procedures, for a complete description of each test.)
7. Independent Variables - There were two fixed independent variables in this study. The sex variable had two levels, male and female, and the age variable had two levels, kindergarten (ages five-to-six) and sixth grade (ages eleven-to-twelve).

8. Dependent Variables - The following testing instruments were the dependent variables in this study: WISC Digit Span, WISC Block Design, Rod-and-Frame, PMA Verbal Ability, and the PMA Spatial Relations Tests.

9. Limitations - The following variables were not controlled and therefore could possibly have affected and contaminated the results of this study as well as the ability to generalize the findings to other populations.

   a. Biological Variables - Individual genetic and hormonal differences; different rates of maturation.

   b. Cultural Variables - Socialization practices, sex role identification, ego strength, family structure, power structure within the family, maternal and paternal attitudes, child rearing and training practices, ethnic, racial, and socioeconomic levels.

   c. Environmental Variables - Agrarian vs urban society, nomadic vs sedentary society, tight vs loose society.
Population and Sample

Subjects were selected from the student population of a public school in Columbus, Ohio. This population represents a predominately white, middle class, urban environment. A volunteer sample of right-handed subjects were drawn from two intact morning kindergarten classrooms, ages five-to-six, and two intact sixth grade classrooms, ages eleven-to-twelve.

Statistical Procedures

Test scores from the five testing instruments (dependent variables) were analyzed in terms of age and sex differences (independent variables) utilizing various statistical procedures. A two factor multivariate analysis of variance (Clyde Manova Program) was used to ascertain main effects and interaction effects for the entire battery of five tests. This was followed by a series of one way analyses of variance (Statistical Package for the Social Sciences - SPSS Anova Program) where significant effects were previously noted. The post hoc Scheffé test (SPSS Program) was then used to determine where significant group differences exist. Finally, the independent variables were used to define four groups which were analyzed as to significant associations or relationships between the five tests by means of the SPSS
Pearson Product Moment correlation. These initial statistical procedures directly tested the hypotheses of this study. The results of these analyses warranted further statistical procedures which employed the SPSS Pearson Product Moment Correlation using eight comparison groups defined by age, sex, and field dependence-independence and the relationships between the five tests.
CHAPTER II

LITERATURE REVIEW

Medical, psychological, and educational literature abounds with studies documenting hemispheric lateralization of function of the human brain and sex differences with regard to visuo-spatial abilities and field dependence-independence (FDI) measures. The literature was reviewed to assess evidence relevant to a neurological model to explain these sex differences and thereby link cerebral functioning and cognitive style. The literature review includes the following sections:

- Split Brain Research
- Brain Lesions and Lobectomies
- Electroencephalogram (EEG) Studies
- Brain Research with Normal Subjects
- Visuo-Spatial Abilities - Sex Differences
- Field Dependence-Independence (FDI)

It is this author's contention that the young child's brain up and through age eight functions essentially like that of a split-brain individual. Each hemisphere of the brain functions separately; the left hemisphere for verbal processes, the right hemisphere for visuo-spatial processes
with limited interhemispheric communication. However, it is the right hemisphere and visuo-spatial processes which seem to evolve and develop before the left hemisphere and language processes. The male brain continues to operate in a lateralized fashion with the development of interhemispheric communication. The female brain, however, becomes less lateralized and exhibits a bilateral hemispheric representation for verbal processes. This sex difference with regard to brain laterality becomes routine and reliable by age ten. The language symmetry between the hemispheres in the human female brain interferes with the right hemisphere's visuo-spatial functioning as verbal processes predominate over visuo-spatial where both coexist due to the importance of language in human development. Sex differences with regard to the degree of hemispheric laterality (greater laterality for males) and Levy-Sperry's interference hypothesis (Levy, 1969) provide a neurological rationale for the known male superiority with respect to visuo-spatial abilities (Harris, 1978) and in FDI measures based upon spatial-visual restructuring abilities (Witkin, Dyk, Faterson, Goodenough, & Karp, 1962).

**Split Brain Research**

As early as 1874, J. Hughlings Jackson suggested the asymmetrical hemispheric lateralization of the human
brain. However, it has been only in the last fifteen years that an accumulation of research studies have been amassed attesting to hemispheric lateralization. The impetus to this field of study was the successful commissurotomies performed by Doctors P. J. Vogel and J. E. Bogen during the 1960's. They surgically severed the corpus callosum of severe and chronic epileptic patients thereby separating the two hemispheres of the brain and enabling the study of the function of each. The hemispheres of these split-brain patients functioned as two separate brains, each with its own set of perceptions, sensations, processes, and memory. R. W. Sperry and M. S. Gazzaniga and their associates conducted numerous follow-up studies of these patients contributing greatly to our knowledge of hemispheric functioning. From their split-brain research, it was positioned that the two hemispheres of the brain process stimuli in different ways. The following list developed by Wittrock (1973) comprehensively summarizes the functional differences found for the hemispheres of the brain:

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<td>Appositional thought</td>
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<td>Spatial relations</td>
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<td>Verbal</td>
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Robert Nebes (1975) suggests additional process differences between the two hemispheres. The left hemisphere analyzes sequentially and serially in order to abstract out relevant details and associate these with verbal symbols. The right hemisphere employs a parallel mode of processing in order to simultaneously code stimuli, looking at the total or whole rather than the parts. Each hemisphere also responds differently. The left hemisphere describes or names whereas the right hemisphere points.

In addition, split brain research has shown stimuli differences. The left hemisphere appears to be specialized for speech, writing, and math calculations while limited in spatial relations. The right hemisphere has relatively few words, can only do simple additions, and specializes in spatial relations and music patterns.

Galin and Ornstein (1975) skillfully relate the process and stimuli differences of the two cortical hemispheres.

...each hemisphere is specialized for a different cognitive style; the left for an analytic, logical mode for which words are an excellent tool, and the right
for a holistic, gestalt mode, which happens to be particularly suited for spatial relations, and music. J. Levy (1970) similarly suggests that "...the two disconnected hemispheres, working on the same task, may process the same sensory information in distinctly different ways, and that the two modes of mental operation..., show indications of mutual antagonism." In her extensive investigations with dextrals and sinistrals, Levy (1976) also postulated different degrees of laterality within the hemispheres of individuals. Individual differences were found based upon unilateralization of verbal and visuo-spatial processes whereby one process may be depressed or bilateralization of the two processes whereby both may be retarded. In the present study it is the unilateral case which is of crucial concern. Since it is theorized that females exhibit bilateral representation of language and therefore both the verbal and perceptual processes are confined to the right hemisphere of the brain, one process will be depressed. It is felt that the verbal capacity will be preserved and the visuo-spatial ability impaired.


Brain Lesions and Lobectomies

Research conducted on patients suffering from brain damage have confirmed the hemispheric differences. As early as 1836, Dax noted the dominance of the left hemisphere of the brain for verbal processes. Broca (1865) and Wernicke (1874) corroborated this left hemisphere function. More recent studies have shown impairment in memory, speech, fluency, and reading as a result of left hemisphere damage or removal (Krashen, 1975; Milner, 1958, 1965, 1974; Russell & Espir, 1961). Newcombe (1974) also found a significant relationship between left hemisphere lesions and defects in tests of primary registration (digit and noun spans).

In contrast, the studies of right hemisphere brain damage have yielded significant dysfunctions regarding spatial orientation. Robert Nebes (1975) reports the following spatial disorientations as a result of right hemisphere damage:

lost in familiar surroundings; baffled by simple mazes; misjudge size, distance, direction of objects; no longer describe well-known routes, use or draw maps; cannot match or copy accurately the slant of a line or position of a dot on a graph; cannot copy simple shapes, not arrange blocks or sticks to form regular patterns; poor on tasks to judge how a pattern looks from a different spatial position; rotate, identical, or mirror image, two-dimensional to three-dimensional representation.4

These disorders have been confirmed by Ettlinger, Warrington, and Zangwill, 1957; Landsdell, 1970; Kimura, 1963a; McFie, Piercy, and Zangwill, 1950; Newcombe, 1974; Sperry, 1975, Warrington, James, and Kinsbourne, 1966. Some other right hemisphere defects include the inability to remember faces (Benton & Van Allen 1968; Milner, 1958; Newcombe, 1974), amusia (Brain, 1941), and dressing apraxia (Hécean, Penfield, Bertrand, & Malmo, 1956). More detail has been given to the defects as a result of right hemisphere damage as they are of particular relevance to the study at hand.

Jerre Levy (1974)⁵ presents an excellent summary of the defects following damage to the left and right hemispheres of the brain.

<table>
<thead>
<tr>
<th>Left Hemisphere Lesions</th>
<th>Right Hemisphere Lesions</th>
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<tr>
<td>1. Aphasia</td>
<td>1. Spatial alexia</td>
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<tr>
<td>2. Alexia</td>
<td>2. Spatial agraphia</td>
</tr>
<tr>
<td>3. Agraphia</td>
<td>3. Constructional apraxia</td>
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<tr>
<td>4. Loss of verbal memory consolidation</td>
<td>4. Facial agnosia</td>
</tr>
<tr>
<td>5. Loss of abstract categorising</td>
<td>5. Hemisomatoagnosia</td>
</tr>
<tr>
<td>6. Amusia</td>
<td>6. Spatial agnosia</td>
</tr>
<tr>
<td>7. Ideomotor apraxia</td>
<td>7. Topographoagnosia</td>
</tr>
<tr>
<td>8. Ideatory apraxia</td>
<td>8. Absence of proper form in drawings</td>
</tr>
<tr>
<td>10. Autopoagnosia</td>
<td>10. Amusia</td>
</tr>
</tbody>
</table>

### Left Hemisphere Lesions (Cont.)

- 11. Simultanagnosia
- 12. Loss of left-right discrimination
- 13. Absence of detail in drawings
- 14. Poor on Raven's Progressive Matrices
- 15. Poor on performance I.Q.
- 16. Worse on verbal I.Q.

### Right Hemisphere Lesions (Cont.)

- 11. Loss of form memory consolidation
- 12. Poor on Raven's Progressive Matrices
- 13. Poor on performance I.Q.

Examination on this summary reveals verbal or language defects associated with left hemisphere lesions and visuo-spatial disorders associated with the right hemisphere lesions, both of which are clearly supported in the literature. One also notes certain defects which follow both left and right hemisphere lesions and as such are not clear indicators of hemispheric asymmetry or specialization.

**Electroencephalogram (EEG) Studies**

Recent studies have been conducted utilizing EEG frequency analysis and evoked potentials in order to determine hemispheric functioning and specialization. Doyle, Ornstein and Galin (1973), Galin and Ornstein (1972), and McKee, Humphrey, and McAdam (1973) discovered greater left hemispheric functioning for verbal tasks based on a Right/Left Ratio > 1 indicating greater right hemisphere alpha or "idling rhythm". Based on this same procedure, musical and nonverbal, spatial tasks were
attended to by the right hemisphere.

Alpha suppression measures were used by Buchsbaum and Fedio (1969) and Morgan, McDonald, and MacDonald (1971) to indicate "non-idling" or hemispheric employment. Alpha suppression was found to be greater in the left hemisphere for activities involving vocabulary, language, logic, and arithmetic questions. Alpha suppression was greater in the right hemisphere for nonverbal, imagery, and musical tasks.

Lastly, a method involving evoked potentials has been employed to determine hemispheric specialization. Two researchers using this method, McAdam and Whittaker (1971) and Morrell and Salamy (1971), observed greater evoked potentials in the left hemisphere of the brain during language related activities. Greater right hemispheric functioning resulted during tasks involving visual stimuli (Morrell & Salamy, 1971; Vella, Butler, & Glass, 1972).

Based upon the variety and abundance of clinical brain hemispheric research, the left hemisphere specialization for verbal processes and the right hemisphere for visuo-spatial processes has become widely accepted.

Brain Research with Normal Subjects

A great deal of evidence regarding hemispheric specialization has been gained from visual and auditory dichotic presentations to the normal, intact human brain. This research is based on the contralateral effect of
stimuli; that is, stimuli presented to the right visual field or right ear will elicit a response in the left hemisphere of the brain. Conversely, stimuli to the left visual field or the left ear will be attended to by the right hemisphere of the brain. Accuracy and/or reaction time measures suggest the hemisphere specialized for the stimuli presented.

Once again a left hemisphere specialization for verbal processes has been shown in the dichotic visual studies. A right visual field or left hemisphere superiority for word and letter recognition has been consistently reported (e.g., Berlucchi, Heron, Hyman, Rizzolatti, & Umilta, 1971; Gilson, Filbey, & Gazzaniga, 1970; Kimura, 1966; Mackavey, Curcie, & Rosen, 1973; McKeever & Huling, 1970; Mishkin & Forgays, 1952). Marcel, Katz, and Smith (1974) demonstrated this verbal dominance of the left hemisphere in children as young as seven and eight years of age. The right visual field has also been shown to be superior in the recall of digits (Hines & Satz, 1974).

The left visual field or right hemisphere has been related to perceptual and visuo-spatial functioning. Kimura (1966, 1969) and McGlone and Davidson (1973) reported a left visual field advantage for dot enumeration tasks. Depth perception and the detection of the slant of a line was also found to be superior in the left visual field by Kimura and Durnford (1974) and Umilta, Rizzolatti, Marzi,
Zamboni, Franzini, Camarda, and Berlucchi (1974). Geffen, Bradshaw, and Wallace (1971) and Gilbert and Bakan (1973) demonstrated right hemispheric specialization for nonverbal material, however, Kimura (1966) was unable to replicate this finding. The dichotic presentation of faces for recall also indicates right hemispheric dominance (Geffen, Bradshaw, & Wallace, 1971; Milner, 1958; Rizzolatti, Umilta, & Berlucchi, 1971; Yin, 1970).

Other research has involved dichotic auditory presentations with similar hemispheric specialization results. A right ear or left hemisphere advantage has been found for the recall of verbal material and digits by Kimura (1961, 1963b, 1967). Knox and Kimura (1970) affirmed the right ear advantage for verbal sounds in five-to-eight year old children. On the other hand, melodies, nonspeech auditory stimuli, sonar sounds, and environmental noises were more accurately reported by the left ear or right hemisphere (Kimura, 1961, 1964, 1967; Knox and Kimura, 1970; Spreen, Spellacy, & Reid, 1970).

A similar contralateral effect for hemispheric dominance has been demonstrated for eye movements by Weiten and Etaugh (1974). They discovered significantly more eye movements to the right visual field or left hemisphere for verbal and numerical material and significantly more eye movements to the left visual field or right hemisphere for spatial and musical material.
Clearly, the various types of research conducted with normal subjects confirms the left hemisphere dominance for verbal processes and the right hemisphere specialization for visuo-spatial activities.

**Visuo-Spatial Abilities - Sex Differences**

Inasmuch as the sex differences regarding spatial abilities seems to correlate with the sex differences observed for FDI, namely the superior performance of males in both, and the seemingly apparent spatial ability factor in FDI measures, it is sufficiently relevant to include this body of research. Studies of sex differences in spatial abilities might reinforce this author's theory regarding sex differences in the degree of hemispheric laterality.

Lauren Jay Harris (1978) provides a comprehensive review of the important literature dealing with sex differences in spatial abilities and possible environmental, genetic, and neurological factors. Harris discusses the male superiority in geometric achievement as evidence of greater spatial ability. Male geometric superiority has been supported by the work of Gastrin (1940), Saad and Storer (1960), and Smith (1964). Saad and Storer (1960) found this sex difference to appear as early as grade five. A correlation has been shown between geometric scores, but not arithmetic and algebra marks, and standard spatial
visualization tests (Barakat, 1951; Siegvald, 1944; Smith, 1960). The male superiority in geometric achievement is then reasoned to be, according to Smith (1964), "...another manifestation of the sex difference in spatial ability, reflecting a greater capacity on the part of boys to perceive, recognize, and assimilate patterns within the conceptual structure of mathematics." ⁶

Other evidence cited in which male superiority is displayed includes the ability to perform left-right discriminations (Bakan & Putnam, 1974) and greater achievement on the PMA Spatial Relations Test (McGlone & Davidson, 1973). Maccoby and Jacklin (1974) also report pronounced sex differences on spatial tests favoring males. Harris lists numerous studies which deal with the ability to recall and detect shapes. There were no significant sex differences for five-to-ten year olds though the trend seems to favor boys (eg., Goodenough & Eagle, 1963; Karp & Konstadt, 1963; Keogh & Ryan, 1971; Witkin, Goodenough, & Karp, 1967; Witkin, Lewis, Hertzman, Machover, Meissner, & Wapner, 1954). However, from age twelve male superiority

in speed and accuracy on these tasks clearly emerges and becomes reliable. In studies involving the Rod-and-Frame Test, the ability to detect the true vertical despite distracting clues, sex differences appear earlier. Male superiority appears in the five-to-ten year old range (Canavan, 1969; Keogh & Ryan, 1971; Witkin, et al., 1967) and becomes a routine finding beyond age ten (Schwartz & Karp, 1967; Silverman, Buchsbaum, & Stierlin, 1973; Witkin, et al., 1962, 1967).

The work of Doreen Kimura (1963a, 1966, 1967) has been mentioned previously with regard to brain research involving normal subjects. It will be recalled that she found a right hemisphere advantage for dot enumeration tasks. In 1969, she conducted a study involving dot localization performance. Interestingly, the right hemisphere of her male subjects proved significantly superior on all dot localization tasks. However, the female subjects exhibited superiority in the right hemisphere for only those dots localized within a circular frame. McGlone and Davidson (1973) similarly found a higher incidence of right visual field (left hemisphere) superiority for dot enumeration tasks for female subjects. Since dot localization and dot enumeration tasks probably reflect the use of the same spatial coordinate system, these two studies suggest a greater degree of lateralization for males with respect to visuo-spatial abilities.
(right hemisphere). In addition, female subjects performed significantly poorer on the spatial tests, thereby implying that the left hemisphere is inferior for visuo-spatial functioning. McGee (1976) also supports the importance of the left hemisphere with regard to spatial processes for females. McGlone and Davidson further noted that those females with high left ear (right hemisphere) dichotic listening scores also showed significant deficits on the PMA Spatial Abilities Test. Bilateralization of verbal processes in these females also serves as an obstacle to efficient visuo-spatial performance. Other studies using dot localization tasks have found no hemispheric superiority (Pohl, Butters, & Goodglass, 1972) or left hemispheric superiority (Semmes, Weinstein, Ghent, & Teuber, 1963). However these two studies employed only male subjects and therefore cannot shed any light on the sex differences found by Kimura. Nebes (1973) also did not investigate sex differences, but did confirm Kimura's right hemispheric superiority for dot localization.

Harris (1978) also presents a very interesting discussion regarding possible environmental factors affecting spatial abilities. These studies are mentioned as they present another source of variation and in some cases even negate previously found sex differences. For example, MacArthur (1967) found a near zero correlation between sex and performance on an Embedded Figures Test for Eskimo men.
and women. He concludes that the absence of sex differences in spatial abilities is due to the 'effective training' of spatial skills experiences provided by the daily life of the Eskimo people. Berry (1966) also found cultural and environmental differences upon comparing Eskimos and the Temne tribe in Africa. Various other cross-cultural studies have yielded greater cultural differences than sex differences (e.g., Bennett, 1956; Chateau, 1959; Porteus, 1965). Spatial abilities and sex differences have also been examined in connection with socialization and sexual expectations. Both Munroe and Munroe (1968) and Witkin, et al. (1962) found socialization practices related to sex differences in spatial abilities. In addition, parent-child studies have resulted in significant correlations between mother and son scores (Barclay & Cusumano, 1967; Corah, 1965; Witkin, et al., 1962) and father and daughter scores (Bieri, 1960; Corah, 1965) on tasks involving spatial abilities. It seems that cultural experiences, socialization practices and experiences, and sex role identification patterns provide experiences critical in the development of spatial abilities. Consequently, when examining sex differences regarding spatial abilities one cannot ignore the traditional nature-nurture controversy. It is for this reason that such studies have been included in the literature review. Male superiority in spatial abilities are related to both environmental and cultural factors.
Neurological Models

Lastly, Harris (1978) discusses three different neurological models for male and female differences with regard to spatial abilities. Model 1 proposes earlier right hemisphere lateralization in males. The work of Rudel, Denckla, and Spalten (1974) and Witelson (1975, 1976) is offered as support for this model. Rudel and his associates used a tactile procedure in order to teach braille letters. They found that seven and eight year old boys learned the letters equally well with both hands while the same aged girls showed superior right hand scores. However, for 13 and 14 year old boys their left hand proved significantly superior. The problem with the results of this study lies in the possible involvement of both hemispheres due to the task employed. On the other hand, Witelson (1975) used a tactile dichotic task involving meaningless shapes and pointing to a visual display of the shapes for the responses thereby mitigating the involvement of the left hemisphere. The females in her study did not display a left hand (right hemisphere) superiority until age 13. However, the male subjects showed a significant left hand superiority by age 5. In her later study (1976), Witelson again found evidence for earlier right hemisphere lateralization for spatial abilities for boys (at about age six) as compared to girls (about age thirteen). Model 2 focuses upon earlier, greater left hemisphere lateralization
in females and bilateral spatial representation in males. This developmental difference is associated with the work of Buffery and Gray (1972). A great deal of evidence regarding earlier female superiority in speech onset (Morely, 1957), vocabulary (Nelson, 1973), word fluency (Herzberg & Lepkin, 1954), and reading ability (Gates, 1961) is offered as support for Model 2. In addition, Kimura (1967) found a significant right ear advantage for a dichotic auditory task involving digits with five-to-eight year old girls and six-to-eight year old boys. The five year old boys did not show this advantage. However, in an earlier study (Kimura, 1963b) this sex difference was not present. Pizzamiglio and Cecchini (1971) also used dichotic presentation of digits as well as words with the result that five year old Italian girls exhibited the strongest lateralization effect. Bryden, Allard and Scaprino (1973) corroborated this finding for grade four females using a task involving speech consonants. Although there is ample evidence to support Model 2, it is essentially a developmental model and therefore not wholly adequate in order to explain the sex differences that persist through adulthood. Model 3 suggests greater hemispheric lateralization in males and bilateral representation of language in females. This bilateral representation of language interferes with the visuo-spatial functioning of the right hemisphere (Levy, 1969, 1976; Miller, 1971, Milner, 1969; Nebes, 1971a,b;
Silverman, Adevai, & McGough, 1966). The majority of these studies involve verbal and visuo-spatial tasks as performed by dextrals and sinistrals. It is the left-handed subjects exhibiting mixed laterality who perform less well on the visuo-spatial tasks and therefore evidence for the interference hypothesis and inferior spatial abilities of females as the consequence of bilateral representation of language. The greater hemispheric lateralization in males is also well-documented in the literature. Lansdell (1968) reported a significant correlation between right hemisphere tissue removal and nonverbal scores for only male subjects. Bogen (1969) confirmed greater male impairment for a perceptual test relative to a verbal test than for female commissurotomy patients. McGlone and Kertesz (1973) similarly found that male patients with right lesions did significantly worse on the Wechsler-Bellevue-Intelligence Scale Block Design Subtest than females and those females with left hemisphere lesions exhibited a significant correlation between the Block Design and Language Subtests. Ray, Morell, Frediani, and Tucker (1976) discovered greater male lateralization as the result of their greater EEG Left/Right Ratios between verbal and math tasks (left hemisphere) and visual and musical tasks (right hemisphere). Further evidence for male greater lateralization comes from studies using normal subjects and were discussed earlier with regard to the work of Kimura (1969), McGlone and Davidson
It will be recalled that these authors found evidence for greater left hemisphere involvement for visuo-spatial tasks and a relationship between right hemisphere listening scores and deficits in visuo-spatial tasks for only female subjects. In view of the overwhelming evidence in support of Model 3 and this author's own views, it is to this model that this study is directed.

Three other competing theories regarding differences in abilities and neurological organization will be briefly discussed. Levy (1976) focuses upon the genetics of handedness and cerebral dominance and possible hormonal effects. Waber (1976) relates the rate of physical maturation regardless of sex to differences in the organization of the brain and concomitant differences in mental abilities. Early maturing adolescents (usually females) do better on verbal rather than spatial tasks, whereas late maturing adolescents (usually males) exhibit the reversed pattern. Finally, Kinsbourne and Hiscock (1978) do not deal directly with sex differences with regard to verbal and spatial abilities. Rather, they contend that lateralization of hemispheres is present at birth and is an attentional phenomena. The hemispheres orient attention to the contralateral sides of space or to contralateral stimuli. Differences in abilities are not the results of increases in degree of lateralization, but increases in efficiency and
learning to allocate attention to the appropriate hemisphere processes. While documentation for all the neurological theories can be found, there is more consistent evidence in support of Model 3, greater hemispheric lateralization in males and bilateral representation of language in females.

**Field Dependence-Independence (FDI)**

The last group of studies to be reviewed deals with the main focus of this study, field dependence-independence measures. Witkin and his associates have found field dependence-independence to be related to one's articulated body concept, the sense of separate identity, and the nature of defenses employed. As originally conceived this construct was felt to be a measure of spatial orientation. It is now defined as the extent of autonomy of external referents (Witkin & Goodenough, 1977) and contained within the larger, more complex term of "psychological differentiation" (Witkin, et al., 1962). Three empirical measures have been consistently used to assess one's degree of FDI - the Body Adjustment Test (BAT), the Rod-and-Frame Test (RFT) and the Embedded Figures Test (EFT). They involve the ability to separate a 'figure' from its embedding 'ground' or context. It has been shown that field dependence-independence is a relatively stable, consistent, and reliable measure. Witkin, Goodenough, and Karp
(1967) found an increase in field independence with age which seems to be completed by age 17. However, the relative standing at each age on a continuum of this measure remained stable at a significant level. Their cross-sectional and longitudinal studies involved subjects from 8-to-13 years old and 10-to-24 years old. Goodenough and Eagle (1963) and Karp and Konstadt (1963) also found an increase in field independence with age in 5-to-8 year olds; the relative standings, however, remain stable at each age. The actual reliability scores for the EFT and RFT are very high for both males and females and are reported in Chapter III. In addition, numerous studies have shown field dependence-independence to be resistant to change (Bauman, 1951; Gruen, 1955; Karp, Witkin, & Goodenough, 1965; Kraidman, 1959; Pollack, Kahn, Karp, & Fink, 1960; Scott, Bexton, Heron, & Doane 1959; Witkin, 1948). A few studies have yielded contradictory results. Wolf (1965), Jacobson (1966, 1968) and Kurie and Mordkoff (1970) have improved RFT performance. In addition, Small (1973) not only has improved RFT scores but also has worsened them with the results consistent after one month. He also cites other studies which have found that direct feedback, practice, and the "set" or "expectancy" can improve RFT performance.

FDI has also been related to child rearing practices (independence training and differential treatment of the
sexes), maternal and paternal characteristics, the child's view of their parents, and the family structure, but not to verbal skills (Bigelow, 1971; Witkin, et al., 1962) or intelligence (Busch & DeRidder, 1971). Of great relevance to this study, this construct has been consistently related to sex differences. Males have been shown to be more field independent than females (Witkin, et al., 1962). Dreyer, Dreyer and Nebelkopf (1971) found this sex difference in kindergarten children using the CEFT and the PRFT, while Witkin, Goodenough, and Karp (1959) discovered this same relationship with eight year olds using the EFT and RFT. However, Crudden (1941) and Goodenough and Eagle (1963) did not find this sex difference in children from five-to-eight years old. Numerous studies have failed to find a sex difference in children five-to-ten years old using embedded figures (Bigelow, 1971; Cecchini & Pizza-miglio, 1975; Domash & Balter, 1976; Goodenough & Eagle, 1963; Karp & Konstadt, 1963; Keogh & Ryan, 1971; Maccoby, 1966; Witkin, et al., 1964, 1967), but in most of these studies the trend is for more field independent male subjects. Surprisingly, Immergluck and Mearini (1969) discovered more field independent female subjects at age 9, but no sex differences at ages 11 and 13. Other studies have demonstrated a significant male advantage regarding FDI performance on the RFT between the ages of five and ten (Canavan, 1969, Keogh & Ryan, 1971; Witkin, et al., 1967) and beyond age ten (Schwartz & Karp, 1967;
Silverman, et al., 1973; Witkin, et al., 1962, 1967). Although there does not seem to be any conclusive FDI sex differences between ages five and ten, it must be noted that there is a considerable range of FDI performance as early as age five with some children already achieving field independence. In addition, as Bigelow (1971) points out the greatest increase in FDI performance seems to be after age 8. Thus it seems that sex differences in FDI favoring males appear to be reliable after age 10.

Some authors have addressed themselves to the sex differences in spatial abilities as accountable for the consistent sex differences in FDI. Sherman's (1967) "cultural reward hypothesis" maintains that it is the link between sex typing which itself is quite stable and spatial perception that relate to the consistent sex differences in FDI. Vaught (1965) similarly contends that it is the relationship between sex role identity and ego strength and spatial abilities that is manifested in sex differences in FDI. He found that it was the feminine role identification for either males or females which was related to field dependence. Additional support for Sherman and Vaught's position regarding the relationship between spatial abilities and FDI is found in the work of Gardner, Jackson, and Messick (1960) and Hyde, Geiringer, and Yen (1975). They found that field independent subjects did better on standardized paper and pencil tests of spatial visualization. However, the latter researchers did not
find support for the sex differences in spatial abilities as related to sex typing. Although sex differences in FDI could be accounted for by sex differences in spatial abilities they felt that a major sex-linked gene (the gene for superior spatial ability being recessive) is responsible for the observed differences. DeFazio and Moroney (1969) found no significant difference between field independent and field dependent subjects using an auditory disembedding task. They concluded that FDI involved only the spatial modality, again, confirming Sherman and Vaught's theory. The relationship between FDI and role identification has also been found by Domash and Balter (1976) who related maternal attitudes with regard to sex expectations (particularly for females) with field dependence. In opposition to these studies which relate FDI and spatial ability with regard to sex differences, McGilligan and Barclay (1974) did not find any sex differences for performance on the PMA Spatial Relations Test. However, when subjects were grouped according to their RFT scores and sex, the male subjects were significantly more field independent than the females. But the high scoring girls did not differ significantly from the high scoring boys on the PMA Spatial Relations Test. They also discovered a negative relationship (r = -.50; p < .01) between FDI scores and PMA Spatial scores but this accounted for only 25% of the variance. These authors concluded that there is more to FDI than simple spatial ability.
Studies of a similar nature have sought to relate FDI with both verbal and spatial ability measures. These are of particular relevance to the study at hand as they employ the Wechsler Intelligence Scale for Children (WISC) or tests that are similar to those used in the present study. Dreyer, Dreyer, and Nebelkopf (1971) reported a significant correlation for both kindergarten boys and girls between the PRFT and the verbal, analytic or performance, and total WISC scores. However, the data suggests that the performance index is a better predictor of PRFT scores for boys ($r= .25; p < .01$) and the verbal index for girls ($r= .22; p < .01$). Goodenough and Karp (1961) also used the WISC and found that field dependent subjects perform less well than field independent subjects. In addition, factor analysis revealed that the Block Design, Object Assembly, and sometimes the Picture Completion subtests loaded on the same factor (perceptual organization according to Cohen, 1959) as did the Rod-and-Frame-Test. They offered various other labels for this common factor of the RFT and the previously noted WISC subtests (e.g., closure, performance, spatial-perception, nonverbal organization, visualization, perceptual speed). Other studies have noted the relationship between spatial tasks and FDI measures. Gough and Olton (1972) discovered a negative correlation between a space relations test requiring the selection of
components to complete a design and scores on the RFT $(r = .33; p < .05)$. The RFT was not correlated at all with verbal ability. Lastly, Satterly (1976) reported a significant correlation between field independence and intelligence and with mathematics and haptic perception scores when intelligence was controlled. Although haptic perception involves the ability to tactually recognize a shape, he concluded that FDI is separate from general ability, spatial-ability, and perceptual speed. This was confirmed by his principal components analysis. Satterly's contradictory results could perhaps be explained by his use of the Embedded Figures Test and an English male population. Thus, it seems a reasonable assumption that FDI relates to spatial ability and the performance index of the WISC, particularly the Block Design Subtest.

The next group of studies to be reviewed relate FDI measures to hemispheric specialization. These studies generally employ embedded figures or hidden figures, overlapping figures, figure completion type tasks, or the Rod-and-Frame Test as measures of FDI.

DeRenzi and Spinnler (1966) used both overlapping figures and completion type tasks and found that right hemisphere brain damaged subjects performed significantly inferior to the left hemisphere damaged subjects. Kimura (1963a) confirms right hemisphere import for overlapping figures, while Warrington and James (1967) confirms right
hemisphere involvement for completion type tasks. Pizzamiglio and Carli (1974) manipulated three types of embedded figures tasks - a traditional, tactile, and acoustical version. They discovered a trend for right hemisphere involvement in these tasks, but achieved significance only for the tactile embedded figures test.

Two other studies are noted here as the tasks employed are significantly correlated to embedded figures tests. DeRenzi and Faglioni (1967) administered the Copy Crosses Test and found right hemisphere significance. Basso, Bisiach, and Faglioni (1974) found left hemisphere brain damaged patients to be less susceptible to the Mueller-Lyer Illusions. They concluded that perhaps the normal right hemisphere of the brain effectively functions on illusion tasks and embedded figures tasks.

Right hemisphere involvement has been routinely associated with the recall and recognition of human faces. (The reader is directed to Freda Newcombe, 1974, for a review of these studies.) The recall of human faces has also been associated with field dependence (Crutchfield, Woodworth & Albrecht, 1958; Ramírez & Castañeda, 1974). However, Hoffman and Kagan (1977) observed the opposite results. For male subjects, field independence was significantly correlated with facial recognition (p < .02), but for females this same relationship was only moderately significant (p < .10). It has also been found that field dependent
children will look at an examiner's face two times more often in stressful situations (Konstadt & Forman, 1965). Greater incidental learning will evolve for field dependent children if the stimuli is human faces as opposed to non-human faces (Messick & Damarin, 1964; Witkin, et al., 1962). Right hemisphere functioning and field dependence as associated with interpersonal relations seem to be related in the majority of these studies.

Studies involving visual coordinate systems in space also indicate right hemisphere specialization. These types of studies employ methods very much akin to those in the Rod-and-Frame Test used to measure field dependence-independence. McFie, Piercy, and Zangwill (1950) provide an extensive survey of cases which indicate right hemisphere involvement in tasks involving visual coordinates and directional operations. DeRenzi, Faglioni, and Scotti (1971) corroborate these findings. Umilta, et al., (1974) substantiate right hemisphere involvement for only the most difficult directional operations in space. Lastly, Hécaen and Ajuriaguerra (1949) reported evidence for visual-constructive deficits, "...errors of orientation of the 'figures' in relation to the 'ground'..." for right brain damaged patients.

Other research has suggested possible left hemispheric involvement in FDI. Poeck, Kerschensteiner, Hartje, and Orgass (1973), Russo and Vignolo (1967), and Teuber and Weinstein (1956) have noted that patients suffering from aphasia, a speech deficiency associated with left hemisphere dysfunction, also do significantly poorer on embedded figures tests. DeRenzi and Faglioni (1967) used a similar task and found aphasic patients to perform at an inferior, though not statistically significant level. In general, both Hebb (1939) and Weisenburg and McBride (1935) found a relationship between aphasic, left brain damaged patients and nonaphasic, right brain damaged patients on nonverbal, visuo-spatial tests. It seems that aphasia (a left hemisphere defect) is similar to defects in visuo-spatial ability following right hemisphere damage as both involve "...defective organization or selection of material (linguistic as well as non-linguistic)."\(^8\)

A small body of research indicates a significant involvement of only the left hemisphere in field dependence-independence. Cohen, Berent, and Silverman (1973) found that all female patients who received an electroconvulsive shock to the left hemisphere showed more field dependence

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(larger errors) whereas all right ECT shocks resulted in fewer errors or less field dependence. Field dependency has also been associated with poor performance on left hemisphere tasks. Berent (1976) found that field dependent subjects exhibited significantly more serial sevens errors and took a longer time to count backward from 100 while subtracting by seven. Berent and Silverman (1973) also found field dependent subjects to show a significant deficit on a verbal - paired associate test (left hemisphere specialization) but not on a visuoperceptive - paired associate test (right hemisphere). Other authors have similarly found a significant positive relationship between left hemisphere skills and field independence. Berent (1974) found field independent subjects to display superior writing skills and DeFazio (1973) related superior language ability skills (verbal predictability and fluency, but not verbal comprehension) to field independence. Hyde, Geiringer & Yen (1975) however did not confirm the relationship between field independence and word fluency when vocabulary effects were removed. White (1971) also demonstrated a significant right visual field (left hemisphere) superiority for a language task and one involving the orientation of a line in space (similar to spatial restructuring ability of FDI measures). These last studies are of particular interest as Cohen and his associates employed only female subjects. The relationship they found between the left
hemisphere of the brain, verbal processes, and field independence for female subjects could be interpreted not as evidence for hemispheric specialization, but as greater lateralization for males, left hemisphere mediation in visuo-spatial tasks for females, or bilateral representation of language for females.

The last group of studies to be discussed deals specifically with FDI performance in terms of the degree of cerebral laterality. Many studies have found that field independent subjects display greater left hemisphere lateralization for verbal processes and right hemisphere lateralization for visuo-spatial processes. Oltman, Ehrlichman and Cox (1977) used a composite face perception test (a right hemisphere function) and found that both male and female field independent adults showed a significantly stronger left visual field bias (right hemisphere). Field dependent subjects exhibited little or no lateralization on this task. These authors also cite the work of Zoccollatti and Oltman (in press) who used tasks involving both hemispheres. They found that field independent subjects displayed a faster reaction time to faces in the left visual field (right hemisphere) and to letters in the right visual field (left hemisphere). Field dependent subjects had no significant hemifield differences for either task. Pizzamiglio (1974), Pizzamiglio and Cecchini (1971), and Waber (1977) report that persons with stronger right ear advantages in dichotic
listening tasks also tend to be relatively field independent. Schroeder, Eliot, Greenfield, and Solken (1976) used boys and girls ages 4.7 to 6.2 and found no significant sex differences on the hidden figures test or in the direction of eye shifts. However, there was a significant difference between inconsistent eye shifters (who did the poorest) as compared to right or left eye shifters. Similarly, Ehrlichman (1977) could not find a relationship between FDI scores and the direction of eye movement. These results, however, do suggest that inconsistency of eye shifts is related to field dependence and incomplete cerebral laterality. Indirect evidence for the relationship between FDI and brain laterality comes from works cited earlier. Kimura (1969) and McGlone and Davidson (1973) found that females tend to be less lateralized and Witkin, et al., (1962) also found females to be relatively more field dependent. It will also be recalled that Dreyer, Dreyer, and Nebelkopf (1971) found that the WISC performance index was a better predictor of boys PRFT scores whereas the verbal index was more suited to the girls PRFT scores. Since studies have shown that right brain damaged patients perform significantly less well on the Wechsler Adult Intelligence Scale (similar to the WISC) performance scale and the left brain damaged patients on the verbal scale (Warrington & James, 1967; Black, 1974) greater hemispheric lateralization for males seems tenable (corroborated by McGlone & Kertesz, 1973, and Ray, et al.,
1976). This is based upon the fact that males also tend to be more field independent and the fact that the WISC performance scale and the RFT heavily load upon the same factor (Goodenough & Karp, 1971). Thus, the suitability for males of the performance scale of the WISC, its relationship to right hemispheric functioning, and its relationship to RFT scores, suggests that greater laterality is associated with field independence.

In conclusion of this chapter, it appears that sex differences in spatial ability and FDI favoring males seem to reflect cortical organization. Traditional brain research clearly indicates left hemisphere specialization for verbal processes and right hemisphere for visuo-spatial processes. However, studies dealing with spatial abilities and FDI measures call for a modification of this brain organization for females. It seems that there is greater lateralization for males along the lines of traditional brain research. But for females there seems to be a bilateral representation of language or at the least an involvement of the left hemisphere in visuo-spatial processes. Field dependent persons who also tend to be female also reflect incomplete lateralization. Thus, females who tend to perform poorer on spatial tasks and more often are field dependent may possibly reflect a lesser degree of hemispheric lateralization.
CHAPTER III

PROCEDURES

The review of the literature dealing with spatial abilities and field dependence-independence (FDI) measures indicates a similar pattern of development. By age twelve, there is a consistent and reliable male advantage for spatial abilities and field dependence-independence (males are more field independent). Clinical brain research clearly confirms a right hemisphere specialization for spatial tasks. However, this hemisphere lateralization is also more reliable and consistent for male individuals. In addition, FDI studies have shown that field independent subjects (who tend to be males) also demonstrate greater hemisphere lateralization for both the right and left hemispheres of the brain. Other studies have shown that females exhibit less hemispheric lateralization and bilateral representation of language as well as field dependence and inferior spatial abilities skills. Thus, it seems reasonable to suggest that these gender differences with regard to spatial abilities and field dependence-independence reflect different neurological organization with respect to
the degree of hemispheric lateralization. This study was designed to investigate the relationship between this neurological theory of greater male hemispheric lateralization and age and sex differences in field dependence-independence and spatial ability measures. The procedures used in this study were designed to attack this problem. As such male and female subjects of two different age groups, five-to-six year olds (kindergarten) and eleven-to-twelve year olds (sixth grade), were given two left hemisphere tasks (WISC Digit Span and PMA Verbal Meaning Tests), two right hemisphere tasks (WISC Block Design and PMA Spatial Relations Tests), and a measure of field dependence-independence (Rod-and-Frame Test).

Subjects were selected from the student population of an urban, public school in Columbus, Ohio. The total student enrollment is 611 with 53.0% males and 47.0% females. The racial make-up of this school consists of 3.9% nonwhite and 96.1% white students. The ADC incidence, families receiving state welfare aid for dependent children, is only 2% and the mobility rate is 5%. There are 18.50 classroom teachers with an average training level of a Bachelor of Arts Degree and an average training experience of 13.12 years. Pupil/classroom teacher ratio is 31.0 to 1. This statistical data comes from the Progress in Education, A Report to the Community, 1976-1977, an annual publication of the Columbus, Ohio, Public Schools. Based upon
this information, this Columbus, Ohio school represents a white, middle class, urban public school population.

Students who participated in this experiment were volunteers who had obtained parental consent and were in either the two morning kindergarten classrooms or the two sixth grade classrooms. These two grades were chosen so as to maximize developmental level differences. Forty-eight kindergarten students out of a total of 58 and 44 sixth grade students out of a total of 53 volunteered to participate in this study. All of these students received the experimental procedures. However, only data from right-handed subjects were included in the study so as to avoid subjects exhibiting reversed or mixed hemispheric laterality and confine the study to subjects exhibiting left hemisphere specialization for verbal processes. This is based upon the overwhelming evidence of the relationship of right-handedness to left hemisphere specialization for language (O'Keefe, 1975). The final sample consisted of a total of 79 subjects, 41 kindergarten pupils, 16 males and 25 females, and 38 sixth grade students, 17 males and 21 females. These students were randomly assigned numbers so as to maintain confidentiality of testing results.

On April 19th, 20th, and 25th of 1978, this experimenter explained the study and testing procedures to each of the kindergarten and sixth grade classrooms and distributed parental letters of explanation and consent forms. The
first testing session was on April 24, 1978, employing the Hand­edness Instrument and the WISC Digit Span Test. All sixth grade testing with these two instruments was done by this exper­imenter. An Ohio State University student teacher working at this Columbus, Ohio school at the time of this investigation, assisted with the kindergarten testing of the Handedness Instrument and the WISC Digit Span Test. Administration of the WISC Block Design Test was begun on May 2, 1978. All subjects received the WISC Block Design Test from this researcher. The Rod-and-Frame Test, as administered by myself of Dr. Marlin Languis, an Ohio State University professor, was begun on May 4, 1978. Lastly, the PMA Verbal Meaning Test and the PMA Spatial Relations Test were given in the same testing session. On June 9, 1978, this experimenter administered the two PMA tests to the sixth grade subjects. On June 12, 1978, a kindergarten teacher at the school administered the two PMA tests to all kindergarten students. Two kindergarten students and one sixth grade student were unable to complete the PMA Verbal Meaning Test and the PMA Spatial Relations Test due to absence. Data from these students were included in this study by assigning to them the appropriate kindergarten or sixth grade mean on these two tests. All testing was completed on June 12, 1978. For a complete schedule of all testing sessions, the reader is directed to Appendix A.
Instruments

A total of six assessment measures were given to all subjects: the Handedness Instrument, the Digit Span Subtest of the Wechsler Intelligence Scale for Children, the Block Design Subtest of the Wechsler Intelligence Scale for Children, the portable Rod-and-Frame Test, the Verbal Meaning Subtest of the Primary Mental Abilities Test, and the Spatial Relations Subtest of the Primary Mental Abilities Test.

1. Handedness Instrument - Eight overt actions appropriate to kindergarten and sixth grade age children were chosen from 23 items on an handedness questionnaire published by D. Raczkowski, J. Kalat, and R. Nebes (1973). These items obtained a better than 90% validity between questionnaire and performance scores (N=47) and a better than 90% reliability between first administration and testing a month later (N=27). The following performance items were used in the present study:

(1) Draw a picture with a crayon.
(2) Write your name with a pencil.
(3) Remove the top card of a deck of cards.
(4) Throw a ball.
(5) Use a toothbrush.
(6) Use an eraser on paper.
(7) Use a pair of scissors.
(8) Stir a liquid in a glass with a spoon.

Demonstrated use of the same hand for 7 out of 8 actions served as the criterion for hand preference. Only subjects displaying firm right-handed preference were included in
this study.

2. Wechsler Intelligence Scale for Children (WISC) - This test consists of 12 subtests divided into two categories, Verbal and Performance. It is written by David Wechsler and published by the Psychological Corporation, 1949. Standardization procedures employed 100 boys and 100 girls at each age from five-to-fifteen years old and sampled various geographic areas, urban and rural populations, and a variety of parental occupations.

a. The Digit Span Subtest is listed as a supplementary test in the WISC Manual. According to Cohen (1959), this subtest consistently loads on his Factor C: Freedom from Distractability. It is an individually administered test that contains two parts. Digits Forward requires subjects to recite a string of digits heard, ranging from three to nine digits. A maximum score of nine indicates the highest number of digits correctly repeated without error. Digits Backward requires the repeating of digits backwards and ranges from two digit to eight digit strings. The maximum score on the Digits Backward is eight. The total maximum score for the Digit Span Test is 17. As reported in the WISC Testing Manual, test-retest correlations were obtained by the split-half technique with appropriate correction for the full length of the test by the Spearman-Brown formula. All correlations were obtained for three age groups as representative of the entire age range from five
to fifteen years old. Test-retest correlations for $7\frac{1}{2}$ years old were .60, for $10\frac{1}{2}$ years old were .59, and for $13\frac{1}{2}$ years old were .50. The WISC Digit Span Test is felt to be indicative of left hemispheric functioning based upon the research of Black (1974), Hines and Satz (1974), Newcombe (1974), and Warrington and James (1967). It will be recalled from Chapter II, Literature Review, that Hines and Satz (1974) found the right visual field (left hemisphere) to be superior in the recall of digits. Similarly, the other three studies cited above related left hemisphere lesions to deficiencies in digit span tasks.

b. The Block Design Subtest is listed as part of the Performance Scale in the WISC Manual. Cohen (1959) identifies this test as consistently loading on his Factor B: Perceptual Organization. It is an individually administered test which involves the duplication of a design shown by an experimenter model and a picture on a card involving four blocks with different colors on their different sides. For subjects under eight years old, three designs A, B, and C, are given with two points scored for constructing the design on the first trial and one point for passing on the second trial. Maximum score is six points. If the subject passes all three designs, they proceed with designs 1 through 7. Subjects eight years or older begin with design C. If they pass that design they are credited with 6 points for designs A, B, and C. They
then proceed to designs 1 through 7. Designs 1 through 4 involve four block design constructions as depicted on a card with a maximum of 75 seconds allotted for each. Designs 5 through 7 involve nine blocks and a maximum of 150 seconds time allowed for each construction. Four points are given for each successful completion of the design and additional bonus points are awarded for rapid performance on correct designs. The maximum score for designs A through C and 1 through 7 is 55 points. According to the WISC Manual, test-retest correlations for 7½ years old were .84, for 10½ years old were .87, and for 13½ years old were .88. The Block Design Test has been related to right hemispheric functioning by Black (1974), Nebes (1975), Sperry (1974), and Warrington and James (1967) who found right hemisphere lesions to be associated with defects in block design tasks.

3. Rod-and-Frame Test (RFT) - This is an individually administered measure of field dependence-independence (Witkin, et al., 1962). The version used was the portable RFT (Oltman, 1968), a modification of the Witkin RFT which is easier to use and more appropriate for children. The child looks into a rectangular enclosure which serves as the frame and can be tilted to the left or the right at an angle of 28°. A tilting rod is seen at the end of the enclosure. Eight trials are given: three trials in which the rod and frame are displaced 28° to the right, three
trials involving displacement 28° to the left, and three trials involving the true vertical. The reader is directed to the Appendix B and the sample of the RFT Scoring Sheet for the exact order of the eight trials. A subject's score is based on the sum of the deviations from the true vertical, regardless of the direction, over the eight trials. Test-retest reliabilities have been consistently high for the RFT. A reliability of .96 for 46 kindergarten children after one month was found by Dreyer, et al., (1971). Witkin, Goodenough, and Karp (1967) computed reliability scores for 8-to-13 year olds and 10-to-24 year olds in an extensive longitudinal study. From 8-to-13 years old, the test-retest reliability scores for males was .76 (N=26, p < .01) and for females, .48 (N=21, p < .05). From 10-to-14 years old, the test-retest reliability scores for males was .71 (N=27, p < .01) and for females, .81 (N=24, p < .01).

4. PMA Verbal Meaning Test (V) - This group test is one of the five basic factors of intelligence contained in the Primary Mental Abilities Test (PMA), Revised 1962, prepared by Thelma Gwinn Thurstone. It is designed for grades K-12 and involves the ability to understand ideas expressed in words. It is a paper and pencil test. The Verbal Meaning Test is indicative of left hemisphere functioning based upon the well-documented association between the left hemisphere and verbal processes. (See Chapter II, Literature
Review.

a. Verbal Meaning Test, K-1 - This is a group vocabulary test in picture form designed for grades kindergarten and one. It contains 49 items with 4 alternatives per item and no specific time limit per item. Students are directed to mark the picture with a slash which corresponds to the word spoken by the administrator. Test-retest reliability for first graders after one week is .83 (N=30) and after four weeks is .77 (N=24), as reported in the PMA Technical Report.

b. Verbal Meaning Test, 4-6 - This is a group vocabulary test designed for grades four through six consisting of two parts. Part I, word synonyms, contains 30 items with four alternatives and a designated time limit of 7 minutes. Students are directed to choose the word that means the same as the word spoken by the tester. Part II, the pictures test, directs the student to choose the picture that stands for the spoken word. There are 30 items with 4 alternative choices and a time limit of 6 minutes. The maximum total score is 60. Test-retest reliability after one week is .91 (N=28) and after 4 weeks is .93 (N=27) for sixth grade children, as reported in the PMA Technical Report.

5. PMA Spatial Relations Test (S) - This paper and pencil group test is one of the five basic factors of intelligence within the Primary Mental Abilities Test (PMA),
Revised 1962, prepared by Thelma Gwinn Thurstone. It is
designed for grades K-12 and involves the ability to visu­
alize how parts of figures or objects fit together, what
their relationships are, and what they look like when ro­
tated in space. The Spatial Relations Test is indicative
of right hemispheric functioning based upon the well-
documented association between the right hemisphere and
spatial processes. (See Chapter II, Literature Review.)
In addition, McGlone and Davidson (1973) specifically em­
ployed the PMA Spatial Relations Test in their study as a
measure of right hemisphere processing.

a. Spatial Relations Test, K-1 - This is a group
test for kindergarten and grade one children and consists
of two parts. Part I contains 12 items and requires the
identification of the part needed to complete a figure,
from 4 alternative choices. Part II also contains 12
items and involves the actual completion by drawing of a
figure as per a model. There are no time limits for either
part and the maximum total score is 24. The PMA Technical
Report provides test-retest reliability for grade one
students' scores after one week as .69 (N=30) and after
four weeks as .72 (N=24).

b. Spatial Relations Test, 4-6 - This is a group
test for students in grades four through six. There are
25 items with four alternative choices per item. The test
involves the identification of the shape or form, which may
be rotated in space, and is needed to complete a given shape. Six minutes is the time allotted for this test. Test-retest reliability for sixth graders after one week is .68 (N=28) and after four weeks is .67 (N=27) according to the PMA Technical Report.
CHAPTER IV

DATA ANALYSIS AND RESULTS

Current research has shown that male individuals tend to be superior in spatial abilities, more field independent, and exhibit greater hemispheric lateralization. Similarly, all field independent subjects have been shown to display a greater degree of hemispheric lateralization. Conversely, females tend to be deficient in spatial abilities, more field dependent, and demonstrate less hemispheric lateralization and possibly bilateral representation of language processes. These research results have justified the need to investigate a neurological model of greater male hemispheric lateralization as an explanation of sex differences with regard to spatial abilities and field dependence-independence. This study has been designed to this need. In addition, it is theorized that the sex differences with regard to hemispheric lateralization are apparent by age ten.

Forty-eight students from two morning kindergarten classes (ages five-to-six) and forty-four students from two sixth grade classes (ages eleven-to-twelve) at an urban,
white, middle class public school in Columbus, Ohio, volunteered to participate in this study. A Handedness Instrument was administered to determine the 79 right-handed subjects which made up the final sample for this study. Only right-handed subjects were used in the study so as to avoid individuals with possible mixed or incomplete hemisphere lateralization. Table 1 reveals the number of subjects according to grade and sex who participated in this study.

<table>
<thead>
<tr>
<th>Grade</th>
<th>Male</th>
<th>Female</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kindergarten</td>
<td>16</td>
<td>25</td>
<td>41</td>
</tr>
<tr>
<td>Sixth</td>
<td>17</td>
<td>21</td>
<td>38</td>
</tr>
<tr>
<td>Total</td>
<td>33</td>
<td>46</td>
<td>79</td>
</tr>
</tbody>
</table>

In order to assess the degree of hemisphere lateralization, subjects were administered two left hemisphere tasks and the two right hemisphere tasks. Chapter III, Procedures, provides documentation for the selection of the WISC Digit Span Test and the PMA Verbal Meaning Test to test left hemisphere processing. Support for the use of the WISC Block Design Test and the PMA Spatial
Relations Test as indicative of right hemispheric functioning is also furnished. The Rod-and-Frame Test was administered as it is a traditional measure of a cognitive construct of field dependence-independence.

For purposes of hypotheses testing, the data was subjected to a variety of statistical procedures. A two factor multivariate analysis of variance (Clyde Manova) was utilized to determine main effects and interactions for the battery of five tests. This was followed by a series of one way analysis of variance (SPSS Anova) and Scheffé post hoc tests where significant effects were previously found. Performances on the five tests were also analyzed in terms of the SPSS Pearson Product Moment Correlation for four groups of subjects based upon grade and sex and eight groups of subjects based upon grade, sex and FDI scores. The criteria for significance was a priori determined to be at the .05 level.

A multivariate analysis of variance was used to determine the main effects of grade level and sex and the interaction effect of grade X sex for the mean performance on each of the five testing instruments for all 79 subjects. Table 2 (page 66) reveals a significant grade level effect (p < .01) for all five tests. For this analysis the appropriate degrees of freedom are 1,78 and their respective F ratios are as follows: WISC Digit Span, F=78.43; WISC Block Design, F=117.49; Rod-and-Frame,
F=16.98; PMA Verbal Meaning, F=75.68; PMA Spatial Relations, F=10.81. Table 2 also demonstrates a significant sex effect, but only for the WISC Block Design Test (F=5.52; df=1,78; p < .05). Finally, there were no significant grade X sex interaction effects for any of the testing instruments.

**TABLE 2**

Multivariate Analysis of Variance for Grade and Sex for the Performance of Five Tests by 79 Kindergarten and Sixth Grade Students

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>Mean Square</th>
<th>F Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Grade</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WISC Digit Span</td>
<td>1</td>
<td>147.32</td>
<td>78.43**</td>
</tr>
<tr>
<td>WISC Block Design</td>
<td>1</td>
<td>10630.17</td>
<td>117.49**</td>
</tr>
<tr>
<td>Rod-and-Frame</td>
<td>1</td>
<td>1216.59</td>
<td>16.98**</td>
</tr>
<tr>
<td>PMA Verbal Meaning</td>
<td>1</td>
<td>2161.88</td>
<td>75.68**</td>
</tr>
<tr>
<td>PMA Spatial Relations</td>
<td>1</td>
<td>151.53</td>
<td>10.81**</td>
</tr>
<tr>
<td><strong>Sex</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WISC Digit Span</td>
<td>1</td>
<td>5.18</td>
<td>2.76</td>
</tr>
<tr>
<td>WISC Block Design</td>
<td>1</td>
<td>499.85</td>
<td>5.52*</td>
</tr>
<tr>
<td>Rod-and-Frame</td>
<td>1</td>
<td>24.79</td>
<td>0.35</td>
</tr>
<tr>
<td>PMA Verbal Meaning</td>
<td>1</td>
<td>3.60</td>
<td>0.13</td>
</tr>
<tr>
<td>PMA Spatial Relations</td>
<td>1</td>
<td>3.54</td>
<td>0.25</td>
</tr>
<tr>
<td><strong>Grade X Sex</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WISC Digit Span</td>
<td>1</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>WISC Block Design</td>
<td>1</td>
<td>303.86</td>
<td>3.36</td>
</tr>
<tr>
<td>Rod-and-Frame</td>
<td>1</td>
<td>38.65</td>
<td>0.54</td>
</tr>
<tr>
<td>PMA Verbal Meaning</td>
<td>1</td>
<td>0.93</td>
<td>0.03</td>
</tr>
<tr>
<td>PMA Spatial Relations</td>
<td>1</td>
<td>5.37</td>
<td>0.38</td>
</tr>
</tbody>
</table>

* p < .05  
** p < .01
The data was then statistically analyzed by a univariate procedure, repeated one way analyses of variance for all significant grade level effects and the one significant sex effect revealed by the multivariate analysis of variance. Table 3 summarizes the results of the repeated one way analyses of variance for the grade level effect for all five tests. Table 3 confirms the Manova results.

### Table 3

Repeated One Way Analyses of Variance
For Grade Level Effect for Five Tests
By 41 Kindergarten and 38 Sixth Grade Students

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>SS</th>
<th>Mean Square</th>
<th>F Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Between Groups</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WISC Digit</td>
<td>1</td>
<td>144.62</td>
<td>144.62</td>
<td>76.24*</td>
</tr>
<tr>
<td>WISC Block</td>
<td>1</td>
<td>10935.29</td>
<td>10935.29</td>
<td>110.94*</td>
</tr>
<tr>
<td>Rod-and-Frame</td>
<td>1</td>
<td>1200.59</td>
<td>1200.59</td>
<td>17.01*</td>
</tr>
<tr>
<td>PMA Verbal</td>
<td>1</td>
<td>2158.88</td>
<td>2158.88</td>
<td>77.43*</td>
</tr>
<tr>
<td>PMA Spatial</td>
<td>1</td>
<td>149.39</td>
<td>149.39</td>
<td>10.85*</td>
</tr>
<tr>
<td><strong>Within Groups</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WISC Digit</td>
<td>77</td>
<td>146.06</td>
<td>1.90</td>
<td></td>
</tr>
<tr>
<td>WISC Block</td>
<td>77</td>
<td>7589.73</td>
<td>98.57</td>
<td></td>
</tr>
<tr>
<td>Rod-and-Frame</td>
<td>77</td>
<td>5435.96</td>
<td>70.60</td>
<td></td>
</tr>
<tr>
<td>PMA Verbal</td>
<td>77</td>
<td>2146.99</td>
<td>27.88</td>
<td></td>
</tr>
<tr>
<td>PMA Spatial</td>
<td>77</td>
<td>1060.33</td>
<td>13.77</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>78</td>
<td>290.68</td>
<td></td>
<td></td>
</tr>
<tr>
<td>WISC Digit</td>
<td>78</td>
<td>18525.02</td>
<td></td>
<td></td>
</tr>
<tr>
<td>WISC Block</td>
<td>78</td>
<td>6636.55</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rod-and-Frame</td>
<td>78</td>
<td>4305.87</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PMA Verbal</td>
<td>78</td>
<td>1209.72</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PMA Spatial</td>
<td>78</td>
<td>1209.72</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*p < .01
A significant grade level effect is found for the WISC Digit Span Test ($F=76.24$), the WISC Block Design Test ($F=110.94$), the Rod-and-Frame Test ($F=17.01$), the PMA Verbal Meaning Test ($F=77.43$), and the PMA Spatial Relations Test ($F=10.85$). The appropriate degrees of freedom are 1,78 and the level of significance is at .01 for all five tests. The one way Anova, however, fails to replicate the significant sex effect for the WISC Block Design Test indicated by the Manova analysis. Table 4 does not indicate a significant sex effect for the WISC Block Design Test ($F=3.50; df=1,78; p < .10$). Based upon all of the results of the repeated one way Anova methodology, only the significant grade level effect for all five tests can be reliably maintained.

**TABLE 4**

One Way Analysis of Variance for Sex for the WISC Block Design Test for 33 Male and 46 Female Subjects

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>SS</th>
<th>Mean Square</th>
<th>F Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between Groups</td>
<td>1</td>
<td>804.95</td>
<td>804.95</td>
<td>3.50*</td>
</tr>
<tr>
<td>Within Groups</td>
<td>77</td>
<td>17720.04</td>
<td>230.13</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>78</td>
<td>18524.99</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*p < .10
In summary, the results of the Manova and repeated one way Anova procedures indicated a significant grade level effect for all five tests. A significant sex effect for the WISC Block Design Test was found for Manova, but not for the one way Anova procedure. These significant effects will now be discussed in terms of the direction of these significant differences. To this end, Table 5 displays the means and standard deviations for the five tests computed for the two grade levels and the two sexes. Inspection of this table indicates that the mean

<table>
<thead>
<tr>
<th>Tests</th>
<th>Kindergarten (N=41)</th>
<th>Sixth Grade (N=38)</th>
<th>Males (N=33)</th>
<th>Females (N=46)</th>
</tr>
</thead>
<tbody>
<tr>
<td>WISC Digit Mean</td>
<td>7.63</td>
<td>10.34</td>
<td>8.73</td>
<td>9.09</td>
</tr>
<tr>
<td></td>
<td>1.20</td>
<td>1.55</td>
<td>2.00</td>
<td>1.88</td>
</tr>
<tr>
<td>WISC Block Mean</td>
<td>8.27</td>
<td>31.82</td>
<td>23.36</td>
<td>16.89</td>
</tr>
<tr>
<td></td>
<td>6.42</td>
<td>12.67</td>
<td>17.41</td>
<td>13.35</td>
</tr>
<tr>
<td>Rod-and-Frame Mean</td>
<td>15.25</td>
<td>7.45</td>
<td>11.89</td>
<td>11.22</td>
</tr>
<tr>
<td></td>
<td>9.00</td>
<td>7.70</td>
<td>9.99</td>
<td>8.74</td>
</tr>
<tr>
<td>PMA Verbal Mean</td>
<td>41.20</td>
<td>51.66</td>
<td>46.33</td>
<td>46.15</td>
</tr>
<tr>
<td></td>
<td>4.37</td>
<td>6.12</td>
<td>7.42</td>
<td>7.52</td>
</tr>
<tr>
<td>PMA Spatial Mean</td>
<td>19.80</td>
<td>17.05</td>
<td>18.64</td>
<td>18.37</td>
</tr>
<tr>
<td></td>
<td>3.23</td>
<td>4.17</td>
<td>4.34</td>
<td>3.67</td>
</tr>
</tbody>
</table>
performances of the kindergarten students as compared to the sixth grade students on the WISC Digit Span, WISC Block Design, and the PMA Verbal Meaning Tests were as expected. The sixth grade students ($\bar{X} = 10.34$, $\bar{X} = 31.82$, $\bar{X} = 51.66$) performed superior to the kindergarten students ($\bar{X} = 7.63$, $\bar{X} = 8.27$, $\bar{X} = 41.20$). The mean performances on the Rod-and-Frame Test were also as expected as a low mean indicates relative field independence. Sixth grade students ($\bar{X} = 7.45$) proved to be more field independent than kindergarten students ($\bar{X} = 15.25$). An unexpected finding was that the kindergarten students ($\bar{X} = 19.80$) did better than the sixth grade students ($\bar{X} = 17.05$) on the PMA Spatial Relations Test. Finally, with regard to the one inconclusive sex difference on the WISC Block Design Test, male subjects ($\bar{X} = 23.36$) were superior to the female subjects ($\bar{X} = 16.89$).

In order to directly test some of the hypotheses appearing in Chapter I, the subjects were divided into four groups: Male, Kindergarten ($N = 16$); Female, Kindergarten ($N = 25$); Male, Sixth Grade ($N = 17$); Female, Sixth Grade ($N = 21$). Their performance on each of the five tests was then analyzed by means of repeated one way analysis of variance in order to ascertain significant group differences. A post hoc Scheffé procedure was utilized to determine which groups were significantly different.
Table 6 is a summary table of the results from the repeated one way analyses of variance for the performance of the five tests by the four groups of subjects. The results indicate a significant difference between the performances of the four groups for all five tests.

### TABLE 6
Repeated One Way Analyses of Variance for Four Groups Determined by Grade and Sex for the Performance of Five Tests

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>SS</th>
<th>Mean Square</th>
<th>F Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Between Groups</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WISC Digit</td>
<td>3</td>
<td>149.80</td>
<td>49.93</td>
<td>26.58**</td>
</tr>
<tr>
<td>WISC Block</td>
<td>3</td>
<td>11738.99</td>
<td>3913.00</td>
<td>43.25**</td>
</tr>
<tr>
<td>Rod-and-Frame</td>
<td>3</td>
<td>1264.04</td>
<td>421.35</td>
<td>5.88**</td>
</tr>
<tr>
<td>PMA Verbal</td>
<td>3</td>
<td>2163.44</td>
<td>721.15</td>
<td>25.25**</td>
</tr>
<tr>
<td>PMA Spatial</td>
<td>3</td>
<td>158.30</td>
<td>52.77</td>
<td>3.76*</td>
</tr>
<tr>
<td><strong>Within Groups</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WISC Digit</td>
<td>75</td>
<td>140.88</td>
<td>1.88</td>
<td></td>
</tr>
<tr>
<td>WISC Block</td>
<td>75</td>
<td>6786.04</td>
<td>90.48</td>
<td></td>
</tr>
<tr>
<td>Rod-and-Frame</td>
<td>75</td>
<td>5372.52</td>
<td>71.63</td>
<td></td>
</tr>
<tr>
<td>PMA Verbal</td>
<td>75</td>
<td>2142.46</td>
<td>28.57</td>
<td></td>
</tr>
<tr>
<td>PMA Spatial</td>
<td>75</td>
<td>1051.43</td>
<td>14.02</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>78</td>
<td>290.68</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* = p < .05  
** = p < .01

The statistical information for each test is as follows:  
WISC Digit Span (F=26.58; df=3.78; p < .01), WISC Block Design Test (F=43.25; df=3.78; p < .01), Rod-and Frame
Test (F=5.88; df=3,78; p < .01), PMA Verbal Meaning Test (F=25.25; df=3,78; p < .01), and the PMA Spatial Relations Test (F=3.76; df=3,78; p < .05). The significant difference between the groups is very much as expected as both Manova and one way Anova procedures have previously confirmed a significant main effect of grade level.

Table 7 reports the means and standard deviations for each of the four groups with respect to the five assessment measures. This data is analyzed and discussed with regard to the post hoc Scheffé test results which follow on page 73.

TABLE 7
Means and Standard Deviations for the Performance of Five Tests by 79 Subjects in Four Groups Determined by Grade and Sex

<table>
<thead>
<tr>
<th>Tests</th>
<th>Kindergarten Males (N=16)</th>
<th>Kindergarten Females (N=25)</th>
<th>Sixth Grade Males (N=17)</th>
<th>Sixth Grade Females (N=21)</th>
</tr>
</thead>
<tbody>
<tr>
<td>WISC Digit</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>7.31</td>
<td>7.84</td>
<td>10.06</td>
<td>10.57</td>
</tr>
<tr>
<td>SD</td>
<td>1.08</td>
<td>1.25</td>
<td>1.75</td>
<td>1.36</td>
</tr>
<tr>
<td>WISC Block</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>9.00</td>
<td>7.80</td>
<td>36.88</td>
<td>27.71</td>
</tr>
<tr>
<td>SD</td>
<td>6.40</td>
<td>6.53</td>
<td>12.94</td>
<td>11.12</td>
</tr>
<tr>
<td>Rod-and-Frame</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>16.80</td>
<td>14.27</td>
<td>7.28</td>
<td>7.59</td>
</tr>
<tr>
<td>SD</td>
<td>8.72</td>
<td>9.21</td>
<td>9.03</td>
<td>6.68</td>
</tr>
<tr>
<td>PMA Verbal</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>41.06</td>
<td>41.28</td>
<td>51.29</td>
<td>51.95</td>
</tr>
<tr>
<td>SD</td>
<td>3.92</td>
<td>4.70</td>
<td>6.47</td>
<td>5.96</td>
</tr>
<tr>
<td>PMA Spatial</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>19.75</td>
<td>19.84</td>
<td>17.59</td>
<td>16.62</td>
</tr>
<tr>
<td>SD</td>
<td>3.79</td>
<td>2.50</td>
<td>4.66</td>
<td>1.79</td>
</tr>
</tbody>
</table>
Table 8 reports the results of the Scheffé test for group differences with respect to the WISC Digit Span Test. Inspection of this table indicates that there is no significant difference between the mean performance of the kindergarten males (\( \bar{X}=7.31 \)) and the kindergarten females (\( \bar{X}=7.84 \)) nor between the sixth grade males (\( \bar{X}=10.06 \)) and the sixth grade females (\( \bar{X}=10.57 \)). Although the means very slightly favor the female subjects at each grade level, the only significant group differences are based upon a grade level effect which confirms previous analyses.

**TABLE 8**

Scheffé Test for Group Differences (p < .05) for the WISC Digit Span Test

<table>
<thead>
<tr>
<th>Subset 1</th>
<th>Kindergarten, Male</th>
<th>Kindergarten, Female</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group</td>
<td>Mean</td>
<td></td>
</tr>
<tr>
<td>Kindergarten</td>
<td>7.31</td>
<td>7.84</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Subset 2</th>
<th>Sixth Grade, Male</th>
<th>Sixth Grade, Female</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group</td>
<td>Mean</td>
<td></td>
</tr>
<tr>
<td>Sixth Grade</td>
<td>10.06</td>
<td>10.57</td>
</tr>
</tbody>
</table>

Table 9, appearing on page 74, reveals an interesting pattern for groups differences as the result of the Scheffé test on data from the WISC Block Design Test. Corroborating previous Manova and Anova results, there is a significant grade level difference for both sexes which favors sixth grade students. Of great relevance is the significant
difference between the sixth grade males ($\bar{X}=36.88$) and the sixth grade females ($\bar{X}=27.71$). This sex difference does not appear for the kindergarten males ($\bar{X}=9.00$) in comparison to the kindergarten females ($\bar{X}=7.80$), although the means do still favor male performance. These results also provide an explanation for the inconsistency with regard to the Manova and Anova results and sex differences. Sex differences on the WISC Block Design Test appear only at the sixth grade level and consequently over-all sex differences may be difficult to detect.

**TABLE 9**

Scheffé Test for Group Differences ($p < .05$) for the WISC Block Design Test

<table>
<thead>
<tr>
<th>Subset 1</th>
<th>Group</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Kindergarten, Female</td>
<td>Kindergarten, Male</td>
</tr>
<tr>
<td></td>
<td>7.80</td>
<td>9.00</td>
</tr>
<tr>
<td>Subset 2</td>
<td>Group</td>
<td>Mean</td>
</tr>
<tr>
<td></td>
<td>Sixth Grade, Female</td>
<td>27.71</td>
</tr>
<tr>
<td>Subset 3</td>
<td>Group</td>
<td>Mean</td>
</tr>
<tr>
<td></td>
<td>Sixth Grade, Male</td>
<td>36.88</td>
</tr>
</tbody>
</table>

It will be recalled that Manova failed to detect a significant sex effect and a significant grade $\times$ sex effect for the Rod-and-Frame Test. However, the one way Anova for the RFT as performed by the subjects divided
into four groups defined by grade and sex did reveal a significant difference between the groups. The results of the follow-up Scheffé procedure are therefore more revealing and of great interest. Table 10 shows the results of the Scheffe test for the Rod-and-Frame Test. Inspection of the table indicates a significant group difference between sixth grade males ($\bar{X}=7.28$) and kindergarten males ($\bar{X}=16.80$) and between sixth grade females ($\bar{X}=7.59$) and kindergarten males ($\bar{X}=16.80$). A grade level effect is apparent but only when comparing sixth grade students to kindergarten males. The sixth grade students, both male and female, are significantly more field independent than only the kindergarten males.

**TABLE 10**

*Scheffé Test for Group Differences (p < .05)*

for the Rod-and-Frame Test

<table>
<thead>
<tr>
<th>Subset 1</th>
<th>Group</th>
<th>6th, Male</th>
<th>6th, Female</th>
<th>Kindergarten, Female</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td></td>
<td>7.28</td>
<td>7.59</td>
<td>14.27</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Subset 2</th>
<th>Group</th>
<th>Kindergarten, Female</th>
<th>Kindergarten, Male</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td></td>
<td>14.27</td>
<td>16.80</td>
</tr>
</tbody>
</table>

The results of the Scheffé test for the PMA Verbal Meaning Test are similar to those found for the WISC Digit
Span Test. Inspection of Table 11, the Scheffé Test for the PMA Verbal Meaning Test, demonstrates a significant grade level difference between the groups which confirms previous analyses. Like the results for the WISC Digit Span Test, the mean performances indicate a very minute advantage for the females at each grade level that is not at all statistically significant. The only significant difference between groups appears for sixth graders (male $\bar{x}=51.29$; female $\bar{x}=51.95$) as compared to kindergarten subjects (male $\bar{x}=41.06$; female $\bar{x}=41.28$) who performed at an inferior level.

**TABLE 11**

Scheffé Test for Group Differences (p < .05) for the PMA Verbal Meaning Test

<table>
<thead>
<tr>
<th>Subset 1</th>
<th>Group</th>
<th>Mean</th>
<th>Subset 2</th>
<th>Group</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Kindergarten, Male</td>
<td>41.06</td>
<td></td>
<td>Sixth Grade, Male</td>
<td>51.29</td>
</tr>
<tr>
<td></td>
<td>Kindergarten, Female</td>
<td>41.28</td>
<td></td>
<td>Sixth Grade, Female</td>
<td>51.95</td>
</tr>
</tbody>
</table>

Table 12 on page 77 shows the results of the final Scheffé Test for the PMA Spatial Relations Test. Unlike any of the previous results, the only significant group difference is found between the sixth grade females ($\bar{x}=16.62$) and the kindergarten females ($\bar{x}=19.84$) and this
difference surprisingly favors the kindergarten females. Manova and Anova procedures had previously revealed this unexpected kindergarten superiority for the PMA Spatial Relations Test. The Scheffé results now limits the grade level difference to only female subjects.

**TABLE 12**

Scheffé Test for Group Differences (p < .05)
for the PMA Spatial Relations Test

<table>
<thead>
<tr>
<th>Subset 1</th>
<th>Group</th>
<th>6th, Female</th>
<th>6th, Male</th>
<th>Kindergarten, Male</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>16.62</td>
<td>17.59</td>
<td>19.75</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Subset 2</th>
<th>Group</th>
<th>6th, Male</th>
<th>Kindergarten, Male</th>
<th>Kindergarten, Female</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>17.59</td>
<td>19.75</td>
<td>19.84</td>
</tr>
</tbody>
</table>

In summary, the repeated one way analyses of variance for the four groups defined by grade and sex clearly indicate significant group differences with regard to their performance on the five instruments. Of more import are the results of the follow-up Scheffé tests which locate which groups differ significantly from one another. For the WISC Digit Span Test and the PMA Verbal Meaning Test, group differences only appear between grade levels. For both these instruments all sixth grade subjects perform at a significantly superior level. This significant grade
difference also appears with regard to the WISC Block Design Test. In addition, for only this test does there appear a clear sex difference at the sixth grade level. Sixth grade males did significantly better than sixth grade females on the WISC Block Design Test. The results of the Scheffé test on the Rod-and-Frame Test data indicate a grade level difference but only for the kindergarten male students who were more field dependent than the sixth grade male and female subjects. Conversely, the data for the PMA Spatial Relations Test when subjected to the Scheffé analysis demonstrate a grade level difference but only for the kindergarten female students. In this case, the kindergarten female students did significantly better than the sixth grade female students. These interesting results provided by the post hoc Scheffé test led this author to employ these same four groups in the next data analysis.

The performance on each of the five testing instruments for the four grade level, sex groups was subjected to the Pearson Product Moment Correlation procedure. The results of this analysis for the kindergarten male subjects (N=16) appears on Table 13, page 79. For these students there is a significant positive correlation between their performance on the WISC Block Design Test and the PMA Spatial Relations Test (R=.57; p <.05). Their achievement on the WISC Digit Span Test as positively related to that of
the PMA Verbal Meaning Test very nearly achieves significance (R=.42; p=.052).

**TABLE 13**

Pearson Correlation Coefficients for Five Tests for 16 Kindergarten, Male Subjects

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. WISC Digit Span</td>
<td>.32</td>
<td>.13</td>
<td>.42*</td>
<td>.10</td>
<td></td>
</tr>
<tr>
<td>2. WISC Block Design</td>
<td>-.03</td>
<td>.19</td>
<td>.57**</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Rod-and-Frame</td>
<td>-.16</td>
<td>-.32</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. PMA Verbal Meaning</td>
<td></td>
<td></td>
<td>.36</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. PMA Spatial Relations</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*p = .052

**p < .05

Inspection of Table 14 found on page 80 reveals a multitude of significant Pearson Correlation Coefficients for the kindergarten female subjects (N=25). There appears a significant negative correlation between the Rod-and-Frame Test and three other instruments: the WISC Block Design Test (R=-.43; p < .05), the PMA Verbal Meaning Test (R=-.46; p < .01), and the PMA Spatial Relations Test (R=-.58; p < .01). In other words, a low score on the Rod-and-Frame Test which is associated with field independence is related to a high score for the other three instruments.
In addition, the WISC Block Design Test is positively correlated with both the PMA Verbal Meaning Test \( (R=0.42; \ p < 0.05) \) and the PMA Spatial Relations Test \( (R=0.58; \ p < 0.01) \). As one would suspect, the PMA Verbal Meaning Test and the PMA Spatial Relations Test are positively correlated for these subjects \( (R=0.66; \ p < 0.01) \).

**TABLE 14**

Pearson Correlation Coefficients for Five Tests for 25 Kindergarten, Female Subjects

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. WISC Digit Span</td>
<td>.27</td>
<td>-.21</td>
<td>.04</td>
<td>.10</td>
<td></td>
</tr>
<tr>
<td>2. WISC Block Design</td>
<td>-.43*</td>
<td>.42*</td>
<td>.58**</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Rod-and-Frame</td>
<td>-.46**</td>
<td>-.58**</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. PMA Verbal Meaning</td>
<td></td>
<td>.66**</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. PMA Spatial Relations</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*  \( p < 0.05 \)
**  \( p < 0.01 \)

Interestingly, the pattern of relationships for the sixth grade male students \( (N=17) \) as shown on Table 15, appearing on page 81, is exactly the same as that previously found with the kindergarten female subjects. Inspection of Table 15 indicates a significant negative correlation between the Rod-and-Frame Test and the WISC Block Design Test \( (R=-0.83; \ p < 0.01) \), the PMA Verbal Meaning Test \( (R=-0.75; \ p < 0.01) \), and the PMA Spatial Relations Test \( (R=-0.65; \ p < 0.01) \).
Field independence or a low score on the Rod-and-Frame Test is related to a high performance on the other three measures. The WISC Block Design Test is positively correlated with both the PMA Verbal Meaning Test ($R=.66; p < .01$) and the PMA Spatial Relations Test ($R=.74; p < .01$). Lastly, the PMA Verbal Meaning Test and the PMA Spatial Relations Test are positively correlated ($R=.67; p < .01$).

**TABLE 15**

| Pearson Correlation Coefficients for Five Tests for 17 Sixth Grade, Male Subjects |
|-----------------------------------------------|--------|--------|--------|
| WISC Digit Span                              | .22    | -.36   | .05    |
| WISC Block Design                             | -.83*  | .66*   | .74*   |
| Rod-and-Frame                                 | -.75*  | -.65*  |
| PMA Verbal Meaning                            |        |        | .67*   |
| PMA Spatial Relations                         |        |        |        |

*p < .01

Table 16 found on page 82 demonstrates the Pearson Correlation Coefficients for the last of the four groups, the sixth grade female subjects ($N=21$). Similar to the results found for the previous two groups of subjects, there exists a positive correlation between the PMA Verbal Meaning Test and the PMA Spatial Relations Test ($R=.45; p < .05$). A positive relationship is also found
between the WISC Digit Span Test and the PMA Verbal Meaning Test ($R = .39; p < .05$). This latter relationship is similar to that found for the kindergarten male subjects, but it is only significant at the a priori criterion level for the sixth grade female subjects.

**TABLE 16**

Pearson Correlation Coefficients for Five Tests for 21 Sixth Grade, Female Subjects

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. WISC Digit Span</td>
<td>.03</td>
<td>.04</td>
<td>.39*</td>
<td>.16</td>
<td></td>
</tr>
<tr>
<td>2. WISC Block Design</td>
<td>-.32</td>
<td>.13</td>
<td>.23</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Rod-and-Frame</td>
<td></td>
<td>-.11</td>
<td>-.04</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. PMA Verbal Meaning</td>
<td></td>
<td></td>
<td>.45*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. PMA Spatial Relations</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*p < .05

Although the hypotheses of this study are not based upon correlations among the five tests for subjects a priori defined as field independent or field dependent, data analysis based upon this classification seems sufficiently interesting and relevant to warrant their inclusion. As such, the original 79 subjects were reclassified into eight groups determined by the grade level, sex, and FDI scores. The procedure used to determine the
groups was to list the Rod-and-Frame Test scores for each of the subjects using the four previous categories based upon grade and sex. Then the lower one-third of the scores was selected as representative of field independence and the upper one-third of the scores as field dependence. Table 17 depicts the eight groups and the number of subjects within each group.

**TABLE 17**

Number of Subjects According to Grade, Sex, and FDI

<table>
<thead>
<tr>
<th>Grade</th>
<th>Field Independent</th>
<th>Field Dependent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kindergarten</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Males</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Females</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>Sixth Grade</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>Males</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>Females</td>
<td>7</td>
<td>7</td>
</tr>
</tbody>
</table>

The performance of these eight groups (52 subjects) was then analyzed by means of the Pearson Product Moment Correlation Coefficient for the WISC Digit Span, the WISC Block Design, the PMA Verbal Meaning, and the PMA Spatial Relations Tests.

Table 18, found on page 84, reveals only one significant correlation for the kindergarten, male, field independent subjects. There exists a positive correlation
between the WISC Block Design Test and the PMA Spatial Relations Test (R=.96; p < .01) for these subjects.

**TABLE 18**

Pearson Correlation Coefficients for Four Tests for 5 Kindergarten, Male, PI Subjects

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. WISC Digit Span</td>
<td>.75</td>
<td>.77</td>
<td>.59</td>
<td></td>
</tr>
<tr>
<td>2. WISC Block Design</td>
<td>.63</td>
<td>.96*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. PMA Verbal Meaning</td>
<td></td>
<td>.38</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. PMA Spatial Relations</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*p < .01

Table 19 on page 85 shows the correlations for the second group of subjects. For the kindergarten, female, field independent subjects this same positive correlation between the WISC Block Design Test and the PMA Spatial Relations Test is found (R=.78; p < .05). In addition, Table 19 shows two other significant correlations. There is a positive correlation between the WISC Digit Span Test and the WISC Block Design Test (R=.75; p < .05) and between the PMA Verbal Meaning Test and the PMA Spatial Relations Test (R=.79; p < .01).
TABLE 19

Pearson Correlation Coefficients for Four Tests for 8 Kindergarten, Female, FI Subjects

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. WISC Digit Span</td>
<td>.75*</td>
<td>.01</td>
<td>.46</td>
<td></td>
</tr>
<tr>
<td>2. WISC Block Design</td>
<td>.58</td>
<td>.78*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. PMA Verbal Meaning</td>
<td></td>
<td></td>
<td>.79**</td>
<td></td>
</tr>
<tr>
<td>4. PMA Spatial Relations</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*p < .05
**p < .01

Tables 20 and 21, appearing on page 86, show the correlations for the kindergarten, field dependent subjects, both male and female. For both of these kindergarten, FD groups there was found to be a significant positive correlation between the PMA Verbal Meaning Test and the PMA Spatial Relations Test. For the male subjects, this correlation is .81 (p < .05) and for the female subjects, the correlation is .70 (p < .05).
### TABLE 20

Pearson Correlation Coefficients for Four Tests for 5 Kindergarten, Male, FD Subjects

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. WISC Digit Span</td>
<td>.65</td>
<td>.31</td>
<td>.27</td>
<td></td>
</tr>
<tr>
<td>2. WISC Block Design</td>
<td>.43</td>
<td>.66</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. PMA Verbal Meaning</td>
<td>.81*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. PMA Spatial Relations</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*p < .05

### TABLE 21

Pearson Correlation Coefficients for Four Tests for 8 Kindergarten, Female, FD Subjects

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. WISC Digit Span</td>
<td>-.47</td>
<td>-.25</td>
<td>-.48</td>
<td></td>
</tr>
<tr>
<td>2. WISC Block Design</td>
<td>-.18</td>
<td>.47</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. PMA Verbal Meaning</td>
<td>.70*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. PMA Spatial Relations</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*p < .05
The one significant negative correlation appears on Table 22 for the sixth grade, male, field independent students. There exists a negative correlation of \(-.84\) (\(p < .05\)) between the WISC Digit Span Test and the PMA Spatial Relations Test.

### TABLE 22

**Pearson Correlation Coefficients for Four Tests**  
for 6 Sixth Grade, Male, FI Subjects

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. WISC Digit Span</td>
<td>-.05</td>
<td>-.66</td>
<td>-.84*</td>
<td></td>
</tr>
<tr>
<td>2. WISC Block Design</td>
<td></td>
<td>-.11</td>
<td>-.12</td>
<td></td>
</tr>
<tr>
<td>3. PMA Verbal Meaning</td>
<td></td>
<td></td>
<td>.62</td>
<td></td>
</tr>
<tr>
<td>4. PMA Spatial Relations</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*\(p < .05\)

Tables 23 and 24, found on page 88, show the results for sixth grade students who are female and field independent and those that are male and field dependent. For both groups there is a significant positive correlation between the PMA Verbal Meaning Test and the PMA Spatial Relations Test. For the former group, the correlation is \(.84\) (\(p < .01\)) and for the latter, the correlation is \(.83\) (\(p < .05\)).
### TABLE 23

**Pearson Correlation Coefficients for Four Tests for 7 Sixth Grade, Female, PI Subjects**

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. WISC Digit Span</td>
<td>.57</td>
<td>-.07</td>
<td>-.13</td>
<td></td>
</tr>
<tr>
<td>2. WISC Block Design</td>
<td>-.11</td>
<td>-.21</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. PMA Verbal Meaning</td>
<td></td>
<td></td>
<td>.84*</td>
<td></td>
</tr>
<tr>
<td>4. PMA Spatial Relations</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*p < .01

### TABLE 24

**Pearson Correlation Coefficients for Four Tests for 6 Sixth Grade, Male, FD Subjects**

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. WISC Digit Span</td>
<td>-.56</td>
<td>-.28</td>
<td>-.25</td>
<td></td>
</tr>
<tr>
<td>2. WISC Block Design</td>
<td></td>
<td>.46</td>
<td>.70</td>
<td></td>
</tr>
<tr>
<td>3. PMA Verbal Meaning</td>
<td></td>
<td></td>
<td>.83*</td>
<td></td>
</tr>
<tr>
<td>4. PMA Spatial Relations</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*p < .05
The final correlation table, Table 25, for sixth grade, female, field dependent subjects fails to yield any significant associations. However, inspection of Table 25 does show a correlation between the WISC Block Design Test and the PMA Verbal Meaning Test that very nearly achieves significance (R=.66; p=.055).

| TABLE 25 |
| Pearson Correlation Coefficients for Four Tests for 7 Sixth Grade, Female, FD Subjects |

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. WISC Digit Span</td>
<td>.18</td>
<td>.51</td>
<td>-.03</td>
<td></td>
</tr>
<tr>
<td>2. WISC Block Design</td>
<td></td>
<td>.66*</td>
<td>.24</td>
<td></td>
</tr>
<tr>
<td>3. PMA Verbal Meaning</td>
<td></td>
<td></td>
<td>.28</td>
<td></td>
</tr>
<tr>
<td>4. PMA Spatial Relations</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*p = .055

In conclusion, the results of the correlation analyses for the eight groups of subjects suggest an interesting and substantive pattern. For all male, field independent subjects, one finds a positive relationship between two spatial tests or a negative relationship between a verbal and a spatial test. For all female, field independent subjects there is a consistent positive relationship between a verbal and a spatial test. For all
field dependent subjects regardless of grade or sex, there also exists a positive relationship between a verbal and a spatial test.
CHAPTER V

DISCUSSION AND IMPLICATIONS

Modern literature suggests a similar pattern of sex differences with regard to field dependence-independence and visuo-spatial abilities. Males tend to be relatively more field independent and superior in visuo-spatial abilities. It seems reasonable to suggest that studies dealing with brain hemispheric lateralization and both FDI and spatial abilities can offer an explanation for these sex differences. Studies have shown that FDI and visuo-spatial tasks seem to be attended to by the right hemisphere of the brain. However, sex differences do appear indicating that this right hemisphere lateralization is more consistent and reliable for male subjects. In addition, studies have shown that field independent subjects also exhibit both greater right hemisphere and left hemisphere lateralization. As such, the degree of hemispheric lateralization seems to be the key factor with regard to the male advantage in FDI and visuo-spatial tasks. Similarly, females who are relatively more field dependent and inferior in visuo-spatial tasks possibly reflect less hemispheric lateralization.
This study was designed to investigate the relationship between the neurological theory of greater male hemispheric lateralization and age and sex differences in field dependence-independence and visuo-spatial measures.

Procedures used in this study were designed to directly test the hypotheses with regard to age and sex differences for measures of hemispheric lateralization and field dependence-independence. Male and female subjects volunteered from two intact kindergarten classrooms (ages five-to-six) and from two intact sixth grade classrooms (ages eleven-to-twelve) located in an urban, white, middle class public school in Columbus, Ohio. The final sample of 79 subjects was selected on the basis of a Handedness Instrument. Only right-handed subjects were chosen so as to avoid subjects exhibiting mixed or incomplete laterality. Hemispheric lateralization was assessed by means of two left hemisphere tasks, the WISC Digit Span and the PMA Verbal Meaning Tests, and two right hemisphere tasks, the WISC Block Design and the PMA Spatial Relations Tests. Field dependence-independence was measured by the portable Rod-and-Frame Test. Scores on these five tests were statistically analyzed by means of various analysis of variance procedures. Age and sex main effects and age X sex interaction effects were determined by a multivariate analysis of variance and one way analyses of variance. Post hoc Scheffé tests were used to locate group
differences. The Pearson Product Moment Correlation was also used to determine the relationship among the five tests for four groups of subjects defined by age and sex. The results of these initial statistical procedures suggested the need for additional data analyses. Consequently, the scores on the two left hemisphere tests and the two right hemisphere tests were further analyzed in terms of the Pearson Product Moment Correlation for eight groups of subjects defined by age, sex, and field dependence-independence.

**Discussion of Results**

Hypothesis 1: Sixth grade children will perform significantly superior to kindergarten children on the WISC Digit Span, WISC Block Design, PMA Verbal Meaning, and PMA Spatial Relations Tests.

A significant main effect of age for the two left hemisphere tasks, the WISC Digit Span and the PMA Verbal Meaning Tests, and the two right hemisphere tasks, the WISC Block Design and the PMA Spatial Relations Tests, was confirmed by both the multivariate analysis of variance (Manova) and the one way analyses of variance (Anova). Inspection of the means for each test and the results of the post hoc Scheffé test reveals that this difference significantly favors sixth grade students for the two left hemisphere tasks and only one of the right hemisphere tasks,
the WISC Block Design. This is consistent with the literature and confirms part of hypothesis 1. However, for the PMA Spatial Relations Test kindergarten subjects unexpectedly performed better than sixth grade students. The fact that kindergarten students were superior on this test can perhaps be explained by the fact that the sixth grade students took both the PMA Verbal Meaning and the PMA Spatial Relations Tests in one testing session in that order. There is some evidence in the literature (Paivio & Ernest, 1971) that spatial ability tasks can be negatively affected if preceded by verbal ability tasks as was the case. In addition, the kindergarten version of the PMA Spatial Relations Test involves not only visuo-spatial ability but also constructional spatial ability and this could have unexplainably affected the results. In conclusion, hypothesis 1 is partially confirmed.

Hypothesis 2: Sixth grade children will be significantly more field independent than kindergarten children as measured by the Rod-and-Frame Test.

The results of the Manova and the one way Anova for the main effect of age for the Rod-and-Frame Test were significant. As expected, the means on the RFT for the sixth grade students were significantly lower, indicating field independence, than those of the kindergarten subjects. This confirms hypothesis 2 and is consistent with FDI literature which indicates increasing field independence.
Hypothesis 3: There will be no significant sex differences for all subjects on the WISC Digit Span, WISC Block Design, PMA Verbal Meaning, PMA Spatial Relations, and Rod-and-Frame-Tests.

As hypothesized there were no significant sex differences for the WISC Digit Span, PMA Verbal Meaning, PMA Spatial Relations, and the Rod-and-Frame Tests as revealed by the Manova. This confirmation of part of hypothesis 3 was expected as it was anticipated that possible sixth grade sex differences would be masked and balanced by the lack of kindergarten sex differences as suggested by the literature. This was the case for all the tests except for the WISC Block Design Test. A significant sex effect favoring male subjects for the WISC Block Design Test was revealed by Manova. However, the one way Anova for this same instrument demonstrated this same sex difference but not at the criterion level of significance. Earlier, as well as greater male right hemispheric lateralization for constructive spatial ability tasks is perhaps indicated by these results (corroborating Witelson, 1975, 1976).

Hypothesis 4: There will be no significant sex differences for kindergarten children on the following measures:

Left Hemisphere Tasks
a. WISC Digit Span
b. PMA Verbal Meaning
Right Hemisphere Tasks

c. WISC Block Design
d. PMA Spatial Relations

FDI Task
e. Rod-and-Frame

Hypotheses 4a through 4e postulating no sex differences for kindergarten children on the two left hemisphere and two right hemisphere tests, and the FDI task were confirmed. The post hoc Scheffé test demonstrated that for these five instruments, the kindergarten male means and the kindergarten female means did not differ significantly. These results are consistent with the numerous studies which failed to find a sex difference in spatial ability and FDI with children under ten years of age (e.g. Bigelow, 1971; Cecchini & Pizzamiglio, 1975; Goodenough & Eagle, 1963; Harris, 1978; Witkin, et al., 1967). This is also indirect evidence for this author's contention that there are no sex differences with regard to brain hemispheric lateralization for young children approximately six-to-ten years old.

Hypothesis 5: Sixth grade female subjects will perform significantly better than sixth grade male subjects on the WISC Digit Span and PMA Verbal Meaning Tests (left hemisphere tasks).
Hypothesis 5 was not confirmed for both the WISC Digit Span and PMA Verbal Meaning Tests. The Scheffé procedure did not show that sixth grade females were significantly superior to sixth grade males on these two tests. Inspection of the means for these two groups reveals only an infinitesimal difference. These results do not support the neurological theories that postulate bilateral representation of language for females (citing as evidence the work of Kimura, 1969; McClone & Davidson, 1973; McGee, 1976) and those that suggest earlier, greater left hemisphere lateralization for females (Buffery & Gray, 1972; Kimura, 1967; Pizzamiglio & Cecchini, 1971) for children twelve years old and younger. This is in part due to the nature of the tasks employed in the present study. Whereas both the WISC Digit Span Test and the PMA Verbal Meaning Test are indices of left hemispheric functioning they are different from verbal fluency tasks used to show female bilateral representation of language or earlier left hemisphere lateralization for females. As such, female neurological organization that is advantageous to verbal processes as measured by the two left hemisphere tasks of this study, while not indicated by these results may still take place at a later age.

Hypothesis 6: Sixth grade male subjects will perform significantly better than sixth grade female subjects on the
WISC Block Design and the PMA Spatial Relations Tests (right hemisphere tasks).

The results of the Scheffe test and inspection of the means for sixth grade males and sixth grade females for the WISC Block Design Test revealed a significant male advantage. These results partially confirmed hypothesis 6 and indicated a greater male right hemisphere lateralization as theorized and measured by a constructive visuo-spatial instrument. However, data analysis procedures utilizing a standardized paper-and-pencil visuo-spatial test, the PMA Spatial Relations Test, did not demonstrate male superiority for sixth grade students as hypothesized. In fact, the results of the Scheffe test showed that kindergarten female subjects performed significantly better than sixth grade female subjects. A possible explanation for this unexpected finding has previously been discussed with regard to hypothesis 1 based on the sixth grade disadvantage due to the administration of both the verbal and spatial tests during one testing session. The fact that this disadvantage is significant for female subjects in particular perhaps indicates a more pronounced effect of verbal process context interference for these subjects. Greater reliance upon left hemisphere processes during spatial tests for females has also been found by McGee (1976). Consequently, hypothesis 6 is only partially confirmed. Greater male right hemisphere lateralization
is corroborated for sixth grade subjects on the WISC Block Design Test.

Hypothesis 7: Sixth grade male subjects will be more field independent than sixth grade female subjects as measured by the Rod-and-Frame Test.

Hypothesis 7 was not confirmed. Sixth grade male subjects were not more field independent than sixth grade female subjects employed in this study; however, the means indicated a slight male advantage. This is contrary to the results of Caravan (1969), Keogh and Ryan (1971), Schwartz and Karp (1967), Silverman, et al. (1973), and Witkin, et al. (1962, 1967) who found a sex difference favoring male subjects ten years or older on the Rod-and-Frame Test. Although many studies have confirmed sex differences on the RFT by age ten, there is evidence that sex differences with regard to spatial abilities and other measures of field dependence-independence are not reliable until adolescence. As such, sex differences on the RFT also may be more reliable and consistent at a later age. The results of the Scheffé test tend to support this position. There was also no significant difference between the kindergarten female subjects and the sixth grade female subjects on the RFT. But the sixth grade male subjects were significantly more field independent than the kindergarten male subjects. An age level difference appears earlier for male subjects.
If males do progress toward field independence earlier or at a more rapid rate, perhaps at a later age they become more field independent than the later starting, slower females. It would be necessary to follow up these subjects at a later age to see when the sex differences on the RFT become apparent. They were not present at ages eleven-to-twelve. These results also tend to support earlier, greater male right hemisphere lateralization for the Rod-and-Frame Test, a FDI spatial restructuring measure.

Hypothesis 8: For kindergarten male subjects there will be a significant negative correlation between Rod-and-Frame Test scores and each of the right hemisphere tasks.
   a. WISC Block Design
   b. PMA Spatial Relations

Hypothesis 8 was not confirmed. Although there was a negative correlation between the RFT and the WISC Block Design and the PMA Spatial Relations as well as for the PMA Verbal Meaning, none of these were at a significant level. The only significant correlation was between the WISC Block Design Test and the PMA Spatial Relations Test. These results indicate that for kindergarten male subjects these two tests, a constructive visuo-spatial and a standardized paper-and-pencil spatial ability, are related. This seems to support earlier, greater male right hemisphere lateralization. But the performance on the RFT was not
significantly related to that of the two spatial tests. Perhaps field dependence-independence is more than simple spatial ability (similar findings were reported by McGilligan & Barclay, 1974).

Hypothesis 9: For kindergarten female subjects there will be a significant negative correlation between Rod-and-Frame Test scores and each of the right hemisphere tasks.

a. WISC Block Design
b. PMA Spatial Relations

Hypothesis 9 was confirmed. For kindergarten female subjects, there was a significant negative correlation between the RFT and both the WISC Block Design and PMA Spatial Relations Tests. Subjects who had lower scores on the RFT, indicating field independence, had higher scores on the two right hemisphere spatial tests. In addition, the WISC Block Design Test was significantly positively correlated with the PMA Spatial Relations Test as would be expected.

However, the Block Design Test and the PMA Spatial Relations Test were also positively correlated with the PMA Verbal Meaning Test at a significant level; and the RFT exhibited a significant negative correlation with the PMA Verbal Meaning Test. Although hypothesis 9 was confirmed, looking at all of the significant results indicates that for kindergarten female subjects there is evidence of functioning similar to split-brain individuals.
interhemispheric communication and/or interference) and a similar developmental level for both left and right hemisphere processes. In addition, since the RFT is negatively related to both spatial and verbal processes two conclusions can be drawn. Perhaps this measure of FDI involves more than simple spatial ability (McGilligan & Barclay, 1974) and/or the female subjects employ left hemisphere processes on this task (similar to the findings of Kimura, 1969; McClone & Davidson, 1973; McGee, 1976).

Hypothesis 10: For sixth grade male subjects there will be a significant negative correlation between Rod-and-Frame Test scores and each of the right hemisphere tasks:

a. WISC Block Design
b. PMA Spatial Relations

Hypothesis 10 was also confirmed. There was a significant negative correlation between the RFT and the WISC Block Design and PMA Spatial Relations Tests for sixth grade male subjects. However, similar to the results noted for hypothesis 9, there were many other significant correlations. Surprisingly, the correlations were exactly the same as those for kindergarten female subjects: a positive correlation between the WISC Block Design and the PMA Spatial Relations, the WISC Block Design and the PMA Spatial Relations with the PMA Verbal Meaning, and a negative correlation between the RFT and the PMA Verbal Meaning.
Again, one notes evidence of functioning similar to split-brain individuals and similar developmental levels with regard to the left and right hemispheres. Similarly, the RFT seems to involve more than simple spatial ability (McGilligan & Barclay, 1974) and some degree of left hemisphere involvement (similar to the conclusions of Berent, 1974, 1976; Berent & Silverman, 1973; Cohen, Berent, & Silverman, 1973; DeFazio, 1973; and White, 1971).

Hypothesis 11: For sixth grade female subjects there will be a significant negative correlation between Rod-and-Frame Test scores and each of the left hemisphere tasks.

   a. WISC Digit Span
   b. PMA Verbal Meaning

Finally, hypothesis 11 was not confirmed. The negative correlations involving the RFT were exactly the same as for the previous three groups of subjects but none at a significant level. (The negative correlations involved the RFT and the WISC Block Design, PMA Spatial Relations, and the PMA Verbal Meaning Tests.) The only significant correlations for the sixth grade female subjects were between the WISC Digit Span and the PMA Verbal Meaning Tests and between the PMA Verbal Meaning Test and the PMA Spatial Relations Test. The first correlation is the first piece of significant evidence supporting earlier greater left hemisphere lateralization for females (corroborating
Buffery & Gray, 1972; Kimura, 1967; Pizzamiglio & Cecchini, 1971). The latter correlation, however, is unexpected and not explainable in terms of neurological theories.

Based upon all of the statistical procedures used to directly test the eleven hypotheses of this study, the following conclusions seem tenable:

1. Children improve their performance on left and right hemisphere tasks with increasing age.

2. Kindergarten children (ages five-to-six) do not exhibit sex differences with regard to left hemisphere and right hemisphere tasks thereby indirectly indicating similar neurological hemisphere organization.

3. Sixth grade children (ages eleven-to-twelve) do not exhibit sex differences with regard to left hemisphere tasks though there is some support for earlier, greater left hemisphere lateralization for females.

4. Sixth grade children (ages eleven-to-twelve) do not exhibit sex differences with regard to right hemisphere tasks measured by standardized paper-and-pencil spatial ability tests.

5. Sixth grade children (ages eleven-to-twelve) do exhibit sex differences with regard to right hemisphere tasks measured by constructive visuo-spatial tests thereby supporting earlier, greater male right hemisphere lateralization.

6. Field independence as measured by the Rod-and-Frame Test increases with age.
7. Sex differences on the Rod-and-Frame Test are not consistent and reliable by age twelve; however, male children exhibit earlier age level differences.

8. The Rod-and-Frame Test, a measure of field dependence-independence, involves more than simply spatial ability and perhaps some left hemisphere involvement.

These conclusions, and in particular the last one, suggested a need for additional statistical procedures. Since it is hypothesized that sex differences in neurological lateralization affects both field dependence-independence and spatial ability and since these were not indices of the same type of processing, additional correlation assessments were performed. Students were divided into eight groups based upon age, sex, and the classification of field independent or field dependent. Correlations among the two left hemisphere tasks (WISC Digit Span and PMA Verbal Meaning Tests) and the two right hemisphere tasks (WISC Digit Span and PMA Spatial Relations Tests) were then measured. The results for all field dependent subjects, kindergarten and sixth grade, male and female, revealed a positive correlation between a left hemisphere task and a right hemisphere task. Split-brain processing (limited interhemispheric communication and interference) and equal development of left and right hemisphere processes seems to be evident among field dependent subjects. In addition, all female field independent subjects also demonstrated a
positive correlation between a left and right hemisphere task. On the other hand, kindergarten, male, field independent subjects exhibited a positive correlation between the two right hemisphere tasks and sixth grade, male, field independent subjects exhibited a negative correlation between a left hemisphere and right hemisphere task (the WISC Digit Span and the PMA Spatial Relations). These results seem to provide evidence for earlier, greater right hemisphere lateralization for field independent males and possibly bilateral representation of spatial abilities which may interfere with left hemispheric processing.

In conclusion, the results of this study lend support to a theory of sex differences with regard to hemispheric lateralization. There is evidence for earlier, greater male right hemisphere lateralization that affects both performance on field dependence-independence and spatial measures. These two measures are similar but not alike and consequently when subjects are both male and field independent, their greater right hemisphere lateralization and/or bilateral representation of spatial abilities can interfere with verbal processes.

**Implications for Education**

Studies dealing with brain hemisphere lateralization and the cognitive style of field dependence-independence have great import to the field of education. It has been
shown that males display earlier, greater right hemisphere lateralization. Yet, educational practices neglect non-verbal forms of intelligence and specifically right hemisphere processes (Bogen, 1969, 1976). Education today leaves one half of the individual's potential unschooled. Bogen suggests that both academic material and methodology should be changed to accommodate both hemispheres of the brain. Instruction should be introduced in the preferred mode of the individual and then elaborated in the second mode. Since this study suggests earlier male right hemisphere lateralization, male children are not only being intellectually neglected but frustrated as well. As Galin and Ornstein (1975) and Gazzaniga (1975) suggest instruction at times is not only inefficient but also inappropriate by interfering with the appropriate processing system. A student should not be forced into a curriculum contrary to his preferred cognitive mode. As such, they recommend the use of electroencephalograms to diagnose the individual's preferred cognitive mode. Studies, such as the present one, which indicate sex differences in hemispheric lateralization, can also be used to this end. Then, a determination of which academic tasks are hemispheric specific needs to be made. Learning material, procedures, and communication techniques should be appropriate to the preferred mode and also encourage participation of the other hemisphere. Involvement of both
hemispheres and interhemispheric communication will result in a higher level of performance (Dimond & Beaumont, 1974; Wittrock, 1975). Specific recommendations to encourage the involvement of the neglected right hemisphere include the use of visuo-spatial abilities in dealing with manipulatives of a hands-on curricula and nonverbal communication techniques.

Literature on brain lateralization also has implications in terms of educational practices for subcultures and ethnic groups. Cohen (1969) and Bogen (1972) found that white, middle class people seem to rely upon a verbal, analytic or left hemisphere processing mode while the urban poor, Black, and Indian subcultures favor a spatial, holistic, right hemisphere mode of operation. Inasmuch as our education system favors development of the left hemisphere, clearly these subcultures are at a disadvantage. Changes in the curricula and methodology as well as bicognitive development for these individuals could foster academic success.

Assessment of the cognitive style of field dependence-independence is equally crucial for the field of education. Satterly (1976) suggests that the knowledge of a child's cognitive style is as useful as his IQ for understanding and teaching that child. Most schools today favor the field independent student (Cohen, 1969). The field independent student favors an analytic, inanimate, impersonal
approach to learning. The field dependent student learns better when faced with situations involving human, social content. In addition, they are much more susceptible to the approval or disapproval of authority figures. Different materials, teaching techniques, and assessment procedures would foster more development for the field dependent learner. In addition, it is critical to assess the teacher's cognitive style as well as the learner's. DiStephano (1970) found that teachers rate students with the same cognitive style as their own in highly positive terms. Ramírez and Castañeda (1974) similarly found that academic performance is enhanced when the cognitive style used by the teacher matches that in which the child learns.

Field dependence-independence has also been related to various subgroups. For example, Guyer and Friedman (1975) note that learning disabled boys are more field dependent than normal boys. Mexican-Americans (Ramírez & Castañeda, 1974), Jewish Orthodox Americans (Dershowitz, 1971), Black, disadvantaged youth (Hallahan, 1970), lower socio-economic groups (Bigelow, 1971), and young children (based upon the results of the present study) employ a field dependent style of processing. Education which more reflects the field independent mode of processing is therefore frustrating and inefficient for these learners. Ramírez and Castañeda (1974) therefore suggest the simultaneous development of both cognitive styles, bicognitive
Ramírez and Castañeda (1974, p. 131) offer specific educational recommendations with regard to FDI and bicognitive development. These are equally relevant and worthwhile in terms of preferred hemispheric cognitive mode and fostering interhemispheric involvement and communication. As such, they will conclude this discussion on educational implications.

1. Assess cognitive styles of children.
2. Assess cognitive styles of teachers.
3. Train teachers to teach bicognitively.
4. Develop curriculum and classroom environments reflecting both cognitive styles.
5. Develop assessment techniques and testing environments appropriate to the cognitive styles of the children being tested.

Implications for Future Research

In view of the results and their discussion in this chapter as well as their significant implications for education, continuing research into a neurological model based upon hemispheric lateralization in order to explain sex differences in field dependence-independence and spatial abilities is both warranted and demanded. Suggestions for future research endeavors are based upon the following modifications and/or expansions of the present study.

1. Use other age groups, possibly adolescents and adults. These populations would provide further confirmation of age and sex differences with regard to left hemisphere tasks, right hemisphere tasks, and field
dependence-independence found in the present study. Confirmation of these differences during later years could also refute any theories based upon developmental lag. Finally, age and sex differences that were not supported by the present study might be revealed at a later point in development.

2. Use other left hemisphere measures, possibly dichotic auditory and visual techniques as well as other standardized verbal tests. The degree of left hemisphere lateralization could be assessed by dichotic listening tasks involving digits, letters, or words which would be based upon a contralateral ear advantage. Analysis of visual field differences could also involve digits, letters, or words. The selection of other standardized verbal tests can be made by consulting the Buros Mental Measurements Yearbooks.

3. Use other right hemisphere measures, other standardized spatial tests and other constructive spatial tests. The degree of right hemisphere lateralization could be measured by dichotic listening tasks involving nonverbal noises or musical material. Similarly, dichotic visual tasks could involve face recognition, dot localization, or dot enumeration. Standardized spatial tests could be found in the Buros Mental Measurements Yearbooks. Constructive spatial tasks could include the Copy Crosses Test, following maps based upon dot patterns, the assembly
or completion of geometric shapes or designs, and finally additional block design constructions. This would enable a researcher to investigate age and sex differences with regard to spatial paper-and-pencil type tests as compared to constructive spatial tests as suggested by the results of the present study.

4. Vary the order of presentation between left hemisphere and right hemisphere tasks. Built into a study could be the variable of context influence. One group of subjects could receive the right hemisphere tasks first and then the left hemisphere tasks. Another group of subjects would receive the opposite order of task presentation. This suggestion is based upon the work of Paivio and Ernest (1971) and the results of the present study which indicate a possible disadvantage to right hemispheric functioning preceded by left hemisphere processes.

5. Employ electroencephalogram procedures to directly assess hemisphere functioning. An EEG reading based upon Right/Left ratios for hemispheric idling rhythm could be used in conjunction with left and right hemisphere tasks. Computer analysis techniques are now being developed in order to more precisely evaluate EEG recordings. Another very exciting dimension to the use of EEG procedures is the use of biofeedback training. This involves the presentation of EEG results to the subject and then the attempt to affect and influence hemispheric involvement
on subsequent tasks.

6. Use other field dependence-independence measures. Other FDI tests include the Embedded Figures Test, the Body Adjustment Test, Ghent Overlapping Figures Test, and the Gottschaldt Hidden Figures Test. Other variables that could be considered include group administered tests versus individually administered tests and visual, tactile, and auditory versions of disembedding tests of field dependence-independence.

7. Assess teacher cognitive style as related to both hemispheric lateralization and field dependence-independence. This would provide indices of educational biases with regard to hemispheric mode of operation and FDI style. In addition, teacher evaluation or rating could be analyzed in terms of their cognitive preferences.

8. Compare teacher cognitive style to student cognitive style in terms of student performance and rating. A study could investigate the results of compatibility or discord between teacher and student cognitive style on achievement and teacher rating of the pupils. Different subject areas could be investigated in terms of achievement as well the effect on different types of students (e.g., normal versus learning disabled, different subcultures, different ethnic groups, different socio-economic levels).
9. Assess the effectiveness of various teaching methods in terms of teacher cognitive style. An experimental study could be designed using whole class instruction, small group instruction, or individualized instruction. Other experimental variables could be deductive versus inductive teaching methods or expository versus discovery teaching. Teachers exhibiting different cognitive styles using different teaching methods could then be analyzed in terms of student achievement and attitude.

10. Assess the effectiveness of various teaching methods in terms of pupil cognitive style. Student cognitive style could be assessed and based upon these results students could be randomly assigned to different teaching methods as suggested previously (refer to suggestion 9). Students of similar cognitive style could receive different teaching methods and then analyzed in terms of achievement and/or attitude.

11. Assess the effectiveness of various instructional materials in terms of teacher cognitive style. Student achievement and attitude could be analyzed for teachers of different cognitive styles using different types of materials (e.g. visual, auditory, manipulative, packaged programs).

12. Assess the effectiveness of various instructional materials in terms of student cognitive style. Student achievement and attitude could be analyzed in terms of
the different types of materials previously mentioned as related to their preferred cognitive style.
APPENDIX A

TESTING SCHEDULE*

April 19, 1978.............Sixth grade explanation of study and distribution of consent forms

April 20, 1978.............Sixth grade explanation of study and distribution of consent forms

April 24, 1978.............Sixth grade testing - Handedness Instrument and WISC Digit Span Test

April 25, 1978.............Kindergarten explanation of study and distribution of consent forms

April 27, 1978.............Kindergarten testing - Handedness Instrument and WISC Digit Span Test

May 2, 1978..............Kindergarten testing - Handedness Instrument and WISC Digit Span Test

Sixth grade testing - Handedness Instrument, WISC Digit Span Test, WISC Block Design Test

*Additional testing time involved kindergarten students and the administration of the Handedness Instrument and the WISC Digit Span Test by an Ohio State University student teacher. Dr. Marlin Languis, an Ohio State University professor, also assisted in the testing of both kindergarten and sixth grade students on the Rod-and-Frame Test.
TESTING SCHEDULE (CONT.)

May 3, 1978................Sixth grade testing - WISC Block Design Test

May 4, 1978..............Sixth grade testing - WISC Block Design Test, Rod-and-Frame Test

May 5, 1978..............Kindergarten testing - WISC Block Design Test, Rod-and-Frame Test

May 9, 1978..............Kindergarten testing - WISC Block Design Test, Rod-and-Frame Test

May 10, 1978.............Kindergarten testing - WISC Block Design Test, Rod-and-Frame Test

May 12, 1978.............Kindergarten testing - WISC Block Design Test, Rod-and-Frame Test

May 15, 1978.............Kindergarten testing - WISC Block Design Test

May 16, 1978.............Kindergarten testing - WISC Digit Span Test, WISC Block Design Test

May 19, 1978.............Kindergarten testing - Handedness Instrument, WISC Digit Span Test, WISC Block Design Test, Rod-and-Frame Test

June 9, 1978...............Sixth grade testing - PMA Verbal Meaning Test, PMA Spatial
TESTING SCHEDULE (CONT.)

June 12, 1978 ............... Kindergarten testing - PMA

Verbal Meaning Test, PMA
Spatial Relations Test*

*Administered by a kindergarten teacher in the school.
APPENDIX B

PORTABLE ROD-AND-FRAME TEST

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