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Factor Analytic Study of Spatial Abilities in Second-Grade, English-Speaking Navajo and Non-Navajo Children

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FACTOR ANALYTIC STUDY OF SPATIAL ABILITIES IN SECOND GRADE ENGLISH SPEAKING NAVAJO AND NON-NAVAJO CHILDREN

by

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ABSTRACT

Factor Analytic Study of Spatial Abilities
in Second-Grade, English-Speaking
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by

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This study was conducted to continue the investigation of apparent differences in cognitive abilities between Navajo Indian children and non-Navajo children. Subjects were 248 second-grade students, ranging from 7 to 9 years old. The Navajo sample lived in the Shiprock, New Mexico, area of the Navajo Indian Reservation, and the non-Navajo sample lived on the east side of Salt Lake City, Utah. Data were collected using six tests designed to measure spatial abilities in primary grade children. Results indicated that the non-Navajo children scored significantly higher on two individual tests and on the total test score under timed conditions, with no differences between groups when timing was not a factor. Two factors were identified for both groups. Factor loadings were different between the groups. As the scoring moved from timed to extended time, it changed for the non-Navajo children but remained the same for the Navajo group. Discriminate function analysis indicated a moderate ability to predict group membership using these tests. Gender differences were noted as well, with females scoring significantly lower than males on timed but not on extended time. Some race/gender interactions also were recorded. Suggestions were made that differences may be related to varying strategies used by not only different racial groups but by both genders as well. The within-group variability indicated a need for investigation of individual differences as well as group differences. Suggestions included using a greater number of instruments, an exploration of strategies, and using a examiner familiar to the students.

(223 pages)

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CHAPTER I

INTRODUCTION

Interest in mental abilities and individual differences can be traced to early science (Hilgard, 1987). However, concentrated efforts to measure and compare the abilities did not begin until late in the 19th century (Hilgard, 1987). Early researchers in this area included Galton, Cattell, Thorndike, and Binet (Hilgard, 1987). Galton and Cattell focused on measurements of sensory processes such as keenness of vision and hearing, dynamometric pressure, and reaction time (Hilgard, 1987). Binet, in keeping with the early definitions of intelligence, which focused on verbal abilities, focused testing on the measurement of reading, writing, and naming. These areas continue to be considered the basics of "mental abilities" (Hilgard, 1987). Binet then joined with Theophile Simon in developing the first test to measure intelligence based on mental age (MA) compared to chronological age (CA), calling it an Intelligence Quotient (IQ). The test has been translated and revised but continues to be used as one of the major measures of intelligence.

Starting in the early 1930s, new ideas about the concept of intelligence were detailed. Work by Stephenson (1931) and McFarlane (1925) laid the groundwork for understanding intelligence as a multifaceted element.

Immediately prior to World War II, David Wechsler used some of this information and published the Wechsler-Bellevue Scale, which attempted to measure several different abilities as components of a total IQ score. The results were reported as an IQ score, as with Binet's test, but did not include the concept of MA (Hilgard, 1987). The test was refined by Wechsler and divided into separate instruments for young children, middle-aged children, adolescents, and adults (Sattler, 1992). In spite of its popularity, it has been investigated for being biased against minority people (McShane & Plas, 1982a, 1982b; Ross-Reynolds & Reschley, 1983).

Building on Stephenson's (1931) and McFarlane's (1925) work, Spearman (1927) and Guilford (1967) provided refinement for the models of multifaceted intelligence, which currently include distinct abilities such as verbal comprehension, word fluency, memory, speed of closure, processing speed, and spatial relations (Royce, 1988).

The concept of learning style, the development of which was aided by the advent and increased use of factor analysis, often included, or was constructed from, this wider definition of intelligence. Developers of more recent tests such as the Kaufman Assessment Battery for Children (K-ABC) (Kaufman & Kaufman, 1983) have tried to coincide with advanced definitions of intelligence, having some success in the process.

In the process of redefining intelligence, Thurstone

(1938) was the first of several researchers to describe a spatial factor as one element of the complex concept of intelligence or cognitive abilities. In spite of suspicion and some resentment in the field, spatial skills separate from verbal skills seemed to be an accepted concept by World War II (Smith, 1964). As the research progressed, the possible existence of not one but two or more spatial factors was reported (Smith, 1964). Thurstone (1938) identified seven factors, three of which he believed were related to visual orientation in space. French (1951) suggested the existence of three spatial factors. With no standardization of test instruments or methodology, researchers had few guidelines to follow in identifying factors. However, there seemed to be dependable similarities among identified factors in spite of the application of different names or numbers. As the body of literature grew, factors labeled spatial visualization and spatial orientation seemed to recur (Michael, Zimmerman, & Guilford, 1950). Another apparent consistency is the seeming relationship between field dependent/field independent research results and spatial ability (McGee, 1979).

With all of the contradictory information, Lohman (1979) gathered data from studies with common methodological and theoretical perspectives and conducted a factor analysis on the combined data. From this analysis, he identified three spatial factors: (a) spatial relations, which is the ability to solve mental rotation problems; (b) spatial orientation, which appears to involve the ability to imagine how a stimulus array will appear from another perspective; and (c) visualization, which is characterized by tasks that frequently require a manipulation in which there is movement among the internal parts of the stimulus configuration or the folding and unfolding of flat patterns (Pellegrino & Kail, 1982). He conceptualized visualization and orientation, as existing on paired continuums from speeded to unspeeded and simple to complex, and factors that were differentiated by their places on the continuum.

In a continuing drive for a better understanding of cognitive abilities, researchers explored differences in spatial relations and visualization factors between males and females (McGee, 1979). In the past, results fairly consistently suggested that males have stronger spatial skills that seemed to have developed after puberty (Buffery & Gray, 1972; Johnson & Meade, 1987; McGee, 1979). Reports also indicated that this difference was more powerful than socioeconomic status or ethnic background (Backman, 1972) and occurred regardless of overall IQ (Hobson, 1947). However, subsequent research intimated that the differences occurred primarily in rotational tasks and not in other types of spatial abilities.

Several theories have been developed to explain the apparent differences. One theory, suggesting that sex-role stereotyping and belief systems drive the differences, seems to be more widely recognized (Tapley & Bryden, 1977). This theory has been used to explain what seemed to be learning effects in women's spatial abilities when they have equivalent training and background as the men being tested (Sherman, 1974).

Other researchers have reported limiting (Maccoby & Jacklin, 1974) or contradictory evidence (Kail, Carter, & Pellegrino, 1979) or have cited methodological inferiorities as the cause of the differences (Caplan, MacPherson, & Tobin, 1985). Several theories have been proposed to explain the apparent sex differences in spatial ability. These theories range from neuroanatomical differences to sex-role typing and personality differences. All theories are interesting and appear viable in some respects, but they have proven difficult to study adequately. Research results have provided no evidence to confirm or deny any of them.

Parallel to the concern with gender differences is the nature versus nurture conflict, as applied to racial and ethnic differences. The environment versus biology conflict is easily the longest standing struggle in psychology, and IQ and mental abilities have often been at the center of the discussion. The debate has fluctuated throughout this century, often in response to current research or in direct reaction to the social atmosphere of the time. In his early work of trying to define "genius," Galton tried to be "fair" and open-minded in his interpretation of data, but his own social status predisposed him to bias against the lower class (Hilgard, 1987). In the late 1960s, conflict about the relative importance of the environment versus genetics drew attention again as Jensen (1969) questioned the validity of the Head Start program as a means of "pulling up" low income children to an equivalent intellectual and academic status. A push seemed to exist to "prove" that racial and ethnic minority children are somehow genetically less "smart" than Caucasian children (Jensen, 1969), though this viewpoint has not always been well received by the psychology community (Berry, 1986; Berry, Poortinga, Segall, & Dasen, 1992; Chrisjohn, Towson, & Peters, 1988; McShane & Plas, 1982a, 1982b).

Researchers working with standardized IQ tests have demonstrated differences in IQ scores and in patterns of scores between minority and Caucasian children (McShane & Plas, 1982b). In the area of spatial abilities, varied results have been recorded. McGee (1979) reported that research with several different ethnic groups had not provided significant differences. However, results from other studies have suggested that differences do exist between groups such as African natives and Anglos (Jahoda, 1979, 1980) and African and Alaskan natives (Berry, 1966).

The apparent contrasts between ethnic groups have led some researchers to converge on possible differences between American Indian and non-Indian people, an area which has long intrigued researchers in the field of cognitive abilities (Garth, 1922; Rowe, 1914). Their work has generated a mass of information that can only be classified as inconclusive because it both supports and rejects the theory of actual differences in abilities (Bowd, 1974; Kleinfeld, 1970).

Some researchers have agreed with the description of differences. Many have suggested that variations are related to abilities other than intelligence such as environmental/survival technique differences, living and navigating in open spaces, hunting versus gathering societies, and the degree of social development (Berry, 1986; Berry et al., 1992; Kleinfeld, 1970).

In an effort to explain what seemed like "real" differences in abilities between American Indians and non-Indians, models were developed to understand and explain these differences. One set of models is the four "D" models (McShane, 1983). These four models are (a) disadvantage/deficit/deprivation, (b) disorganization/disruption, (c) difference, and (d) developmental change. Another set of models focused on the previously described concept of "learning style" and integrated genetic, social, and cultural factors (More, 1986; Rhodes, 1988). The learning style models have led to extensive research on patterns of abilities in different ethnic and racial groups, including American Indians (Burg & Belmont, 1990; Lesser, Fifer, & Clark, 1965; Stewart, 1976).

The areas of cognitive abilities within the learning style models, which have been most commonly researched with American Indians, are laterality (Brokenleg, 1983; Browne, 1984), field independence/field dependence (Utley, 1983), sequential versus simultaneous thinking (Brokenleg, 1983; Matsalla, n.d.), and spatial abilities (Berry, 1966; Kleinfeld, 1970). In general terms, the American Indian children tested were deemed to be "right brained," field independent, simultaneous thinkers with good spatial skills. Obviously, this is a broad characterization and, like all generalizations, can be inaccurate and unfair.

However, a significant body of research has suggested that differences exist between American Indians and non-Indians on scores of spatial ability tests (Bowd, 1974; Browne, 1984; Kleinfeld, 1970). Research results indicate that American Indians often score better on measures of spatial ability than on measures of verbal ability and that these higher scores are often above those of non-Indians (Bowd, 1974). There are some contradictory conclusions, but the majority of results demonstrates some consistency, which is heartening. Many of the studies, though, are not based on the use of instruments that have been validated as measures of spatial abilities.

The assessment of this concept is complex and involved. The present study was not designed to clarify the full spectrum of the problem, but it was designed to investigate the possible differences between Navajo Indian and non-Navajo children on selected spatial tasks. In addition, because different factors of spatial abilities seem to be present, different groups of children may produce different factor structures that could, again, relate to success in school; or, if they produce the same factor structures, mean differences in ability on different factors might exist.

CHAPTER II

LITERATURE REVIEW

Development of Mental Testing

Francis Galton (1822-1911), a pioneer in the study of cognitive abilities, became interested in individual differences in mental abilities at approximately the same time other psychologists were starting to examine behavior and thinking (Hilgard, 1987). He believed biological heredity was the basis for the development of genius. Therefore, he looked particularly at families of eminence and wealth for evidence to support his theory. He acknowledged a heredity versus environment conflict, but because of his own upbringing and the belief system it engendered, his writings had an elitist sound to them which seemed to persist in later studies of intelligence (Hilgard, 1987). He is, in fact, credited with strong support of eugenics programs in which selective breeding for intelligence is highlighted (Weiten, 1989). Among his many additional accomplishments was the study of the distribution of ability among people that led to the belief that quantitative measurement was an important and necessary aspect of the study of individuals (Oakland & Parmelee, 1986). Galton then developed a series of tests to measure constructs such as keenness of vision and hearing, dynamometric pressure, and reaction time (Hilgard, 1987).

The struggle to make his measurements as accurate as possible was a powerful one for Galton and may have even led to the development of statistical techniques to assist in his analysis. In spite of his apparent concern and attempts to be fair, many of his interpretations were biased by his apparent stereotypes of different groups (Hilgard, 1987).

Following in Galton's footsteps and those of another early psychologist, Wilhelm Wundt, was J. M. Cattell. He is credited with coining the term "mental tests" (Cattell, 1890). He, like Galton, concentrated his measurements on sensory processes, and, working in conjunction with researcher Livingston Farrand, focused on measuring abilities that seemed to have definite measurable responses such as speeds of reaction, sensory discrimination, and word association (Hilgard, 1987).

Thorndike, a student of Cattell's at Columbia University, continued the trends started by his two predecessors by developing methods for the systematic study of individual differences (Adams, 1989). He, too, was interested in the relative effects of nature and nurture but seemed to have a less biased attitude than Galton. He hypothesized that if all differences in mental abilities are a result of learning inequities, then they should disappear with training. If, however, they do not disappear with training, the differences are inherited. The results of his studies suggested variability increases between groups with and without training. He inferred that the differences in abilities among people from varied backgrounds will disappear with education (Adams, 1989), and he concluded that nature had triumphed over nurture. Of course, this answer was not definitive for the psychology community, and work in this area continued.

In 1954, Reynolds and Adams compared subjects from the top and bottom deciles on two psychomotor tasks and found the variance of the groups, as a whole, decreased with training. They concluded that the evidence suggests some low achievers "will benefit disproportionately once given the opportunity to learn" (p. 6).

On a different front and in response to a concern about educating low functioning people, the French minister of education, in 1904, appointed Alfred Binet (1857-1911) and Theophile Simon (1873-1961) to a commission assigned the task of developing a discriminating test of intelligence (Brody, 1992). As part of their responsibility, they were asked to generate methods to identify mentally deficient children to receive special instruction (Oakland & Parmelee, 1986). Binet believed that earlier work in the field of intellectual measurement failed to evaluate important dimensions that defined individual differences in intelligence (Brody, 1992). He concluded that tests with more "complex" tasks, similar to the mental activities of everyday life, would be better measures of intelligence

(Carroll, 1990). Binet and Simon's early efforts in test development looked at aspects of reading, writing, and naming, as opposed to the sensory measures used by Galton (Hilgard, 1987). Their first test was published in 1905 and consisted of tasks that relied on "the understanding of language and the ability to reason with either verbal or nonverbal (spatial, numerical) materials" (Carroll, 1990, p. 35) and was the first instrument to measure what was seen as overall intelligence (Oakland & Parmelee, 1986). The scale was designed to be administered on an individual basis and contained multiple tasks of increasing difficulty, each of which was to represent the typical performance of children at particular CAs (Carroll, 1990). The assumption was that human functions, cognitive and otherwise, tended to mature at a specified rate in some predetermined order. This assumption has become the basis for many tests and hypotheses, including Piaget's theory of cognitive development.

Each task in Binet and Simon's measure used familiar materials, suggesting that what has been learned from the surrounding culture may, in fact, be a reflection of intelligence. This structure led to the development of the concept of MA in which children of a specific age would respond to respective test items with similar answers (Hilgard, 1987). With the advent of this construct, Binet and Simon's goal of test construction was met (Carroll, 1990).

Over the next several years, this test was revised several times and eventually translated to English. The best known and longest lasting revision was developed by Lewis Terman at Stanford. This version, called the Stanford-Binet, was published in 1916 and included the concept of the IQ (Hilgard, 1987) that was developed by Stern, a European psychologist, and Terman. In this test, the measurement of intelligence became the quotient of MA divided by CA. When he revised Binet's test, Terman integrated this quotient, multiplying it by 100 to remove the decimal (Hilgard, 1987).

During the 1920s, the individual IQ test was modified to create group intelligence tests, which were then further developed for use with the Army. The group test design varied in at least two ways from individual tests. First, the group tests required recognition of an answer rather than recall of information, a process that some people deem easier. Second, the tests demanded that all examinees be able to read, a skill not held by all entrants (Carroll, 1990). Analysis of cumulative scoring patterns revealed several flaws with these group tests. First, in a study comparing scores on the Army Alpha and Army Beta tests with the Stanford-Binet, it appeared the MA of the American soldier was between 13 and 14 years (Hilgard, 1987). The second problem was a distinct hereditary aspect that led to the consistent assigning of low average intelligence scores to some racial and ethnic groups (Hilgard, 1987).

In spite of the problems of the Army test, as new tests were constructed, they were developed by similar procedures. On the newer tests, the items increased in difficulty as the test progressed. In addition, many tests were now timed. Finally, all tests carried an assumption that whatever ability was being tested, the relative strength of that ability would be directly related to the total score or number of items passed on each test (Carroll, 1990). In reviewing this process, Carroll (1990) expressed concern that scores on these tests could depend on either the examinee's level of ability or the speed with which he or she can attempt and complete items or both. He believed the scores then could be difficult to interpret accurately because these two processes can mean very different things as far as success in different work or educational areas. Carroll (1990) also noted that one problem with the underlying assumption of these tests is that two people might receive the same total score but pass different items, which could suggest very different abilities.

In 1939, the Wechsler-Bellevue Scale was devised by David Wechsler (1896-1981) for the American Council on Educational Psychology Examinations (Hilgard, 1987). This scale competed with the Stanford-Binet and preserved the IQ concept without using the concept of MA. Wechsler believed intelligence was a part of the personality and aspired to design a test that would consider all contributing factors. He did not, however, attempt to measure "primary abilities" or to form a hierarchy of importance for his subtests (Sattler, 1992). This instrument was further developed into separate editions for adults, children, and preschool children, with each edition undergoing at least one more revision since that time (Hilgard, 1987).

Interestingly, most of the tests developed in the early part of this century were designed to measure verbal skills, as those were viewed as the true measures of "intelligence" (Smith, 1964). However, in 1931, Stephenson demonstrated the existence of a group factor of verbal ability distinct from general ability. This information provided the drive for the initial development of nonverbal tests such as Progressive Matrices (Smith, 1964). In Britain, it was believed, following the principles of the early investigator Spearman concerning the existence of a central factor of intelligence labeled (g), that nonverbal tests such as Progressive Matrices provided a measure of this factor. This belief marked the beginning of research into the existence of different forms of intelligence that could be combined to represent the total intellectual abilities of a person or group of people.

McFarlane, in 1925, using a number of performance tests, concluded that the tests

> measured an ability whose uniqueness lies in the fact that those persons possessing it in high degree analyze and judge better about concrete spatial situations than do other individuals who perhaps excel in dealing with more highly abstract symbols. (Smith, 1964, p. 23)

Several developments occurred over the next few years that had great bearing on tests and measurements but which can only be briefly addressed here. One step was the identification of raw scores and their subsequent conversion to "standard scores" (Carroll, 1990). Another area was the development of more advanced statistical methods. The correlation coefficient was refined and then used by Spearman in what he termed "factor analysis." He used this technique primarily to support his theory of mental abilities, but others used it to better develop mental ability measures (Carroll, 1990). A major contributor to this field was Truman L. Kelley, an associate of Terman's at Stanford. He published two books that reviewed previous work on statistics and mental test theory. In addition, he contributed to the development of factor analysis, easing it toward its more refined and useful current state (Carroll, 1990).

On another front and described by Carroll (1990) as "one of the most creative workers in the development of psychological tests" (p. 46) was L. L. Thurstone who was involved in the construction of examinations for college admissions. He had a desire to elevate psychological testing to the level of a "quantitative, rational science"

(p. 46). In addition, he contributed to the use of statistics in psychology by learning higher order mathematical procedures and applying them to factor analysis. He expanded Spearman's work to include multiple factors. Working with his wife and their students, he built a data base to test his new ideas. He published a monograph called "Primary Mental Abilities" (Thurstone, 1938), which summarized the results of their work. One obvious limitation to their factor analytic work was the lack of technological support in the form of computers, which have allowed researchers to use larger data bases and more intricate manipulations.

Development of improved statistical techniques, test theory, and sampling methods have led to refinement of the testing of intelligence in the period just prior to and after World War II. Thurstone promoted the concept of a scale with two scores (an "L" [linguistic] score and a "Q" [quantitative] score) as early as 1924 (Hilgard, 1987). However, most mental testing conducted prior to 1938 was based on the idea that intelligence was a unitary trait (Carroll, 1990). In 1938, some of this changed with the publication of Thurstone's Primary Mental Abilities battery, which was based on his previously published monograph. The battery was built on his factor analytic work in which seven factors were identified. These factors have been defined as (a) P, perceptual ability; (b) N, numerical ability; (c) V, verbal ability; (d) S, spatial-visualizing ability; (e) M, memory; (f) I, induction or generalizing ability; and (g) D, deductive or reasoning ability (Hilgard, 1987).

With the increased need for rapid descriptions of abilities during World War II, group testing took a leap forward (Hilgard, 1987). Various tests based on Thurstone's ideas about mental abilities and his method of factor analysis were developed. Guilford, who worked with factor analysis during the war, conducted extensive research into measurable mental abilities. Through this work he developed a model of the structure of mental abilities (Meeker, Meeker, & Roid, 1985). Called the "Structure of Intellect," this model separated factors of mental process (memory) and content (number computation) and placed some elements in a hierarchical structure while leaving others out. Basically, Guilford believed cognitive abilities or intelligence could not be defined as a unitary concept and therefore could not be forced into any simple model (Meeker et al., 1985).

Another group attempting to measure multiple abilities was Kaufman and Kaufman (1983). Their test, the K-ABC, is designed to measure modes of mental processing such as simultaneous and sequential, as well as verbal abilities, spatial abilities, and visual-motor abilities, and is described as a "process-based scale" (Naglieri, 1989, p. 186) rather than a content-based scale. The K-ABC was originally designed to be used with children but recently has been released in a version for use with adults.

In spite of Kaufman and Kaufman's (1983) efforts, the K-ABC was still seen as inadequate because they stayed within the current limits of definition of ability, thus continuing to limit "real" knowledge of cognitive ability (Naglieri, 1989). Naglieri proposed a model labeled Planning, Attention, Simultaneous, and Successive, which is based on the neuropsychological model of Luria. Naglieri believed this to be the best opportunity to assess accurately cognitive abilities because this model

> has a strong base in theory, has been sufficiently operationalized, and has implications for understanding exceptionality and predicting academic and job performance. (Naglieri, 1989, p. 187)

As work with these tests and cross-cultural concerns about the uses of testing have concurrently developed, many of the old "so-called" standard tests have come under fire for being biased against ethnic and racial minorities (McShane, 1983). Again, evaluators seem unable to agree, but much evidence exists that would suggest these tests need to be used with care when applied to minority children and adults (McShane, 1983).

Concepts of Intelligence

Test instruments evolved across the decades, as did the concept of intelligence, though these developments were not always parallel. The change in definition can be seen in the evolution of the terms from mental ability to intelligence to cognitive processing. One of the most difficult tasks has been to define "intelligence" in a way that is meaningful, useful, and relatively easy to understand and apply across a number of disciplines. Galton was interested in the study of the genius, whereas Binet was more concerned with identifying the grades of mental deficiency for educational purposes. Army psychologists, on the other hand, acknowledged the importance of information learned in school and emphasized tasks demonstrating the individual's "ability to profit from his total experience" (Carroll, 1990, p. 36).

The task of defining intelligence has been complicated by a number of factors such as increased technical machinery and understanding that has (a) led to more detailed analysis of processing, (b) additional years of observations, and (c) a greater awareness of group and individual differences in style. The last item, while highly controversial, is hypothesized to cause various people to score very differently on standard measures while actually exhibiting little variation in ability to function from day to day. Thus, as a means of setting the stage for the current research, a brief history of the development of the various definitions of intelligence is presented.

Thorndike (Thorndike, Bregman, Cobb, & Woodyard, 1927) prescribed a multifaceted concept of intelligence that covered several areas, which included rational and abstract thinking. In later examining Thordike's ideas, Carroll (1990) explained the definition as "a capacity for forming bonds or connections among ideas, concepts, and so on" (p. 36). Thus, people with high levels of intelligence are those who

> have the capacity to form a large number of bonds and have had the opportunity (through experience, education, etc.) to do so. Insofar as the capacity to form bonds might be regarded as innate, and the actual formation of these bonds is thought to be a result of appropriate opportunities to form them. (Carroll, 1990, p. 36)

In 1921, Brown and Thomson proposed what was called the "sampling theory" in which any mental task "samples" several different mental operations (Carroll, 1990). This approach had some similarities to Thorndike's theory but was never fully developed.

Following Brown and Thomson (1921), several definitions were derived from a 1921 symposium on intelligence (Carroll, 1990). Several members of the symposium were apparently dissatisfied, if not disturbed, by the lack of agreement over a definition, as they ranged from simple to complex (Carroll, 1990). One person, Henmon, even suggested the tests in practice at the time were not general intelligence tests but tests of limited areas of intelligence upon which the schools placed a premium. This confusion is particularly interesting in light of the previous information outlining the tests that were being designed and used to measure the elusive concept of intelligence. Obviously, the definitions did not always correspond to a measure or series of measures. They dealt with everything from the basic ability to absorb information, to deal effectively with abstract information, and to use information once it was learned.

Spearman (1927), another early explorer of the concept of intelligence, examined interrelationships between tests of various abilities, concluding that all intellectual abilities have a general underlying factor (g) in common and a number of specific factors (s) that are unique to each ability. Spearman framed his theory as a two-factor theory in which each ability is loaded with the (g) factor and includes a special primary ability (Spearman, 1927). He reportedly defined (g) as a person's level of mental energy. His belief in this concept was so strong that he spent much of his professional life trying to establish the universality of the two-factor theory. However, Royce (1988) reported this was not an appropriate interpretation of factor analysis and identified Spearman's theory as a single-factor design, a point of view that is supported by Sternberg and Powell (1990). Spearman defended his model, but he was believed to be selecting his data to fit the model. Subsequent correlational research suggested that it did not hold up in all conditions.

> It was noticed that specific groups of intelligence tests—by virtue of special

> similarities in content, format, or the response processes involved—tended to exhibit intercorrelations that were greater than would be predicted by the two-factor theory. (Carroll, 1990, pp. 38-39)

Spearman was seen as eventually accepting these ideas, but he and his supporter Karl Holzinger remained committed to the existence of (g) (Royce, 1988). He maintained that this factor was central and primary in all intelligence tests and it might even have physiological correlates (Carroll, 1990). Therefore, in subsequent factor analyses, he and his coworkers always interpreted the first general factor as (g) and then looked at how the variables clustered otherwise (Royce, 1988). Carroll (1990) suggested that since intelligence tests are a measure of ability at a single point in time, the identified (g) factor may actually be a measure of total learning rather than of the rich array of intelligence such as learning, memory, problem solving, and concept formation.

As a further development of the two-factor model of intelligence, Cattell (1963) identified two aspects of intelligence that he labeled crystallized and fluid. Snow and Yalow (1990) stated that crystallized intelligence

> represents previously constructed assemblies of performance processes retrieved as a system and applied anew in instructional or other performance situations not unlike those experienced in the past. (p. 520)

In contrast, fluid intelligence "represents new assemblies, or the flexible reassembly of performance processes needed for more extreme adaptations to novel situations" (Snow & Yalow, 1990, p. 520). Cattell's (1987) belief in these factors has remained firm throughout the course of his work.

In a theory closely resembling Thorndike's theory of intelligence, Thomson (1939) also suggested that intelligence was composed of a number of "bonds," including reflexes, habits, and learned associations. For each task undertaken, a large number of bonds would be activated with related tasks sampling overlapping subsets of independent bonds. A factor analysis of a set of tests could look like a single general factor, but in Thomson's view the communality would be due to the overlap rather than a unitary source of individual differences.

In the process of trying to support his theory of intelligence, Spearman (1904) had developed a preliminary concept of factor analysis. He utilized the technique with his own research to a limited degree, but Thurstone mathematized and refined the technique including rotating the reference frame to organize the data (Royce, 1988). In 1938, Thurstone applied his multiple factor analysis to abilities. He identified several first-order factors of intelligence, including Number, Spatial Relations, Induction, Perceptual Speed, Verbal Comprehension, Word Fluency, Associative Memory, Speed of Closure, and Flexibility of Closure (Thurstone, 1938). He labeled these factors as primary because they emerged repeatedly over a variety of investigators and instruments. Cattell (1987) reported that a (g) factor could be obtained as a second-order factor among the primary factors. These findings were reported in a meeting of the American Psychological Association in 1941, thus strengthening the belief in the existence of a (g) factor. He seemed to believe that Thurstone agreed with him, whereas other writers reported that Thurstone initiated the concept (Royce, 1988).

Guilford's model was a further elaboration of the factor model of intelligence (Cattell, 1987; Royce, 1988). Royce (1988) described this theory as "the most complete version of the multiple-factor theory in the form of his structure of intellect model" (p. 151). The theory is an orthogonal, three-dimensional taxonomy of 120 elements or factors. Cattell (1987) later questioned the accuracy of this description and debated the finer points of statistical manipulation, though seeming to accept at least parts of the overall concept.

In his own theory, Cattell (1987) was unable to discuss the development of different abilities, but he listed what he saw as the most important factors. The first factor was Verbal Ability, which included "mainly size of vocabulary and command of syntactical [grammatical] and stylistic sense but also many other relatively minor aspects of verbal skill" (pp. 39-40). Numerical Ability, the second factor, was said to involve "skills (accuracy and speed) in the basic processes of addition, multiplication, subtraction, and division, and the somewhat more complex procedures commonly superimposed on them" (p. 40). Cattell described the next factor as "Mechanical Aptitude," stating that it arises from cultural learning but does not typically exist in the scholastic area. He stated that spatial ability, while often seeming the same, is "actually very different, showing no apparent impress from any cultural institution" (Cattell, 1987, p. 41). Carroll (1990), in his review of early factor analytic studies of cognitive abilities, noted that using this method (as many psychologists did) is "a poor exemplar of correlational science" (p. 45) because researchers did not base their work on prior research or use consistent methodologies in conducting their research.

Aspects of the concept of intelligence continue to change as new theories are developed. Recent research continues to explore the notion of different types of intelligence, ways of measuring it, and styles existing in different children. Differences in theories continue to exist, but most authorities seem to support the idea of intelligence being multifaceted (Cattell, 1987; Hilgard, 1987).

Racial and Cultural Differences in IQ Testing

The environment versus biology conflict has been long standing in the field of psychology as part of the search to explain individual differences. The conflict often has focused on cognitive differences, possibly in an attempt to prove superiority of one race or socioeconomic group over another. Galton, in the early years of the 20th century, attempted to be "fair" in interpreting the results of research into the concept of genius. However, he held some strong beliefs about genetic predisposition toward greater intelligence; thus, many of his reports reflected a bias against lower socioeconomic groups (Hilgard, 1987). With the influx of eastern European immigrants and the change in status of African Americans and other minority groups, many investigators became interested in relative differences, some probably with an eye toward protecting their own elevated status in society. In the late 1930s, researchers in this field became more sensitive to possible racial and cultural bias both in theory and in testing because of events in Europe with Hitler's rise to power (Hilgard, 1987). The debate seemed only to quiet but not to resolve. The continuing difference in viewpoints prompted Skodak and Skeels (1949) to publish the results of an examination of a body of research in the area. They noted what seemed to be the basic difference in methods between the two camps: (a) those who leaned toward heredity tended to rely on correlational data, whereas (b) those who favored environment relied chiefly on changes in mean IQ (Hilgard, 1987).

The issue of more specific racial differences in IQ became a "headline" concern again in the late 1960s with the advent of the Head Start Program. Jensen (1969) published an article in the Harvard Educational Review entitled "How Much Can We Boost IQ and Scholastic Achievement?" In this article, Jensen strongly favored the heritability of racial differences, with an emphasis on the lower intelligence of African Americans. In 1974, Jensen published the results of a further study examining the relationship of race, socioeconomic status, and intelligence with African Americans and Anglo Americans. He proposed two levels of abilities: (a) Level I, which is measured by rote learning tasks and (b) Level II, which is measured by tests of general intelligence, "especially those of the nonverbal, fluid-intelligence, culture-fair variety" (p. 99). He reported that Anglo American and African American groups differed more, on the average, in Level II than in Level I ability. He did, however, qualify the impact of the results by noting that the two groups were basically from two different socioeconomic groups and that more background information was needed before conclusions could be drawn (Jensen, 1974).

Jensen's (1974) research was not the first study to produce results suggesting differences, but he is probably one of the more outspoken of those in this area. Much of his writing seems to have a qualitative overtone in the manner in which he described groups or applied research results. These results could be interpreted as biased, if not racist, and raised suspicions about his results, suggesting he may see what he wants to see.

More recently, in his review of the literature on IQ testing with African Americans and Anglo Americans, Brody (1992) noted that a 1 standard deviation difference exists between the two groups on a variety of tests of intelligence. In the research cited, the African American group has a consistently lower IQ than the Anglo American group on standardized measures. In further analysis of available research, Brody reported that, although IQ test scores increased for both groups, the differences between the two groups have remained the same.

Rushton (1988) suggested that "Mongoloidal" people have a higher IQ than "Caucasoidal" people who are higher than "Negroidal." He congratulated himself on the thoroughness of his review, but he also admitted he eliminated information from reports that demonstrated no differences in IQ. He included the results of studies using variables such as head circumference, size of brain, and occupation as measures of intelligence. He dismissed any environmental factors that might affect these elements, attempting to make a case for genetic differences among the three groups.

In spite of apparent missing evidence, Rushton (1990) published an article in which he enforced his assessment of

IQ differences. In his own work, Brody was not willing to accept Rushton's conclusions, and he pointed to numerous studies in which African American children who were raised in adoptive homes by African American, mixed, and Anglo American parents were tested. The results of these studies gave some validity to his belief in an environmental differences hypothesis. In his conclusion, he made several important points. One, the differences do not seem to be due to bias in the tests, but they may, in some respects, reflect differences "not in particular bits of cultural knowledge but in more general and abstract abilities" (p. 309). Second, they are

> related to criteria such as the acquisition of knowledge that are valued by many if not all individuals in both the black and the white communities of the United States. (p. 309)

His summary is that the differences are most likely correlated with the "distinctive cultural experiences encountered by black individuals in the United States" (p. 309).

Testing with American Indians

Testing cognitive abilities of American Indian children began early in the 20th century (Garth, 1922; Rowe, 1914). A wide selection of tests has been used, including (a) Goodenough Draw-A-Person Test (Dennis, 1942; Telford, 1932); (b) Illinois Test of Psycholinguistic Abilities (Sabatino, Hayden, & Kelling, 1972); (c) Peabody Picture Vocabulary

Test (Lonner, Thorndike, Forbes, & Ashworth, 1985; Skruggs, Mastriopieri, & Argulewics, 1983); (d) Arthur Performance Test (Havighurst & Hilkevitch, 1944); (e) Bender-Gestalt (Moore & Zarske, 1984); (f) Raven Progressive Matrices (Das, Manos, & Kanungo, 1975; Taylor & Skanes, 1976; Utley, 1983); (g) Wechsler Intelligence Scale for Children (WISC) and Wechsler Intelligence Scale for Children-Revised (WISC-R) (McShane & Plas, 1982a, 1982b; Sabatino et al., 1972; Wilgosh, Mulcahy, & Watters, 1986); and (h) K-ABC (Naglieri, 1984). The results of these studies have not provided consistent information from which to draw conclusions about the cognitive abilities of the American Indian. Some researchers (McShane & Plas, 1982b; Sabatino et al., 1972; Wilgosh et al., 1986) have reported that American Indian children perform significantly lower than Anglo American children on IQ tests, whereas others (Bowd, 1974; Dennis, 1942; Havighurst & Hilkevitch, 1944) have reported significantly higher scores on intelligence measures for American Indian children. Telford (1932) reported mixed results. These differences occur because of the wide variety of testing instruments used by researchers. In addition, researchers found lower mean scores for American Indian children using tests with strong verbal factors such as the WISC (Cundick, 1970; McShane & Plas, 1982a), WISC-R (Hynd & Garcia, 1979; McShane & Plas, 1982a, 1982b; Wilgosh et al., 1986), and Stanford-Binet (Guillmans, 1975). Those who found higher performance by American Indian children than non-Indian children used instruments such as the Goodenough Draw-A-Man, Ravens Matrices, and Porteus Mazes, which were more spatial and performance oriented, as noted in Bowd's (1974) review of the literature on testing with American Indians.

In using the K-ABC with Navajo children, Naglieri (1984) reported that the mean Mental Processing Composite from the K-ABC was significantly higher than the Full Scale IQ on the WISC-R. He suggested that the discrepancy may be due to the apparently greater use of English on the WISC-R (Naglieri, 1984).

In his review of research data with the Wechsler tests, McShane (1980) recorded fairly consistent results, suggesting that American Indian children score lower than non-Indian children on the overall IQ score, as well as on the Verbal IQ score. American Indian children scored as well as, if not better than, the non-Indian children on the performance subtests, but there was also a consistent Performance IQ greater than Verbal IQ pattern that seems to be congruous across diverse American Indian groups. These results have been seen in reports issued by other researchers as well (Brokenleg, 1983; Browne, 1984; McShane & Plas, 1984; Ross-Reynolds & Reschley, 1983; Snyder, 1991; Zarske & Moore, 1982).

Examining the results of WISC-R testing with 366 Inuit children, Wilgosh et al. (1986) determined that 77.04% of the group would be misclassified as "retarded" based on the verbal scores and that approximately one third would be misclassified based on full scale scores.

Another way of examining WISC-R scores has been to recategorize them based on Bannatyne's model (1971). In this model, a factor analysis is conducted on the subtest scores, and the resulting factors are placed in sequence from high to low scores. Using this method, Zarske and Moore (1982) found a pattern of Spatial > Sequential > Conceptual factors in American Indian children who were deemed learning disabled. This finding contrasted with the pattern of Spatial > Conceptual > Sequential for Anglo American learning disabled children. In a similar study, McShane and Plas (1982a) reported a factor pattern consistent with Zarske and Moore for American Indian children. Similar results were reported by Teeter, Moore, and Peterson (1982) as well. Factor analysis of WISC-R scores with three ethnic groups demonstrated a slightly different factor structure, with four factors identified with Hispanic Americans and three with Anglo Americans and American Indians (Snyder, 1991).

A different approach to research with the WISC-R and American Indian children was utilized by Chrisjohn et al. (1988). They used local examiners and changed testing conditions slightly to allow for the cultural conditions, as noted in previously published literature. Under those conditions, no significant differences were found between performances of the American Indian and non-Indian samples. This study seemed, in some measure, designed to cope with Chrisjohn and Lanigan's (1984) criticism of research with American Indian children, as cited in the next paragraph, and gave credence to their concerns.

Chrisjohn and Lanigan (1984) listed five primary problems identified in the approach taken to research with American Indians. These problems included the following:

1. Pan-Indianism, or "a curious tendency to treat members of different nations as more or less interchangeable" (p. 50). They maintained that there is homogeneity of American Indian cognitive processes yet to be studied. What work has been done points to marked differences between American Indian groups.

2. Small sample sizes. Information gleaned from a study is not necessarily representative and does not lead to responsible decision making.

3. Use of improper instruments. Their primary concern is the use of projective tests such as the Draw-A-Person because they do not meet minimal psychometric requirements and have inherent bias through the interpretation procedure.

4. Lack of fundamental psychometric research. In using certain tests with different populations to compare

groups, assumptions are made about the instrument being used for which there are no empirical supports. Two assumptions they refer to are a lack of bias and the test measures the same information in both groups.

5. Lack of theory. The authors contended that there is no "Indian-specific or Indian-generated" model of intelligence from which intelligence testing has been developed. They stated that all theories have come from work with non-Indians and thus are deficient (Chrisjohn & Lanigan, 1984).

Models of Cognitive Differences

In his extensive review of the subject, Cattell (1987) examined differences in intelligence test scores from many perspectives and then made several important points. First,

> obstacles to clear concepts in this area due to emotionalism are rendered unusually formidable because prejudice can readily hide in intrinsic conceptual subtleties and evade disciplined statistical thinking. (p. 306)

In addition, Cattell (1987) claimed that if one had the tools to study this area in detail, one would find variations in the proportion of differences because of nature versus proportion due to nurture; for example, small groups such as families might function differently than large cultural groups. As an example, he suggested that in a group of families the strongest will be pushed to excel, whereas among individual family members in the smaller system, the intellectually slower child will be pulled up toward the mean. He further commented that even identical twins in the same family do not experience the same environment because of the push by themselves and their parents to develop their identities. A third critical point, based on Cattell's earlier work in this field, was his contention that "the population heritability is noticeably lower for crystallized than fluid intelligence" (p. 324). This third point was supported by his report of the literature on twin studies. In this discussion, he noted one factor (correlating to differences in school application and other stimulation) was observed among identical twins. In contrast, two factors (one relating to fluid-type abilities and one to environmental influences) were seen with fraternal twins. An obvious difficulty with this concept is, as previously noted, that fluid intelligence is difficult to measure and thus far most "so-called" intelligence tests tend to measure more crystallized or education-bound abilities. However, under somewhat ideal conditions in which, as Cattell (1987) noted "culture-fair, fluid ability tests are used," he suggested

> a 9:1 ratio of genetic to environmental influence between families. In crystallized ability, however, the value will typically be lower and more dependent on the accidents of the particular cultural regime. (p. 334)

His ideas became more thought provoking when he stated:

> As the term "investment theory" indicates, g(f) is liable, in its generation g(c), to all the risks of an investment. Laziness may cause it scarcely to be invested at all; differences of individual interest may cause it to be invested in directions different from that in which "traditional" intelligence tests measure it—as Darwin's schoolboy interest went to discriminating butterflies and insects instead of the Latin participles by which his teachers judged his intelligence. Whole cultures may invest their g(f) resources in what seem peculiar directions to others. . . . The nature-nurture ratios for g(c) are thus at least as much of sociological as of psychological interest and are not fully described until content area as well as ratio become fixed. (pp. 334-335)

What this seems to mean is that cultures make choices that may be strongly attached to evolutionary or survival needs about how they "invest" their fluid abilities that then directly relates to the content and functioning of their crystallized intelligence. Since different groups or different individuals living in dissimilar environments or facing distinct challenges will not all require the same knowledge, they could look very different across the same test. Some may be judged "bright" and some "intellectually impaired," even though they function equally well within their respective environments.

In exploring environmental factors, Cattell (1987) strongly suggested that in addition to studying nutrition, richness of environment, and favorableness of emotional atmosphere, patterns of childrearing practices, parental occupation, freedom from physical diseases, family size, exposure to a large vocabulary in the language of the culture (including effects of a second minority language), income, books, television, social class, and race backgrounds also need to be considered (Cattell, 1987).

Berry (1986) refined the traditional view of intelligence through cross-cultural work with cognitive abilities. In one lecture on culture and cognition, he asked the question, "Clearly people in different cultures do different things with their lives; does this mean they function differently psychologically?" (p. 59). In this work, which is a summary of his lifetime research and theory, he described four contemporary positions on cognition across cultures. The first (ethnocentrism) is focused on an idea stating that the people of Euro-American background do better on tests of cognitive abilities than people of other backgrounds. Therefore, this is a statement about their "value" or place in the world order. His comments about this view suggest a strong warning for those in the field:

> One can take this observation as an indication of convergent validity, or as a warning signal that our science is not independent of our ideology. . . . To remain fixed in the view that our tests tap cognitive abilities well, for other peoples in other places, is to do bad science. (p. 61)

Berry (1986) labeled the second position "relativism." He said that relativism is driven by the desire to see each group as exhibiting a unique set of cognitive abilities that can best be understood within their own cultural context.

Berry suggested this is a realistic perspective, cautioning only that one should discover information that is uncomfortable.

"Universalism" was identified in the third position. Berry (1986) saw this as a combination of the two previous positions in which one considers differing cultural contexts while maintaining an ability to generalize information without using hierarchies.

The fourth position, as advocated by Berry (1986), was labeled "ecological context." In this theory, he noted:

> the local ecological context sets the stage for the performance, and no understanding of cognitive abilities is possible until the nature of their setting is also understood. (Berry, 1980, p. 220)

He argued that while all cultures develop cognitive abilities, it is unknown whether they are developed to the same degree and whether the cognitive goals, which are based on lifestyle needs, are the same or different among cultures. His concluding argument succinctly summed his discussion:

> We propose that cognitive abilities develop and display themselves in different ways in different cultures according to the adaptive requirements in those ecocultural contexts. (p. 72)

Clearly, Berry (1986) strongly believed that different cultures develop skills to different levels, but he also believed the emphasis must be on different rather than better or worse and higher or lower (Berry, 1986). Chrisjohn and Peters (1986) supported this stand in their work with American Indians who have traditionally been identified as "less than" compared to their non-Indian counterparts.

The Laboratory of Comparative Human Cognition (1990) provided evidence counter to Berry's (1986) theory on the development of cognitive abilities in cultures. Their results indicated a "cognitive style" should "cluster within domains [perceptual, cognitive, social, and affective] and correlate highly across domains" (p. 659). In their report, they cited evidence suggesting that consistency does not exist to the degree expected when one moves from one domain to another such as from perceptual/cognitive to social/ affective areas. They also noted that in deriving his experimental results, Berry used a combination of tests that were inappropriate such as some had no "right" or "wrong" answers, just differences, and others very clearly measured "right" and "wrong," high and low scores. The use of instruments utilizing right or wrong answers to measure field independence and field dependence left some subjects with low scores. Berry's goal was to gather information from a wide selection of measures of field-dependent traits, but the Laboratory of Comparative Human Cognition maintained that the scores on some of his instruments could easily be misinterpreted to suggest low scoring people were less well-developed cognitively than others. This led the group to conclude:

> Berry and his colleagues have been dealing with a less pervasive set of individual accomplishments than their theory commits them to. By using behavioral indicators that have clear implications of higher and lower levels of performance, they leave open an interpretation that links field dependence (the style that generates low performance) to lower stages of development. (p. 661)

In prior work by Dasen, Berry, and Witkin (1979), this apparent problem had been reframed into the acceptance of specific evolution in which adaptive improvement is related to the adaptive problem; that is, different styles were developed to adapt to different environments. The Laboratory of Comparative Human Cognition (1990) was not satisfied with the explanation and described their concerns further. They referred to many of the measures as "function specific" and suggested when exploring differences in function and attempting to make generalities that the researchers are only reaching limited aspects of cultural differences and opening themselves to making false judgments about differences. In their view, cross-cultural differences are better identified in context-specific terms in which not only the function itself is assessed but also its usefulness within the context of a particular culture is explored (Laboratory of Comparative Human Cognition, 1990).

Attempts to implement these theories led to the development of several working models to explain apparent differences in cognitive abilities. An intricate set of models developed by McShane (1983) to explain perceptible differences between American Indians and non-Indians was labeled the four "D" models: (a) disadvantage/deficit/ deprivation, (b) disorganization/disruption, (c) difference, and (d) developmental change. In the first of this group of models, American Indian children are said to have experienced detrimental environmental conditions that place them at greater risk and disadvantage than more fortunate groups of children. This model accounts for the effect of malnutrition, poverty, inadequate health care, poor housing, crowded living space, and access to lower quality educational programs and experiences. The effect of mobility on learning and academic success also is included. The model suggests that these factors are especially important because of the many secondary effects such as underdevelopment of cognitive abilities and/or impaired sight and hearing from inadequate health care (McShane, 1983).

The second "D" model (disorganization/disruption) relates to the integrity of American Indian culture embedded within the context of the majority culture and the subsequent effect on the American Indian child.

> They are pressured to assimilate (relinquish cultural identity and move into a larger society), to integrate (maintain cultural integrity while becoming a part of a larger society), to reject (by withdrawing from contact or influence or by resisting passively or actively), or to experience marginality (a combination of cultural loss, deculturation, and exclusion from participation in a dominant society). (McShane, 1983, p. 35)

The third "D" model surveys how American Indians differ on both an individual and cultural level. This difference is evident in the greater reliance on cooperation as opposed to competition and significant differences in nonverbal behavior that can lead to miscommunication between American Indians and non-Indians. Hess and Shipman (1965), in their study on communication styles, substantiated this model by stating that certain communication styles seem to be related to success in school, and not using the styles in the home is a form of cultural disadvantage affecting the children's cognitive style and subsequent learning.

The fourth "D" model (developmental change) has many components. These components include academic performance changes over time and neurosensory system changes that include the effects of physical growth and illness, verbal and nonverbal language ability, identity, stress and mental health factors, child rearing, competence and development, motivation orientation, and family integrity and stability (McShane, 1983).

Cognitive Style

A more widely used model that also developed out of concern about apparent differences among ethnic groups on intelligence test scores was cognitive or learning style. Several different definitions existed of this concept, but the majority of these definitions seemed directed at finding a means to match school with students as opposed to matching students to school. Messick (1984), aware of a variety of definitions as well as overlap between concepts, defined those that are described from a system's perspective as "structural properties of the cognitive system itself" (p. 60). Under this definition, cognitive style is seen to include dynamics of cognitive complexity versus cognitive simplicity, degree of permeability of boundaries, and degree of compartmentalization.

A second formation defines cognitive style as "self-consistent characteristic modes of perceiving, remembering, thinking, and problem solving" (Messick, 1984, p. 60). In this realm, concepts such as leveling versus sharpening and scanning versus focusing are the mainstays.

Messick (1984) also included in his review of cognitive styles conceptions such as

> cognitive preferences, preferred or habitual decision-making strategies, intraindividual patterns of abilities, intraindividual patterns of cognitive controls, intrapersonal contrasts, differential facility, preference for processing different forms of information, ingrained strategies of learning and knowledge acquisition, attitudes toward thinking, learning, and intellectual activity, or cognitive consequences of personality trends. (p. 60)

Okonji (1980) defined cognitive styles as "configurations of cognitive control principles found in a given person" (p. 2) in which the principles are actually "modes of perception and thinking and constitute dimensions of personality organization" (p. 2). Through this definition, cognitive styles were postulated to be stable over time (Okonji, 1980).

Dunn and Griggs (1990) also believed learning style incorporated several factors, including environmental stimuli, emotional stimuli, sociological stimulus, and physical stimulus. In a review of eight studies exploring learning style with several cultural and ethnic groups including African Americans, Chinese Americans, Mexican Americans, Greek Americans, Asian/Pacific Islander Americans, and Cree Indians, they noted, "There were clear differences among the groups, with respect to the patterns of strategies the students reported" (Dunn & Griggs, 1990, p. 275). The authors then suggested that some of the differences may be cultural in nature, in which case "many people in each culture differ dramatically from each other" (p. 275).

Cohen (1969) theorized that patterns of conceptual organization and field articulation are related to dominant styles of family and friendship group participation. She proposed that two types of group participation operate in family settings: (a) "shared function" and (b) "formal primary group" (p. 831). She believed that people brought up in a shared-function setting will be more likely to define their identity within the group context and in perceptual tasks might be unable to act field-independently. Conversely, people brought up in a formal-function family setting are better able to define their identities outside of a group context and thus will be more field-independent in perceptual tasks (Cohen, 1969).

These patterns seem to relate in some way to the absorption of information by individuals, that is, the manner that differs across individuals. There is some apparent disagreement as to how cognitive styles are started in an individual, with some researchers describing them as habits and others as related to an interaction between personality and environment. There is agreement, however, that these styles seem to be stable over time, involve cognitive, personality, and interpersonal domains, and do not seem open to change by specific tuition or training (Messick, 1984). The environmental factors often associated with cognitive style have been identified as (a) socialization, (b) social organization structure, (c) ecology, and (d) nutrition (Witkin & Berry, 1975).

In their review of the literature, Vernon, Jackson, and Messick (1986) stated:

> The patterns-of-abilities hypothesis holds that a major contributing factor in the development of differential patterns of abilities between groups is the difference in the cultures to which the members of the groups have been exposed—especially with respect to learning experiences, opportunities, and value emphases. (p. 209)

Citing supportive research results, Vernon et al. (1986) also claimed that an increasing entrenchment exists of cultural influence with age for Chinese American and Puerto Rican American groups, whereas Jewish American and

African American groups demonstrate increased diffusion. The differences among groups seem to hold steady when language used in the home is controlled or when socioeconomic status is controlled but not when both are controlled (Vernon et al., 1986). Lesser (1976), when discussing results of a study in which four ethnic groups were compared on measures of cognitive ability, reported:

> The findings were that each ethnic group displays its own distinctive pattern of mental abilities, significantly different from that of the other groups, and that social class variations within the ethnic groups do not alter this basic pattern specific to each ethnic group. (p. 143)

Additional research with Chinese American, African American, and Puerto Rican American 1st-grade students (Coleman et al., 1966) and 6th-grade students (Lesser, 1976) found similar patterns of abilities, as did Flaugher (1971) at the Educational Testing Service with 11th-grade children. These patterns have been reported to exist in children as young as 4 years old (Willerman, 1979).

In a large study on patterns of abilities in 12th-grade Jewish American, non-Jewish American, African American, and Oriental American students, Backman (1972) reported that gender accounted for the largest part of ability differences, followed by ethnic differences, and then socioeconomic status. Burg and Belmont (1990), using the same tests and procedures as described by Lesser et al. (1965), collected data on mental abilities of 320 first-grade, Israeli-born children whose parents had emigrated from four culturally distinct areas. The results demonstrated that each of the four groups exhibited its own pattern of mental abilities. However, the results of discriminate analysis suggested that the largest proportion of children in each group tended to follow the general pattern of their own group but that there were also large numbers of children in each group who showed patterns unlike those of their group (Burg & Belmont, 1990). The authors further suggested that there is no one "African American," "Puerto Rican American," or "Chinese American" pattern but "that abilities are related to the different origins, migrations, traditions, and social experiences of different cultural groups" (p. 105).

In a continuing examination of the concept of patterns of abilities, Feldman (1973) reexamined the results obtained by Lesser in his studies of mental abilities (Lesser, 1976; Lesser et al., 1965). Feldman concluded, "Rankings on sets of tests may lead to different 'patterns' as a function of data transformations" (p. 16). He believed that there is limited basis for which type of data, normalized versus raw scores, should be interpreted; thus, the differences reported by Lesser and associates remain obscure (Feldman, 1973). Feldman (1973) discussed several other problems with the data, including Lesser's conclusions about individual differences and applicability of a "best-fit" model. Since the Burg and Belmont (1990) study was based closely on the

Lesser et al. (1965) work, it follows that these concerns could be stated about his work as well. Vernon et al. (1986) also contended the manner in which data are transformed makes some of the patterns of abilities appear arbitrary, and these transformations allow questions about what the profiles really are and what they mean. He later stated, "The evidence regarding the existence of distinct ethnic group ability profiles is at best sparse and at worst equivocal" (p. 221).

However, there does seem to be a strong body of literature that suggests between-group patterns of abilities seem to exist. One inherent problem with this collection of information is to what purpose it is being used. Is it live ammunition for those, as Chrisjohn and Peters (1986) suspected, who wish to prove genetic inferiority of ethnic and racial minorities? Or is it a more thorough knowledge-gathering effort, the results of which can be used to better understand one's ethnically and racially diverse population? The results, should they continue to demonstrate between-group differences, need to be used carefully to further educational causes and recognition of the richness of differences.

American Indian Learning Styles

Kaulback (1984), in his review of literature on American Indian learning styles, stated:

> Although far from conclusive, there is a growing

> body of research to suggest that distinctively different child-rearing—one stressing observational learning and another emphasizing learning through verbalization—has fostered the development of very different styles of learning among Native and white children. Whereas many white children, by virtue of their upbringing and their linguistic exposure, are oriented towards using language as a vehicle for learning, Native children have developed a learning style characterized by consequences in the formal education of Native students, particularly in view of the fact that the formal educative process almost always favors those who are highly verbal. (p. 34)

More (1986), in his work on learning styles, sees the childrearing practices of cultures as a viable source of differences in cognitive ability patterns. There may be many similarities, particularly with the development of media and electronic information transfer, but many subtle and strong differences still exist that he believed impact not only socialization but thinking styles as well.

Kleinfeld and Nelson (1991), in their examination of the literature on learning styles, drew two conclusions. The first, based on a broad body of research, is that American Indians do have distinct strengths in spatial abilities and visual memory, and observational learning is an important cultural orientation. The second conclusion is that the research does not demonstrate that instruction adapted to the visual learning styles of American Indians results in greater learning. Their first conclusion was based on several years of research results, but the second conclusion was based on only three studies—the only empirical research they could locate in an apparently exhaustive review of the literature. They referred several times to 20 years of research, suggesting that adaptation of teaching styles to learning styles increases learning. The body of research testing this hypothesis was minimal, considering the depth of the conclusion they were drawing (Kleinfeld & Nelson, 1991). The review suggests that more carefully controlled research is needed in this area to examine the matching hypothesis.

Kleinfeld and Nelson's (1991) conclusions have been contradicted by several researchers who stated that a divergence in cognitive functioning is, in some part, responsible for problems experienced by American Indian students and the subsequent difference in their success rates (Dunn & Griggs, 1990; Krywaniuk & Das, 1976; Matsalla, n.d.; More, 1986). School curriculum is said to be directed at students who "utilize linear, sequential modes of thinking" (Young-hee & Gordon, 1983, p. 98) while possibly minimizing other processes such as spatial abilities (Young-hee & Gordon, 1983). Atwell (1989) found that there were significant differences across eight academic areas in American Indian children's learning style, as measured by the Canfield Learning Style Inventory. In this study, she concluded that learning styles contribute to the success of American Indian children, that the children should be made more aware of their strengths, and that the teachers should receive counseling to teach learning strategies.

In a further exploration of relationships between cognitive style and educational experience, Tamminga (1991) tested Navajo males with the Witkin Group Embedded Figures Test. He correlated the scores with ethnographic information, including degree of acculturation and feelings about being Native American. He found that the cognitive style was in transition from field dependent to field independent but also was related to school experience. He noted that negative feelings about being Native American were correlated with what he referred to as the adaptive "field independent" style.

In a discussion about American Indians and the issue of learning style, Chrisjohn stated:

> We have doubts about the validity of intervention programs based on assessment of style. More fundamentally, however, we find that the styles most frequently mentioned—field dependence-independence, reflection-impulsivity, and the like—simply do not capture the depth of the cognitive mismatch between Indians and schooling. (Chrisjohn et al., 1988, p. 259)

Furthering this idea, they declared:

> Rather than attributing this disparity in achievement level to some deficiency on the part of Indians, we would like to suggest that Indian academic performance is an understandable, adaptive reaction to the circumstances typically encountered by the students. (p. 258)

Some of the "circumstances" encountered in school by American Indian children were delineated by Wilson (1991). He reported that students believed they were viewed by teachers as less capable than other students and thus treated differently than non-Indian students. The American Indian students believed interactions with teachers were different, and the guidance for class selection was based on lower expectations than non-Indian students received.

In a similar hesitance to accept the concept of differences in learning styles as a panacea for American Indian students' school problems, McCarty, Wallace, Lynch, and Benally (1991), in their article reporting curriculum changes made at a school on the Navajo Indian Reservation, suggested that the rhetoric about learning styles is detrimental to American Indian learning. They stated that it tends to "type" American Indians as a singular entity rather than a grouping of varied people. They contended this manner of discussing the issue is racist because it separates American Indians as a group. Their point was that the process underlying the defined "style," such as how information is transmitted in an observational learning style, is important but is not addressed. They suggested that, without looking at the processes, the educational system may continue to seem a difficult environment for American Indian children.

In spite of the valid concerns of these later groups, researchers have identified this area as one requiring greater investigation as a possible source of information to explain the relative success rates of American Indians compared to non-Indians. There is also a campaign to explain apparent differences in cognitive abilities that seem to appear consistently.

In his work with American Indian learning styles, More (1986) observed that traditional learning styles included global/analytic, "watch-then-do" strategies, use of legends and stories for learning, and cultural differences relating to the view of the future and the use of symbolism to make a point (More, 1986). More, along with Rhodes (1988), also noted that childrearing practices and communication patterns are integral to traditional learning styles and are often carried to school with American Indian children.

Research with American Indian cognitive processing styles has focused on four major areas of interest: (a) laterality (Brokenleg, 1983; Browne, 1984); (b) field dependence/field independence (Berry, 1966; MacArthur, 1968; More, 1986; Weitz, 1971); (c) sequential versus simultaneous thinking (Brokenleg, 1983; Matsalla, n.d.); and (d) spatial abilities (Bowd, 1974; Cohen, 1985; Dasen, 1975; Lipinski, 1988; Marjoribanks, 1972).

Researchers exploring laterality in American Indians have used a number of different methods to determine laterality. This type of method seems to affect the conclusions. McShane and Plas (1982a) and Browne (1984) (using the Wechsler batteries) suggested that American Indians use right-hemisphere processing. They extrapolated this to mean that American Indians use nonverbal, holistic, simultaneous thinking processes.

Using the Cognitive Laterality Battery, which is a test designed to explore cognitive profiles and laterality, Lipinski (1988) conducted a study with rural remote and urban Alaskan Native male children and urban Anglo American male children. She reported significant differences between cognitive profile scores of rural remote Alaskan Native and urban Anglo American and urban Alaskan Native and urban Anglo American males (Lipinski, 1988). The patterns indicated that Alaskan Native male children tended to perform better on visuospatial tasks compared to verbal sequential, whereas non-Indian male patterns were the reverse. The visuospatial abilities are often believed to be right-hemisphere skills, whereas verbal-sequential abilities are typically associated with the left-hemisphere skills (Springer & Deutsch, 1985). Ross's (1982) anecdotal information also supported the hypothesis of right-hemisphere processing. In his later writing, some of Ross's statements suggested that he viewed the proposition almost as fact rather than one hypothesis (Ross, 1989). In response to the proclamations of right-hemisphere processing by American Indians, McCarty et al. (1991) commented that, in spite of efforts to the contrary, much of this work has led to further stereotyping of American Indians, which continues to box all tribal groups as though they were the same and then justifies remedial and nonacademic curricula for them. McCarty et al. characterized this process as racist and expressed concern about the tendencies to stop at the apparent differences without exploring underlying mechanisms.

McKeever (1981) used a tachistoscope (a machine designed to display stimuli specifically to either the right visual field or the left visual field) to explore language processing in American Indians. He reported no differences in direction and magnitude of language laterality between Navajo and Anglo subjects. He also found no apparent differences between English-speaking Navajos and bilingual Navajos for laterality of language.

Chrisjohn and Peters (1986) also questioned the hypothesis of right-hemisphere processing. They believed that it is based on stereotypes and racist thinking and is being used to keep the American Indians in a subordinate position.

Another concept (simultaneous vs. sequential processing) was explored by Krywaniuk and Das (1976), Matsalla (n.d.), Brokenleg (1983), and Davidson (1992). They found similar results with somewhat different methods, but Brokenleg and Davidson used the K-ABC as a measurement of these abilities. They independently concluded that American Indian children tended to use simultaneous thinking more than sequential thinking, which differed in non-Indian children. Thus, their American Indian subjects used a code that was "quasi-spatial in nature, having the characteristic that all points of it are immediately surveyable" [as opposed to one that is and] more temporal in nature, being accessed only in a linear way" (Cummins & Das, 1980, p. 777). Krywaniuk and Das (1976) also reported that, with training, a significant increase in sequential tasks such as auditory and visual memory and reading tests could be seen. However, in an attempt to investigate Krywaniuk and Das's work, McShane and Plas (1982b) factor analyzed WISC-R results from 77 Ojibwa children. They did not find a factor structure that would support a clear simultaneous/ sequential differentiation.

Berry (1966), Weitz (1971), MacArthur (1968), and More (1986) all reported that their American Indian subjects seemed to be more field independent than field dependent, suggesting that American Indian children would be better able "to provide an organization structure to a disorganized set of facts or observations (e.g., making a mental map of the surrounding terrain)" (More, 1986, p. 11) than field-dependent children.

In contrast, Pelto (1991) recorded results opposite to the above findings, stating that American Indian children seemed more field dependent than non-Indian children and demonstrated differences by age and gender. Utley (1983) explored field dependence/field independence in Menominee

Indian children, noting that there were no significant cultural differences in field dependent/field independent but that there were significant gender differences in field dependent/field independent. When intelligence was controlled, the degree of variance lessened (Utley, 1983). However, intelligence was measured by the Raven's Progressive Matrices, which is occasionally used to measure field dependent/field independent patterns (Berry, 1966, 1969), suggesting an overlap of measures and making the conclusions somewhat suspect.

Most researchers examining spatial abilities in American Indian and non-Indian children reported that Indian children appeared to have stronger spatial skills than verbal skills and stronger spatial skills than non-Indian children (Bowd, 1974; Browne, 1984; Kleinfeld, 1970; Lipinski, 1988; McShane & Plas, 1982a). Interestingly, research results also suggest that the primary component of field dependence/field independence processes is spatial abilities (McGee, 1979); thus, differences in field independence/field dependence found with males and females and between American Indians and non-Indians may be artifacts of group differences in spatial aptitudes. Evidence also exists suggesting that there is no difference between American Indians and non-Indians in spatial abilities (Cohen, 1985).

All four of these areas (laterality, simultaneous/

sequential processing, field dependence/field independence, and spatial abilities) are seen by educators as important components in the overall assessment of learning styles in American Indians (More, 1986). These investigations seem to be somewhat closer to Chrisjohn and Lanigan's (1984) suggestions for conducting research on intelligence in American Indians, but one final comment from More (1986) is in order. More and other researchers (Chrisjohn, Towson, & Peters, n.d.) also suggested that the use of means for comparison may be faulty, as all items of all tests do not necessarily behave the same with different groups. More suggested, therefore, that examination at the item level should occur before "telling us that Indians are right-brained, learning disabled, or possessed of a negative self-image" (p. 12).

Research on Spatial Ability

One area that has been consistently identified as a component of both intelligence and cognitive styles is spatial ability. In his review of the literature on factor analytic studies of spatial aptitude, McGee (1979) reported that a spatial factor distinct from verbal factors was identified as early as 1925. This distinct spatial ability factor has been reported as being manifested "in situations ranging from navigating through one's environment to determining the trajectories of approaching objects"

(Pellegrino, Alderton, & Shute, 1984, p. 239).

Researchers in the field, including Spearman (1927), seemed to be hesitant to accept the possibility that an additional factor did exist, something above and beyond the (g) factor. In 1935, Alexander (in Smith, 1964) conducted research using a number of different performance scales, the scores from which he entered into a factor analysis. From this finding, he demonstrated that an additional factor seemed to exist. He labeled this the F factor, which he related to concrete abilities as opposed to abstract verbal abilities typically measured (Smith, 1964).

Cattell (1987) noted, "Spatial thinking involves especially keeping 'orientations' in mind" (p. 41) and reported that Thurstone (1938) believed thinking in two dimensions might be different from thinking in three dimensions. Spatial reasoning and visualization were seen as being factors distinct from spatial thinking, even though they were not explained in-depth (Cattell, 1987). Visualization was seen as a much broader concept, including

> "seeing" what will happen to a piece of paper when cuts are made in a folded state, imagining the change of view when an object is rotated, and envisaging the direction of movement in one part of a machine when another part moves. (Cattell, 1987, p. 42)

Smith (1964) reported that Kelley (1928) identified a spatial factor in several tests using children aged 10 to 16 years. He also concluded that the spatial factor could be separated into two parts that he described as "an ability involving the sensing and retention of geometric forms, and a facility in the mental manipulation of spatial relationships" (Smith, 1964, p. 46).

Contradicting the rush of evidence supporting a spatial factor was a large body of information that cast doubts on its very existence. In response to the doubts, a series of studies was conducted by several research groups using large numbers of test instruments with large groups of subjects. A stronger base of information was established, indicating the presence of some factor involving spatial abilities and relating to mechanical and mathematical success (Smith, 1964). These studies often used more advanced statistical techniques such as factor analysis with orthogonal rotation, which were not previously available. In addition, many of these reports on spatial abilities published prior to World War II related that spatial abilities did not appear until approximately 14 years old.

Spatial skills have been referred to as a single distinct ability. However, research using information-processing models suggests that the term "spatial ability" is a generalization for several distinct abilities requiring spatially oriented aptitudes (Kosslyn, 1987).

<u>Factor Analytic Studies</u>

As noted previously, Kelley (1928) first reported the apparent existence of two spatial factors as early as 1928 (Smith, 1964). Michael et al. (1950) reported findings that, again, implied the existence of two separate spatial factors: (a) spatial relations and (b) visualization. The spatial relations factor was suggested to represent "the arrangement of elements within a visual stimulus pattern, primarily with reference to the human body" (Michael et al., 1950, pp. 189-190). In contrast, the visualization factor was believed to represent "an ability that requires the mental manipulation of visual imagery" (Michael et al., 1950, p. 190).

Thurstone (1938) identified seven factors, three of which related to visual orientation in space that he labeled S1, S2, and S3. In 1951, he reported 10 factors, 3 of which again were related to spatial visualization abilities and labeled S1, S2, and S3 (Smith, 1964). S1 (the first factor) appeared in tests in which the subject had to determine whether or not a figure could be made to coincide with a given figure by rotation in the plane of the paper. The second spatial factor (S2) seemed to occur in tests involving paper puzzles and surface development. Thurstone had difficulty identifying the third factor because it only appeared in two tests (Smith, 1964).

French (1951) also published a report discussing the constructs of three spatial factors, which were identified in several factorial investigations. He identified these as space, spatial orientation, and spatial visualization. He believed that the space factor represented "the ability to perceive spatial patterns accurately and to compare them with each other" (Smith, 1964, p. 86). He stated that the spatial orientation factor seemed "to involve a person's ability to remain unconfused by the varying orientations in which a spatial pattern may be presented" (Smith, 1964, p. 86). Finally, he identified the spatial visualization factor as "the ability to comprehend imaginary movement in three-dimensional space, or the ability to manipulate objects in imagination" (Smith, 1964, p. 86).

Reports at a symposium in September 1952 suggested that the space and visualization factors were linked but were differentiated by relative amounts of complexity or difficulty. In a follow-up report, Guilford and Zimmerman (1953) suggested that the distinction between Thurstone's space factors (S1 and S2) also could be interpreted in terms of the continuum hypothesis.

In later research synthesizing the findings of research in this field, Michael, Guilford, Fruchter, and Zimmerman (1957) described three spatial factors, the two previously identified and a third factor called kinesthetic imagery. They said:

> [This factor] represents merely a left-right discrimination with respect to the location of the human body, so that the left and right hands seem vicariously or tentatively to move in response to a simple visual stimulus displayed in a test item. (Michael et al., 1957, p. 191)

Subsequent researchers who explored this area using factor analysis had difficulty agreeing on the number of spatial factors. DeFries et al. (1974) found four factors, and Humphreys and Taber (1973) reported six factors. The lack of agreement in the field represents the methodological deficiencies in the studies. Different tests were used to measure the same factors, factors similar in structure were given different names and specific definitions, and different researchers used different criteria for factor analysis (Lohman & Kyllonen, 1983).

Two components of spatial abilities (spatial visualization and spatial orientation) seem to reoccur consistently in the literature (McGee, 1979; Vandenberg, 1975). Ozer (1987) suggested, based on Sherman's (1967) work, that the spatial orientation component is strongly related to the concept of field independence. In addition, there are several suggestions that correlates of performance on field independence tasks extend into the domain of personality and social behavior (Goodenough et al., 1977; Ozer, 1987; Witkin & Goodenough, 1981). In a review of Ozer's work, Waggett and Lane (1990) suggested a lack of evidence to support Ozer's conclusions about the relationship between personality and cognitive correlates spatial ability. Interestingly, they support other research demonstrating the relationship but indicating that Ozer may have found a "pattern of relationships that hold under some as yet unspecified conditions" (p. 130), a proposal that may vaguely explain other group differences.

Ozer (1987) conducted a study to explore three aspects of spatial visualization. He reported that, contrary to previous belief, spatial visualization seemed to be related to verbal ability in females, but not males, and to remain consistent across ages. He also reported that in females spatial visualization ability seems to be related to social responsiveness and willingness to face problems, but this relationship is not seen in males.

Another variable that is often explored is "handedness." Linking handedness to any ability on a consistent basis is difficult. However, Levy (1976) presented previous research reporting that sinistrals were generally poorer than dextrals in spatial ability (McGlone & Davidson, 1973).

Out of frustration with contradictory data presented in the existing literature about spatial aptitude factors, Lohman (1979) collected data from prior studies that had common methodological and theoretical perspectives and conducted a factor analysis on the combined original data. His results suggested the following: (a) Several mechanisms were present that affected the efficiency of processing spatial information, and (b) three spatial factors were present. The factors were reported and defined as follows: (a) spatial relations, which is the ability to solve mental rotation problems "by whatever means" (Lohman & Kyllonen, 1983, p. 111); (b) spatial orientation, which is "the ability to imagine how a stimulus array will appear from another perspective" (Lohman & Kyllonen, 1983, p. 111); and (c) visualization, which is characterized by tasks requiring a manipulation in which there is movement among the internal parts of the stimulus configuration or the folding and unfolding of flat patterns (Pellegrino & Kail, 1982). Pellegrino and Kail proposed that visualization and orientation tasks exist on dual continuums from speeded to unspeeded and simple to complex and that the two factors are differentiated by their places on the continuums. This differentiation seems similar to the one made by Zimmerman in 1951 (Smith, 1964). Ozer (1987) stated that the difference between the two is probably reducible to the difference between manipulation of, and adaptation to, visual stimuli.

In a different vein, Kosslyn (1987) hypothesized that humans process two different types of spatial-relation representations. The first type is used to assign spatial relation to a category such as "outside of" or "above." The other type of representation holds location information with a metric coordinate system in which distances are effectively specified. Suspecting that the best way to support this hypothesis was through neurological substrate data, Kosslyn suggested the following: (a) The left cerebral hemisphere makes more effective use of the categorization processing subsystem, and (b) the right cerebral hemisphere makes more effective use of the metric distance processing subsystem (Kosslyn, 1987). Hellige and Michimata (1989), in a follow-up study examining this hypothesis, reported results that were consistent with Kosslyn. They stated:

> The brain computes two different kinds of spatial-relation representations: one used to assign a spatial relation to a category and the other used to specify metric distances with precision. (Hellige & Michimata, 1989, p. 775)

This is a somewhat different domain than factor analysis results previously reported, but it speaks to the direction research on spatial abilities is taking. Greater emphasis has been placed both on locating areas of the brain that seem to process spatial information and what precise steps are utilized in processing that information.

Gender Differences

Several studies have been conducted to examine individual differences on spatial problems between males and females (Buffery & Gray, 1972; Johnson & Meade, 1987; Marino & McKeever, 1989; Mayes, Jahoda, & Neilson, 1988; McGee, 1979). The results of these and other studies suggest overwhelmingly that males have stronger spatial abilities than females (Backman, 1972; Linn & Petersen, 1985; McGee, 1979). Jensen (1975) stated, "No other ability identified by factor analysis shows so consistent and marked a sex difference in favor of males as do spatial tests" (p. 152). Backman (1972) reported (in his study of 2,925 12th-grade students of different ethnic and socioeconomic backgrounds tested on 60 tests with 11 factors) that gender differences accounted for a larger proportion of the total variance than either ethnicity or socioeconomic status. Hobson (1947) declared that girls scored lower on a space factor in spite of having a higher overall IQ.

Wilson, et al. (1975) commented, when exploring family patterns of cognitive ability, that significant gender differences in spatial ability (seemingly related to age) existed in their sample. They consistently found that males scored better than females in the sample and that the differences were somewhat less in the younger groups.

Fenema and Sherman (1977) explored gender differences in spatial ability among high school students at four different high schools in one city. They were looking at spatial visualization ability and mathematics ability, of which spatial visualization is believed to be an important component. They found that gender-related differences varied over schools as did differences in attitudes toward mathematics. Significant differences in spatial visualization scores were found in only two schools, though boys tended to score higher at all four schools. The boys also reported a greater degree of confidence in their mathematical ability and ranked their parents' acceptance of their math study higher than girls. Fenema and Sherman concluded that apparent gender differences were interrelated with sociocultural differences—the source of the actual areas of differentiation.

In a review of the literature exploring lateralization and spatial ability, Levy (1976) stated, "There seems to be a constant depression in spatial scores of females relative to males" (p. 186). Levy proposed several theories about the occurrence, which will not be discussed here.

However, after many years of what seemed to be confirming evidence in this field, the results of more recent research are questioning the validity of these apparent differences. Maccoby and Jacklin (1974) reported that the differences seemed to appear primarily on rotation tasks; however, Kail et al. (1979) found no significant differences in any interactions involving gender.

Sherman (1974), when looking at spatial visualization and field articulation with males and females, found significant differences on only one of six measures—with a strong overlap on that measure. Even though test score differences were limited, he noted that males were more confident of their Rod and Frame Test performance and "differed from females in response to orientation of the frame on the RFT [Rod and Frame Test]" (p. 1233). Caplan et al. (1985) suggested that reported differences have been inconsistent, differences are often small, and the studies tended to be flawed. Goldstein, Haldane, and Mitchell (1990) found gender differences in spatial abilities, but these disappeared when the tasks were untimed and when the results were examined using the ratio of number correct to number attempted. Linn and Petersen (1985) conducted a factor analysis of spatial ability, stating, "General ability is described as the ability to select from among one's repertoire of strategies an appropriate one for a particular problem" (p. 93). In exploring gender differences, they concluded that males and females do not seem to differ in the ability to select the best strategy, but they may differ in the type of strategies available to them. They continued by suggesting that the most efficient strategy for a particular task may be less developed in females than males (Linn & Petersen, 1985). This point of view also was proposed by Halpern (1986).

Cattell (1987) suggested a need to consider three factors when interpreting gender differences in abilities. These factors are

> (1) maturational differences, genetically determined in neurology and hormone balances, (2) culturally produced differences through training for specified roles and ego (dials), and (3) systematic differences in opportunity. (p. 135)

In addition, Halpern (1986) suggested that since such a large number of different tests are used in research that gender differences may be related to the specific test and its actual validity. They reported that some tests do not reveal gender differences, whereas others do, including the "Water Level Test" devised by Piaget and Inhelder (1956, in Halpern, 1986).

Several theories have been proposed to explain the apparent differences. One of the earliest theories suggested that an X-linked recessive gene was discovered related to stronger spatial abilities (Goldberg & Meredith 1975; Goodenough et al., 1977; Stafford, 1961). Because it was recessive, the abilities were seen more in men who had no other gene to dominate the spatial gene. Another suggested theory is that lateralization is different between the genders, implying that males are more finely lateralized than females. This difference in lateralization is determined by timing of puberty, and it accounts for differences in spatial abilities (Halpern, 1986; Waber, 1977). This theory has been linked with the idea that differences are caused by hormonal differences between the two genders (Halpern, 1986).

All of these theories have been supported by research in the field, but there has been a lack of confirming evidence. An additional theory (sex-role typing) has been examined with some success (Fenema & Sherman, 1977; Serbin & Connor, 1979). Research results have demonstrated that men and women who perceive themselves as more masculine tend to perform better on spatial tasks (Signorella, Jamison, & Krupa, 1989), and, if a task is perceived as masculine, men will perform better than women (McMahan, 1982). However, Robert (1990) did not find this to be true of the Water Level Test. This test was often judged to be neutral, but the men still outperformed the women. He suspected that the task was actually seen as more masculine but was not reported as such, which would then support the above theory (Robert, 1990). Results of other studies have suggested that spatial abilities can be taught (Newcombe & Bandura, 1983), and women who have equivalent training in spatial tasks tend to perform as well as males on spatially oriented instruments (Brinkman, 1966). Many of the differences seem to exist across cultures, but it is apparent that many of the same sex-role stereotypes that may affect perception and performance of people in the mainstream culture also seem to exist in minority cultures (Halpern, 1986).

In spite of the contradictions whether differences actually exist or what the causes are, the findings thus far suggest that sex differences do seem to exist but do not appear until puberty (Johnson & Meade, 1987; McGee, 1979). Conflicting evidence continues about the timing of puberty (Newcombe, 1982) and whether late maturers develop cognitive skills differently than early maturers (Newcombe, Dubas, & Baenninger, 1989). Newcombe (1982) concluded that small gender differences exist in childhood and increase in size with age, particularly with spatial orientation and spatial visualization factors. She qualified this statement by remarking that investigators had used different definitions of spatial abilities, which is the same problem noted in earlier descriptions of work with spatial abilities. Halpern (1986) also suggested that socialization has a greater relationship with differences in spatial abilities than biological processes, particularly puberty. He based this conclusion on changes in numbers of women successfully entering and completing architecture and engineering programs.

In the area of cross-cultural gender differences, much of the research conducted in the last several years has seemed to focus on within-group gender differences as opposed to between-group gender differences. This work may be in progress, or the lack of obvious research results may again be due to the tendency to generalize from one ethnic group to another without consideration for cultural influences.

Cross-Cultural Research in Spatial Ability

McGee (1979) cited several researchers who had compared groups of different ethnic and socioeconomic backgrounds including Jewish Americans, Asian Americans, and African Americans on different constructs of spatial abilities. He reported that few differences were found among the groups on these constructs. However, studies with other groups have revealed possible differences between African people and

Anglo people of Scottish descent (Jahoda, 1979, 1980) and between Alaskan people and African people of the Temne tribe (Berry, 1966). The African people had relatively lower spatial ability scores than either the Anglo people or Alaskan people, even though the two researchers used different tribal groups, different instruments to measure the construct, and the effect of language was not discussed.

Jensen (1975), in his review of the literature on gender and race differences in spatial visualization, summarized the work of several authors who had reported stronger spatial skills in Anglo Americans than in African Americans and Jamaican Americans. He used this information to support a theory that spatial ability is enhanced by a recessive sex-linked gene. He suggested that this same theory applies to gender differences in spatial ability as well.

In exploring differences between two cultural groups (Ethiopian immigrants and native Israelis) on the Progressive Matrices Test, Kaniel and Fisherman (1991a) noted differences in the mean score and distribution of errors. They stated that, when the groups were matched for total score on the Progressive Matrices Test rather than age-matched, both groups exhibited approximately the same pattern of distribution of errors. They suggested that the differences were more likely due to a developmental delay in Ethiopian immigrants rather than a difference in cognitive style.

In an adjunct study, Buriel (1978) explored the relationship between field dependence and reading and math achievement in Mexican American and Anglo American children. The study consisted of testing 40 children from each of the two groups on the Portable Rod-and-Frame Test, the Children's Embedded Figures Test, and the Wechsler Intelligence Scale for Children-Block Design (WISC-BD) subtest. Data analysis revealed no significant cultural effect on either the Portable Rod-and-Frame Test or the Children's Embedded Figures Test (Buriel, 1978). However, he reported significant differences on the WISC-BD. A significant relationship between the WISC-BD and math achievement was found, but a pattern was not found with the other two tests. These results suggest a limited relationship between field dependence and achievement in reading or math. However, if the information from McGee (1979) (i.e., field dependence is actually spatial ability) is combined with Browne's (1984) assertion (i.e., WISC-BD is the only "pure" measure of spatial abilities on the WISC), then these results are strongly suggestive of a link between spatial abilities and achievement and the existence of differences in abilities across cultures.

Spatial Ability Research with American Indians

As reported previously, several researchers have found differences between American Indian and non-Indian subjects (Bowd, 1974; Browne, 1984; Kleinfeld, 1970) in spatial abilities. In an anecdotal report of spatial abilities of the Avilik Eskimos living near Hudson Bay, Carpenter (1955) gave several examples of what he saw as remarkable abilities, which seemed to have no easy explanation. He was aware of how the Eskimos navigated the area with what he viewed as no indicators of place or direction. He commented, as well, on their apparent map-drawing and mechanical ability. Of even greater interest might be his descriptions of their ability to perceive figures in space regardless of orientation. He gave, as examples, the cribbage boards being made out of walrus tusk and a brief experiment he conducted with paper and pencil. He stated that the Eskimos were able to carve animals from the tusks without reorienting the tusk and that they were able to identify correctly animal shapes from a line drawing, again without reorienting the paper—a task he admitted he could not do.

Kleinfeld (1970) also reported anecdotal information from other sources that was similar to Carpenter's (1955). Summarizing spatial ability research with Eskimos, Kleinfeld concluded that when education levels were equivalent and the tasks were educationally oriented, Eskimos scored significantly higher than non-Eskimos. She also suggested that on noneducation-oriented tasks, Eskimos "with very little education may surpass the performance of western groups" (Kleinfeld, 1973, p. 350). Kleinfeld (1971) found that village Eskimo children scored significantly better than urban Anglo American children on measures of visual memory, and the visual memory scores increased significantly with age. She did not find any interactions between age and ethnic group, however.

McShane and Berry (1988) reported results of several studies begun in the mid 1960s in which spatial ability scores in Eskimos were apparently higher than those of non-Eskimos. Dasen (1975) found that Inuit and Australian Aborigine children developed spatial operations earlier than a sample of African children. Berry (1976) examined spatial abilities in James Bay Cree, Ojibwa, Carrier, and Tsimshian groups. He predicted that all groups but the last would have strong spatial skills based on eco-cultural factors such as a hunting lifestyle and the tightness of their social system. The results of the study supported his hypothesis, with the Crees scoring higher than the other groups. This finding was further supported by Schubert and Cropley (1972).

Looking at relative abilities of Alaskan people and members of the Temne tribe in Africa, Berry (1966) found that the Alaskan people scored better on a measure of spatial abilities than another hunting group. In an extensive study using the WISC-R with an Inuit sample, Wilgosh et al. (1986) concluded that a perceptual organization factor was relatively stronger than the verbal comprehension factor, but they did not compare the results to a non-Indian sample.

Kleinfeld (1971) found Yup'ik and Inuit village students scored higher than urban students on a modified memory for designs test. Bland (1975) used the same test with Navajo, Hopi, Jicarilla, and Anglo American students with similar results.

Bowd (1974) found trends supporting the idea that American Indians have stronger spatial abilities than verbal abilities and that these abilities are often stronger than non-Indians. However, some of his information were derived from anecdotal reports and, along with Carpenter's (1955) information, remain inconclusive. In his review of the literature, McShane (1980) reported on two studies in which American Indian children scored better than Anglo American children on the Block Design and Object Assembly subtests—tests that are often seen as measures of visuospatial ability (Sattler, 1992).

Two research groups (McShane & Plas, 1982a; Zarske & Moore, 1982) recategorized WISC-R scores and determined a factor structure in which spatial ability seemed to be the strongest area. However, McShane and Plas (1982a), who divided their group into traditional and acculturated, found significant results only with the traditional group.

Using Alaskan native children as subjects, Lipinski (1988) found that these children scored better on visuospatial tasks than on verbal-sequential tasks from the Cognitive Laterality Battery. She also found that their cognitive profile scores were significantly different from those of Anglo American male children, with the Anglo American males scoring better on the verbal-sequential tasks. In addition, remote Alaskan native boys scored significantly better on the localization subtest (a subtest strongly suggestive of absolute spatial processing) than on other subtests.

In Davidson's (1992) study using the K-ABC to look at abilities, she noted that the samples of Sioux and Navajo Indian children tested for norming of the test scored above the mean on three measures of visuospatial ability, which are part of the simultaneous measures. The results of her study, in which she compared American Indian students with Anglo American students on the K-ABC, demonstrated that American Indian student scores were significantly higher than Anglo American student scores on the same three subtests (Davidson, 1992).

In spite of what seems to be strong evidence supporting a hypothesis of greater spatial skills in American Indian children, some doubt still remains. First, many of the instruments used by the different examiners have not been carefully validated as measures of spatial ability. Again, Browne (1984) noted that the Block Design subtest is the only "pure" measure of spatial ability on the WISC-R, yet scores on all the performance subtests of the WISC-R are used to support the notion of relatively stronger spatial abilities. In looking carefully at the subtests, it is possible to identify verbal strategies that could be used to solve many of the so-called spatial problems. Probably one of the best supports of the theory is Lipinski's (1988) data in which the rural Eskimo males scored high on the Localization subtest of the Cognitive Lateral Battery. In addition, researchers again seem to have difficulty defining the American Indian in generalizing the results from one study to another and from one tribe to another.

In fact, rather than generalizing results across tribal groups, it may be important to explore relative differences within tribes, which may be fostered by an abstract concept such as "acculturated." Some researchers have been aware of this factor (Lipinski, 1988; McShane & Plas, 1982a), but it is a difficult one to capture. Most researchers seem to think about it, but, possibly due to its defiance of definition, they do not attend to it in an organized manner in much of their work. Thus, in order to assess this area with some degree of accuracy, tests designed to measure spatial ability need to be used in an organized progressive manner with groups of students in which some aspect of acculturation such as language skills are acknowledged.

Summary

Intellectual abilities have fascinated researchers for much of recent history. As capabilities for more advanced techniques have developed and as the science of psychology has grown, exploration of this area has expanded. Theories of intelligence have evolved from a belief only in what could be seen in trying to understand processes that are best captured in computer simulation. In parallel process, tests that supposedly measure this elusive concept of intelligence were developed. The problem has been that the theory and the test have not always been compatible. As with all theoretical areas, this is one area that engenders debate and concern. The quality of the tests and their validity has been, and continues to be, scrutinized. It has proven increasingly difficult to measure a concept that seems to be more complex and abstract, and yet the mind-set of the culture and society demands this to be done. This society continues to struggle and, in the process, to explore the possibility of defining intelligence as an amalgamation of parts that can be understood and measured with some individuation rather than as an untameable whole.

As one of the pieces, spatial abilities have been researched for several decades with controversy and confusion. The concept of "spatial ability" is a complex group of factors, with each factor made up of different skills. Researchers have alternately reported the presence and absence of factors. In addition, the identified factors carry a myriad of names, even though there seems to be significant overlap in the definitions. In order to codify the mass of information, Lohman (1979) reanalyzed data from 10 years of research on spatial ability. From this information, he identified three factors: (a) spatial relations, (b) visualization, and (c) spatial orientation. Research with a general construct of spatial ability and with individual factors has revealed strong evidence of gender differences, with males achieving higher mean scores than females. Most researchers agree that the differences do not appear until after puberty, which may begin as early as 10 or 11 years. Much research and observational data seem to confirm the presence of factors, but it is an area that likely will continue to spawn debate and controversy until sufficient and consistent data are provided.

Cross-cultural research with spatial abilities has been conducted with several groups, often suggesting no differences between ethnic groups and Anglo groups. However, results of research conducted with American Indians have found American Indians of different tribes score higher on measures of spatial abilities than measures of verbal skills and receive higher scores on tests of spatial abilities than non-Indians. In spite of a fairly consistent collection of supporting evidence, such results are deemed inconclusive, in part, because of the types of instruments used. Also, the information seems to have surfaced as an artifact of investigations into other areas rather than because spatial abilities were the focus of the examination. This has been identified by many to be an important area for research since various people believe that patterns of cognitive abilities are a meaningful component of a complex system that affects American Indian and other children's achievement in school.

Some researchers and American Indian educators have claimed that educational methods need to be altered in order to emphasize these patterns of cognitive abilities once they have been well-defined. This push continues in the face of reports suggesting that such definitions are, in fact, racist and do more harm than good. Some might see the continued belief in different cognitive or learning styles as born more of desperation to do something to help than as an accurate concept. However, the continued gathering of evidence has consistently suggested that it is a real phenomena, albeit, not well defined as yet.

In spite of the apparent ongoing interest in cognitive and/or learning styles among American Indian students, few places exist in which a blending of cognitive information processing research and ethnographic research can be found.

Little research has been conducted comparing American Indian and non-Indian children on test scores using an array of instruments specifically designed to measure spatial abilities. In addition, defined factor structures of spatial abilities similar to those previously identified in other groups might exist in one or both of these groups. If so, it is possible that factor structures could be similar or different between groups and that the mean scores achieved by each group on measures of spatial abilities for each factor also could be the same. Suggestions have been made that comparison of means and an examination of relative factor structures are faulty techniques and that the comparison is incomplete without exploring differences at the level of the item. Therefore, in addition to examining individual test and total test mean scores, possible differences in patterns of answering were explored.

Purposes and Objectives

The purposes and objectives of this study were to answer the following questions:

1. Are there differences in mean scores between male and female second-grade children on spatial ability instruments?

2. Are there differences in mean scores between Navajo Indian second-grade children and non-Indian second-grade children on instruments designed specifically to

measure spatial skills?

3. Is there a difference in mean scores between second-grade Navajo Indian children and non-Indian children on an overall measure of spatial ability found by combining scores of all the instruments?

4. Are there any apparent relationships between gender and race on any of the six individual tests or on the sum of scores of all tests?

5. Are the results of the testing conducive to factor analysis, and, if so, are the identified factors comparable to those reported by previous researchers such as Lohman (1979)?

6. If factor structures are found, are they similar between the two groups of subjects?

7. If factor structures are found and are similar, are there differences in the mean scores received by each group on each factor?

8. If the data are not conducive to factor analysis, are there other statistical methods through which groups can be distinguished using these data?

9. Are there differences in the pattern of responses at the item level between genders or racial groups; that is, do these tests "behave" differently for the various subgroups?

CHAPTER III

METHODOLOGY

Subjects

Two groups of second-grade children were compared: (a) English-speaking Navajo Indian children and (b) English-speaking non-Navajo children. The Navajo children were from three elementary schools in the Central Consolidated School District headquartered in Shiprock, New Mexico. The non-Navajo children lived in the Salt Lake City, Utah, area. Second-grade children were selected as subjects for this study for several reasons. It is highly unlikely that any of these children would be entering puberty, which has been found as a time for the development of gender differences in spatial abilities, and they were among the oldest group to use the battery of tests designed for primary children. If there is an acculturation effect based on exposure to school, it might still be minimal at the second-grade level.

Because travel between Utah and New Mexico is difficult, authorities in the Central Consolidated School District agreed to help with identification of the population and collection of parent permission forms. Principals of the three schools identified all second-grade students and, with the help of teachers and information they had from parents, further selected English-speaking Navajo students. English speakers were identified as those who spoke at least some English at home and used it efficiently at school. This information was verbally double-checked by the examiner with the principal, teachers, and students during data collection. Original plans called for use of a school questionnaire on language usage to determine English or non-English status; however, this information was not uniformly available across all three schools.

Once students were identified, they were given information to take home to their parents. The information included a letter explaining the study and the parent permission form. Both forms were edited and approved by school district personnel before use and are included in Appendix A.

Only children who returned signed permission forms to the school before the start of data collection were included in the study. One hundred thirty-one students returned signed permission forms. Four students were absent during the time of data collection and thus were not included. Three more were identified by teachers as non-English-speaking children who had mistakenly been given permission forms, leaving a sample of 124 second-grade students. The description of the sample is found in Table 1.

The non-Navajo sample consisted of 135 second-grade children whose parents were given the same information as the Navajo Indian parents. The parents signed and returned permission forms prior to data collection. The children were located through the Boys and Girls Club, Salt Lake County Recreation, and Granite School District. Five children were eliminated because of incomplete test results, and data for one child was not used because she was non-English speaking. Because the non-Navajo sample was younger than the Navajo Indian sample, after the subjects were matched to the Navajo Indian sample for gender, the youngest subjects of each gender were eliminated, bringing the sample size to 124 (with as close to equal matching of girls and boys as was possible). By observation, the non-Navajo group included children from African American, Japanese American, Polynesian American, and Hispanic American groups by approximately 5% of the sample. The description of this sample is also included in Table 1.

Table 1

Age of Participants by Gender and Race

	Gender					
	Boys		Girls		Total	
Race	Mean	SD	Mean	SD	Mean	SD
Navajos	(n=43)		(n=81)		(n=124)	
	8.30	.56	8.24	.53	8.32	.55
Non-Navajos	(n=45)		(n=79)		(n=124)	
	7.97	.46	7.80	.47	7.90	.48

Data and Instrumentation

Six instruments were used to measure developmental patterns of spatial ability for first-grade through fourth-grade children (Johnson & Meade, 1987). These tests were selected based on their identification as relatively pure measures of spatial abilities (Johnson & Meade, 1987) and as possible measures of the factors identified by Lohman and Kyllonen (1983).

Identified as potential measures of the spatial relations factor were the Flags and Spatial Relations tests. In Flags, the subject sees pairs of pictures of American flags, which are presented in various orientations to be judged as the same (rotated within the horizontal plane) or different (a mirror image that has been rotated). In Spatial Relations, a stem is presented, and the student must select from four alternatives the one that, when properly rotated, completes a square with the stem. Flags was selected because it was recommended as a measure of the spatial relations factor by Lohman and Kyllonen (1983). The Spatial Relations subtest was selected based on results and recommendations reported by Johnson and Meade (1987) and because of its apparent similarity to tests recommended by Lohman and Kyllonen (1983).

Blocks (Johnson & Meade, 1987), in which stacks of blocks are presented and the subject is asked to determine the number of blocks (including those hidden from view), and

Hidden Figures (Johnson & Meade, 1987), in which a simple line drawing is presented in the stem and the student must select which of three alternatives contains the unrotated stem, were selected as possible measures of the spatial visualization factor. Johnson and Meade (1987) found Blocks to load frequently on a spatial visualization factor, and Hidden Figures was recommended by Lohman and Kyllonen (1983) as representing the spatial visualization factor.

The Hands test was selected as a measure of the spatial orientation factor with the assistance of Cindy Berg, PhD, a University of Utah psychology professor specializing in the information processing aspects of spatial abilities and spatial abilities in the elderly. In this test, the subject is shown a series of pictures of hands in different orientations and is asked to identify the hand as either left (L) or right (R). In order to do this correctly, the subjects must be able to orient the hand with respect to themselves and within space. Sticks, Poles, and Jars (Johnson & Meade, 1987), a Piagetian task of spatial orientation, was selected as a possible measure of the spatial orientation factor (also with the recommendation of Cindy Berg, PhD) because of its description as a spatial orientation task and the skills that, on face examination, are apparently needed to complete it.

Johnson and Meade (1987) reported split-half reliabilities for their tests when given to a group of first-grade through third-grade students (see Table 2). Research is still being conducted on Sticks, Poles, and Jars by Dr. Johnson in North Carolina. Preliminary results (D. Johnson, personal communication, June 20, 1990) suggest consistent differences between males and females in scores on this measure. The overall spatial ability score was derived by computing the mean number of items correct on all spatial ability tests for students in each group.

Table 2
Reliability Coefficients for Five Spatial Ability Tests (N=292)

Measure	Items	Reliability
Flags	24	.86
Hands	16	.48
Blocks	18	.84
Hidden Figures	15	.83
Spatial Relations	27	.98

Reliability testing of the instruments with the current subject pool was conducted using an item analysis approach to examine the relative weight of each item in the scale. Table 3 provides a summary of overall alpha levels for each instrument. Item analysis of the first five tests revealed consistent alpha levels, indicating each item was approximately equivalent and contributed equally to the instrument. However, on Sticks, Jars, and Poles, alpha levels varied from .37 for the first Poles item to .57 for the Sticks item, suggesting the items, at least for this group of students, are not equivalent.

Table 3

Reliability Coefficients for Six Spatial Ability Tests

Measure	Items	Reliability
Flags	24	.79
Hands	16	.67
Blocks	18	.81
Hidden Figures	15	.64
Spatial Relations	27	.74
Sticks, Jars, and Poles	6	.53

Procedures

Children were assigned to test groups by principals of the different schools based on the schedules of the student and the school. Students were tested during school hours in rooms that were separate from the classroom. The testing was conducted in groups ranging in size from 4 through 12, except for one non-Navajo sample group that was significantly larger. During that testing session, the examiner was aided in monitoring the students by the classroom teacher, though all instructions and demonstrations were still given by the examiner. Testing for each group of students took between 45 and 60 minutes to complete. Testing sessions began with a brief introduction of the purpose and procedures of the study, as well as a statement of appreciation for the help of the students.

Prior to any testing, the children were each given a sharpened #2 pencil and a sharpened colored pencil. After the first instrument, they also were given an empty manila folder on which they were asked to write their names. The order of administration for the different test instruments was rotated from group-to-group; thus, each group started and finished with different instruments than the group before or the group after. The test instruments were distributed individually prior to being used; therefore, the children had no opportunity to look at a future instrument while they were waiting. Once they completed a test, it was placed in the folder, thus not allowing them to work on it later.

Three tests (Blocks, Flags, and Hands) required a brief demonstration with models, as described by Johnson and Meade (1987). For the Blocks test, students were shown individual blocks, how they could be fastened together in groups, and how to count them; thus, each block was only counted once, but all blocks were counted whether seen or not. This demonstration was followed by examples using models of groups of blocks that were glued together and matched the sample items on the first page of the test. The children were asked to count the blocks in the models and to record the numbers. After four examples, they were given the answers, shown how the blocks were correctly counted, and given time to correct their answers for the samples.

For the Flags test, four American flags mounted on cardboard were shown to the class. Two flags matched and two flags were mirror images of the first two. These flags were used to demonstrate to the children the concepts of "same" (within the same plane) and "different" (mirror image). Again, the children were allowed time to answer on their own and then given the correct answers and explanations or further demonstrations as necessary.

For the three other tests, directions, as noted in Johnson and Meade (1987), were given for each test, questions were answered, and time was allowed for sample problems to be solved (see Appendix B). When the group finished the samples, the correct answers were given, as well as explanations of how to arrive at that answer.

Using Johnson and Meade's (1987) procedure, the children started each test using a #2 pencil after the time limit (2 minutes for Flags and Hands, 3 minutes for Hidden Figures, and 4 minutes for Spatial Relations and Block

Counting). The students who were still working were told to change pencils to their colored one and asked to finish the test with that pencil. They were given an additional 2 to 4 minutes, depending on the instrument to finish. For those who did not finish the tests after the complete amount of time, the unanswered questions were marked as wrong, as suggested by Johnson and Meade (1987). Some of the subjects in both groups had difficulty following the directions related to starting time and when to switch to the colored pencil. In spite of clear directions, intervention by the examiner, and notice by their peers, assorted children in each group started early and/or neglected to change their pencils when asked. This number varied from approximately 1 per 12-student group to as many as 3 or 4 per test group. Thus, the data collected for "timed" analysis were tainted. However, because the problems ran across groups, the results are included in the study for comparative purposes and are discussed in greater depth later.

All data collection was completed by this researcher. Inquiries were made to hire American Indian people involved in education or psychology to be trained in administering the tests; however, insufficient numbers were available to conduct the data collection in a timely manner. Because it would have complicated the study further to have both an American Indian and a non-Navajo examiner, only the non-Navajo examiner was used. In the future, this is a variable that may need to be included and is examined further in the discussion.

Data Analysis

The first phase of data analysis was to explore whether data fit a normal distribution. This factor is important because subsequent procedures have the basic assumption that data are normally distributed.

Several statistical methods were used to analyze the data and to test the hypothesis: (a) A two-way analysis of variance (ANOVA) was used to test for differences in mean scores between race and gender, as well as whether there was an interactive effect; (b) factor analysis was conducted; (c) a discriminate analysis was conducted; and (d) a cross-tabulation was used to determine which items, if any, were answered at a significantly different rate by either the Navajo Indian or non-Navajo groups. Independent variables in the ANOVA were gender and racial groups. Dependent variables were mean test scores of individual tests and the sum of all test scores for each group. Prior to using ANOVA, the equalities of frequencies for each cell were checked. The cells were unequal; therefore, the procedure conducted was a two-way ANOVA-unbalanced design to accommodate the unbalanced cells.

Hypotheses

The following hypotheses were tested:

1. H_o: There will be no difference in any mean scores on spatial tests, individual and combined, between males and females.

1a. H_o: There will be no difference in mean scores, timed, for individual tests between males and females.

1b. H_o: There will be no difference in mean scores, extended time, for individual tests between males and females.

1c. H_o: There will be no difference in total mean scores, timed, between males and females.

1d. H_o: There will be no difference in total mean scores, extended time, between males and females.

2. H_o: There will be no difference in any mean scores on spatial tests, individual or combined, between Navajo Indian and non-Navajo children.

2a. H_o: There will be no difference in mean scores on any of the six tests between Navajo Indian and non-Navajo children for the timed version of the tests.

2b. H_o: There will be no difference in mean scores on any of the six tests between Navajo Indian and non-Navajo children for the extended time version of the tests.

2c. H_o: There will be no difference in mean total score, timed, as measured by all spatial ability instruments, between Navajo Indian and non-Navajo children.

2d. H_o: There will be no difference in mean total score, extended time, as measured by all spatial ability instruments, between Navajo Indian and non-Navajo children.

3. H_o: There will be no relationship between gender and race on the mean scores, individual and combined, for spatial tests.

3a. H_o: There will be no relationship between gender and race on mean timed scores for individual tests.

3b. H: There will be no relationship between gender and race on mean extended time scores for individual tests.

3c. H_o: There will be no relationship between gender and race on mean timed total scores.

3d. H: There will be no relationship between gender and race on mean extended time total scores.

4. H_o: There will be only one spatial factor found in either group.

5. H_o: The Navajo Indian and non-Navajo children will have similar factor structures.

6. H_o: There will be no differences in mean scores on each factor between the Navajo Indian and non-Navajo children, assuming Hypothesis 5 is correct.

7. H_o: Group membership will not be predicted using these data.

7a. H_o: Group membership, as defined by Navajo Indian and non-Navajo children, will not be determined using scores from five timed tests and Sticks, Jars, and Poles.

7b. H_o: Group membership, as defined by Navajo Indian and non-Navajo children, will not be determined using scores from five extended time tests and Sticks, Jars, and Poles.

7c. H_o: Group membership, as defined by Navajo Indian/non-Navajo children and male/female, will not be determined using scores from five timed tests and Sticks, Jars, and Poles.

7d. H_o: Group membership, as defined by Navajo Indian/non-Navajo children and male/female, will not be determined using scores from five extended time tests and Sticks, Jars, and Poles.

8. H_o: Analysis of tests, by item, will demonstrate no significant differences in scoring patterns on any instrument.

CHAPTER IV

RESULTS

The present study was conducted to explore whether differences exist between a sample of second-grade Navajo Indian children and a sample of second-grade non-Navajo children on six tests of spatial ability. In addition to looking at average scores on each test, the literature reviewed suggested that separate factors of spatial abilities might be identified using these instruments. Then there was a question of whether, if factors were identified, the structures would be the same or different between the two groups. Also, questions have been posed about differences between groups at the item level. An initial analysis was completed to examine patterns of scoring across items on each test.

Mean scores for each test, timed and extended time, by gender are displayed in Table 4. Table 5 contains mean scores, timed, and extended time for each test by race. Because of the unequal cell frequencies, a two-way ANOVA, unbalanced design was used. Also, some problems were present in the collection of accurate data for the timed tests. However, since the problems were consistent across groups and involved only a portion of the sample, these scores are included in the analysis for comparison.

Table 4

Mean Scores for Six Tests, Timed and Extended Time, by Gender

Measure	Females				Males			
	Timed		Extended time		Timed		Extended time	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Spatial Relations	15.01	4.35	17.24	3.96	15.59	4.29	17.48	4.26
Hidden Figures	7.16	2.90	8.81	2.79	7.01	2.95	8.78	2.83
Flags	10.22	4.70	14.76	4.58	12.98	5.94	15.55	5.18
Hands	9.44	3.36	10.82	2.62	9.96	3.72	10.27	3.43
Blocks	5.80	3.39	6.09	3.56	5.89	3.79	6.19	3.84
Sticks, Jars, and Poles			2.07	1.37			2.36	1.70
Total	47.63	10.63	59.81	11.27	51.43	12.72	60.64	12.80

Table 5

Mean Scores for Six Tests, Timed and Extended Time, by Race

Measure	Navajo				Non-Navajo			
	Timed		Extended time		Timed		Extended time	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Spatial Relations	15.23	4.08	17.07	3.86	15.19	4.58	17.58	4.26
Hidden Figures	6.62	2.87	8.70	2.80	7.60	2.89	8.90	2.80
Flags	10.00	5.27	14.15	4.57	12.40	5.14	15.93	4.89
Hands	9.66	3.40	10.76	2.91	9.60	3.61	10.50	2.98
Blocks	5.80	3.45	6.10	3.60	5.86	3.62	6.15	3.72
Sticks, Jars, and Poles			1.76	1.40			2.60	1.48
Total	47.31	11.20	58.55	11.20	50.65	11.67	61.65	12.24

1. H_o: There will be no difference in any mean scores for spatial tests (individual and combined) between males and females.

1a. H_o: There will be no difference in mean scores (timed) for individual tests between males and females.

Results of the two-way ANOVA indicated significant differences ($F(1,3) = 15.14$, $p < .05$) between males and females on the Flags test. The hypothesis is rejected for this test and not rejected for the other four tests that had timed conditions (see Table 6).

1b. H_o: There will be no difference in total mean scores (timed) between males and females.

The difference in total scores for the five tests that were timed between males and females was significant ($F = 7.72$, $p < .05$). Hypothesis 1b is, therefore, rejected (see Table 6).

1c. H_o: There will be no difference in mean scores, extended time, for individual tests between males and females.

Significant differences between groups were not found for any scores of tests using the extended time results. Therefore, Hypothesis 1c is not rejected (see Table 7).

1d. H_o: There will be no difference in total mean scores (extended time) between males and females.

In the extended time condition, the difference between total mean scores was not significant ($F = 2.20$, $p > .05$);

Table 6

Results of Two-Way Analysis of Variance, Unbalanced Design, Comparing Effects of Race and Gender on Individual and Total Timed Test Scores

Source	*df*	*MS*	*F* value
	Spatial Relations		
Gender	1	28.68	1.52
Race	1	1.68	0.089
Gender/race	1	9.24	0.491
	Hidden Figures		
Gender	1	0.093	0.01
Race	1	47.96	5.72*
Gender/race	1	1.74	0.21
	Flags		
Gender	1	390.35	15.17*
Race	1	367.06	14.26*
Gender/race	1	7.65	0.297
	Hands		
Gender	1	19.83	1.63
Race	1	.19	0.015
Gender/race	1	68.45	5.61*
	Blocks		
Gender	1	0.83	0.07
Race	1	0.06	0.005
Gender/race	1	33.27	2.59
	Total score		
Gender	1	1027.15	7.72*
Race	1	1054.64	7.93*
Gender/race	1	7.22	0.054

*$p < .05$.

Table 7

Results of Two-Way Analysis of Variance, Unbalanced Design, Comparing Effects of Race and Gender on Individual and Total Extended Time Test Scores

Source	df	MS	F value
	Spatial Relations		
Gender	1	6.95	0.42
Race	1	9.40	0.57
Gender/race	1	52.83	3.21
	Hidden Figures		
Gender	1	0.008	0.001
Race	1	2.52	0.32
Gender/race	1	.74	0.095
	Flags		
Gender	1	55.89	2.40
Race	1	139.48	5.99*
Gender/race	1	11.71	0.50
	Hands		
Gender	1	9.27	0.31
Race	1	1.48	0.68
Gender/race	1	22.62	0.11
	Blocks		
Gender	1	1.12	0.085
Race	1	0.002	0.00
Gender/race	1	68.42	5.17*
	Sticks, Poles, and Jars		
Gender	1	3.52	1.72*
Race	1	49.22	23.98*
Gender/race	1	0.89	0.433
	Total score		
Gender	1	98.38	0.40
Race	1	497.68	3.62
Gender/race	1	256.34	0.17

*$p < .05$.

thus, Hypothesis 1d is not rejected (see Table 7).

2. H_0: There will be no difference in mean scores for any spatial tests (individual and combined) between Navajo Indian and non-Navajo children.

2a. H_0: There will be no difference in mean scores on any of the five tests that were timed between Navajo Indian and non-Navajo children for the timed version of the tests.

The scores of the non-Navajo sample were significantly higher than the scores of the Navajo Indian sample on two of the five tests using a timed version. The tests with differences were Hidden Figures ($F(1,3) = 5.72$, $p < .05$) and Flags ($F(1,3) = 14.26$, $p < .05$). Thus, Hypothesis 2a is rejected for these two tests but not for the other three (see Table 7).

2b. H_0: There will be no difference in mean total score (timed), as measured by all spatial ability instruments, between Navajo Indian and non-Navajo children.

Comparison of total mean scores under timed conditions between Navajo Indians and non-Navajos revealed that the non-Navajo group scored significantly higher than the Navajo Indian group ($F(1,3) = 17.93$, $p < .05$). This pattern held true using all six tests and using only the five tests that had both timed and extended time results. Therefore, Hypothesis 2b is rejected (see Table 7).

2c. H_0: There will be no difference in mean scores on any of the six tests between Navajo Indian and non-Navajo children for the extended time version of the tests. Scores for Flags ($F(1,3) = 5.99$, $p < .05$) and Sticks, Jars, and Poles ($F(1,3) = 23.98$, $p < .05$) were significantly higher in the non-Navajo group than in the Navajo Indian group, whereas no differences were found for the other instruments. Hypothesis 2b is rejected for Flags and Sticks, Jars, and Poles but not for the other four (see Table 7).

2d. H_o: There will be no difference in mean total score (extended time), as measured by all spatial ability instruments, between Navajo Indian and non-Navajo children. The difference in mean scores between Navajo Indians and non-Navajos was not significant, even though it might be considered to approach significance ($F = 3.62$, $p > .05$). Therefore, this hypothesis is not rejected (see Table 7).

3. H_o: There will be no relationship between gender and race in mean scores for spatial tests (individual and combined).

3a. H_o: There will be no relationship between gender and race on mean timed scores for individual tests.

Both gender and race had a significant effect on the scores for the timed Flags test, but there were no significant interactions between the two variables. However, results of a Scheffe's comparison between group means broken down by gender and race indicated that the mean score for Navajo Indian girls was significantly lower than mean scores for all three other groups. Significant interaction effects were found for the Hands test ($\underline{F}(3,244) = 5.61$, $\underline{p} < .05$). Therefore, Hypothesis 1e is rejected for the Hands test but not for the other four tests with timed conditions (see Table 4, Figures 1, 3, 5, 7, and 9). Rank ordering of the groups indicated the following: Navajo Indian girls < non-Navajo boys < non-Navajo girls < Navajo Indian boys (see Figure 7). Post hoc testing using Scheffe's method to detect differences between means of the four groups revealed no significant differences between groups.

3b. H_o: There will be no relationship between gender and race on mean timed total scores.

No significant interaction effects were found; therefore, Hypothesis 3b is not rejected (see Table 6, Figure 12). Analysis of means for groups separated by race and gender using Scheffe's method revealed no significant differences between any two means at the 0.05 level.

3c. H_o: There will be no relationship between gender and race on mean extended time scores for individual tests.

Significant interaction effects between race and gender were noted on the Blocks test ($\underline{F}(3,144) = 5.17$, $\underline{p} < .05$) in the extended time condition. Analysis using Scheffe's method indicated no significant differences between any of the four group means on this test. Hypothesis 3c is rejected for Blocks but not for the other five tests with extended time (see Table 7, Figures 2, 4, 6, 8, 10, and 11).

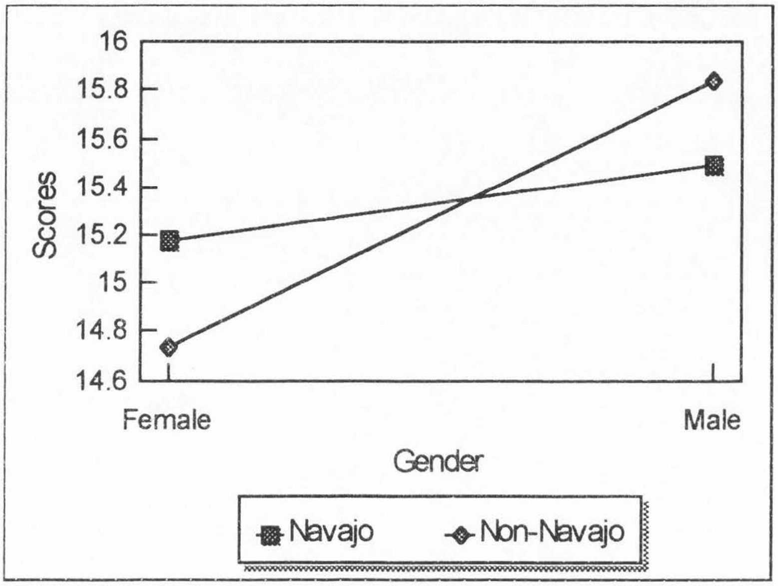


Figure 1. Mean scores by race and gender, Spatial Relations, timed.

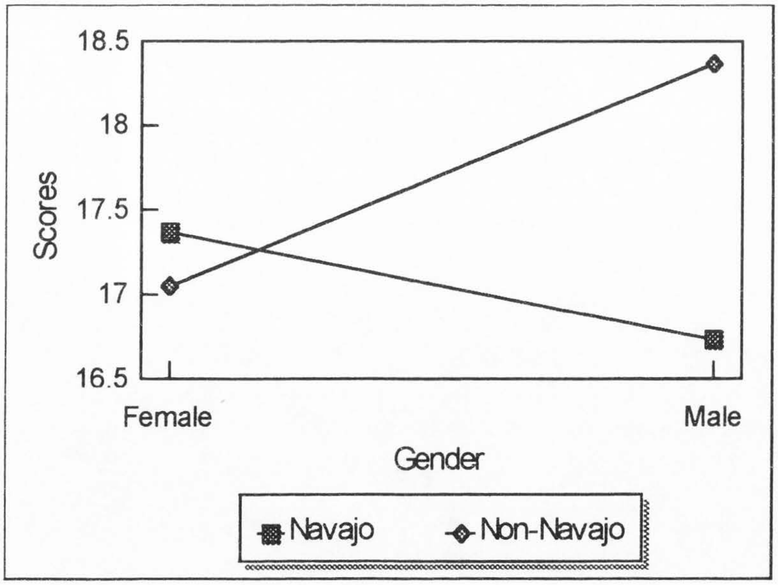


Figure 2. Mean scores by race and gender, Spatial Relations, extended time.

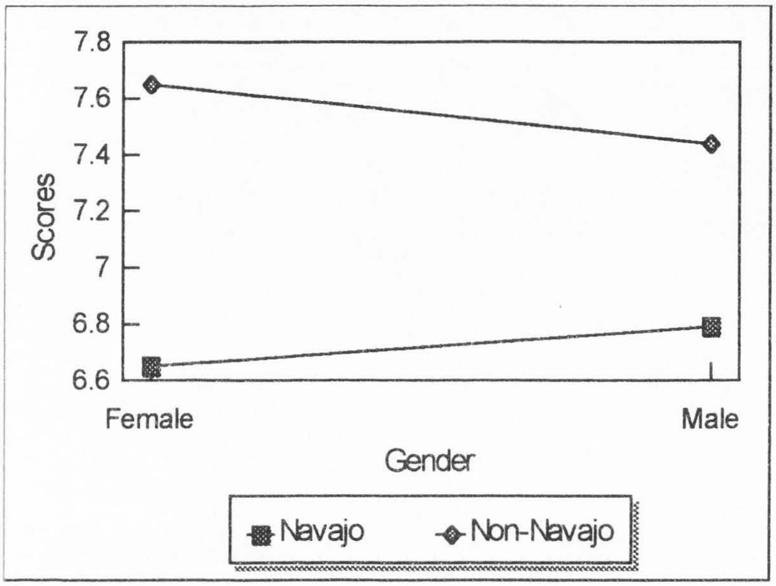


Figure 3. Mean scores by race and gender, Hidden Figures, timed.

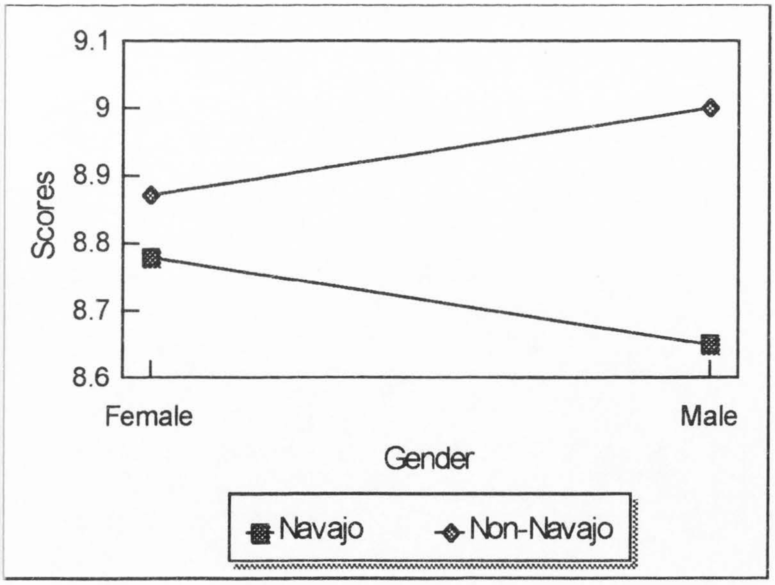


Figure 4. Mean scores by race and gender, Hidden Figures, extended time.

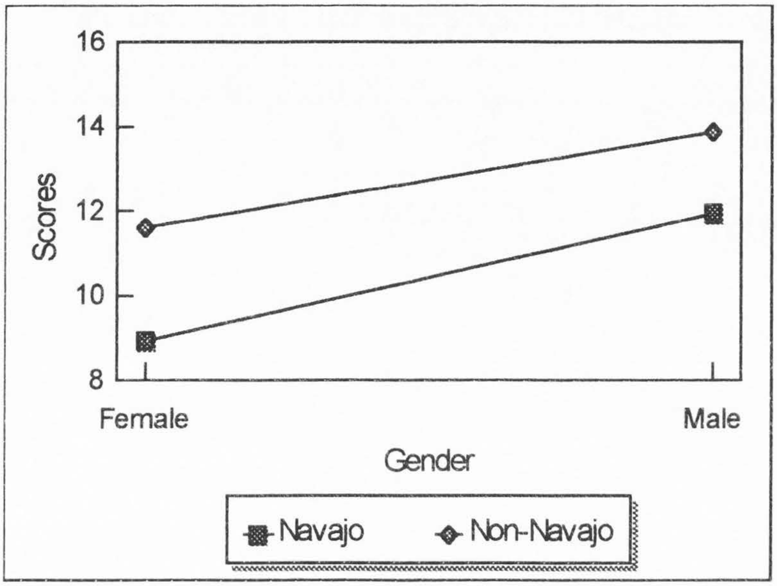


Figure 5. Mean scores by race and gender, Flags, timed.

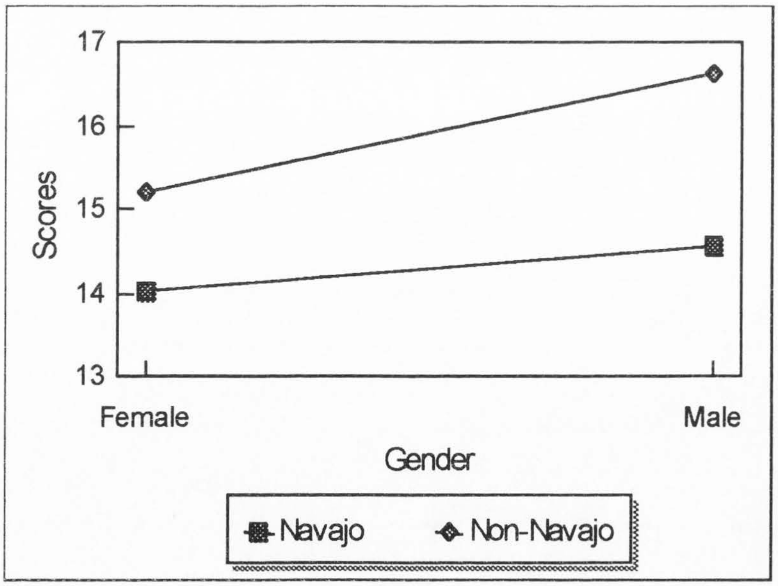


Figure 6. Mean scores by race and gender, Flags, extended time.

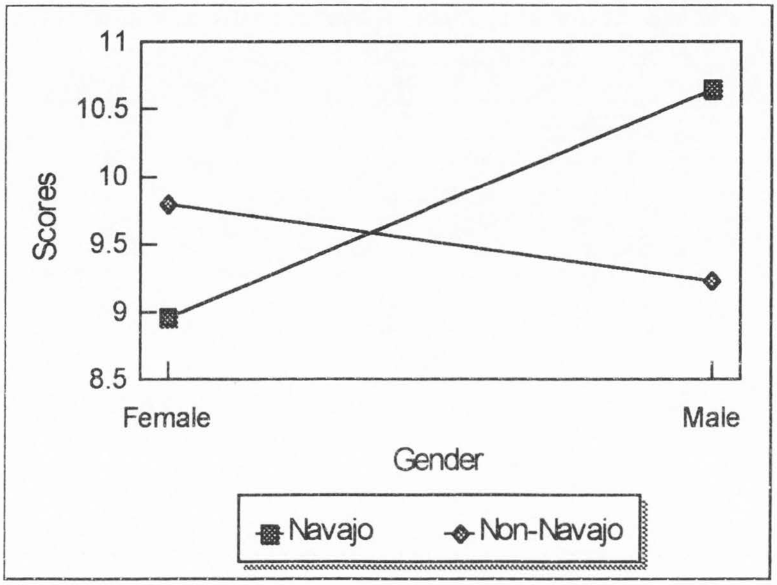


Figure 7. Mean scores by race and gender, Hands, timed.

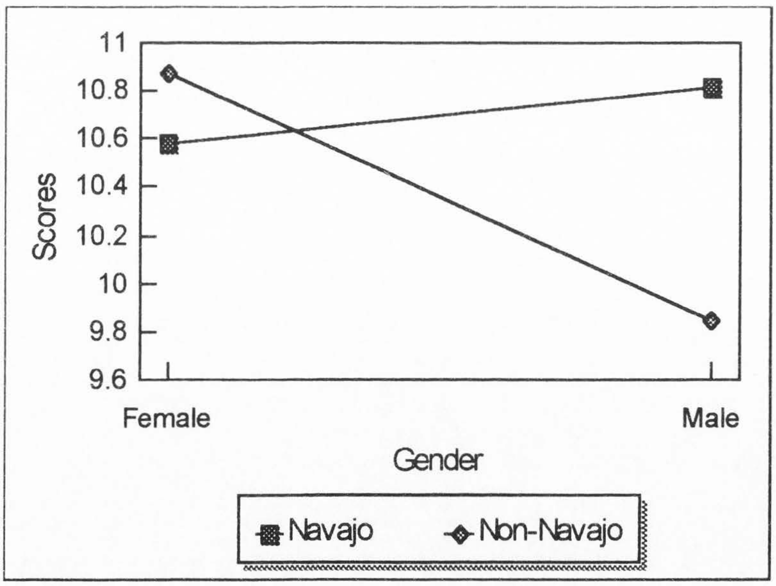


Figure 8. Mean scores by race and gender, Hands, extended time.

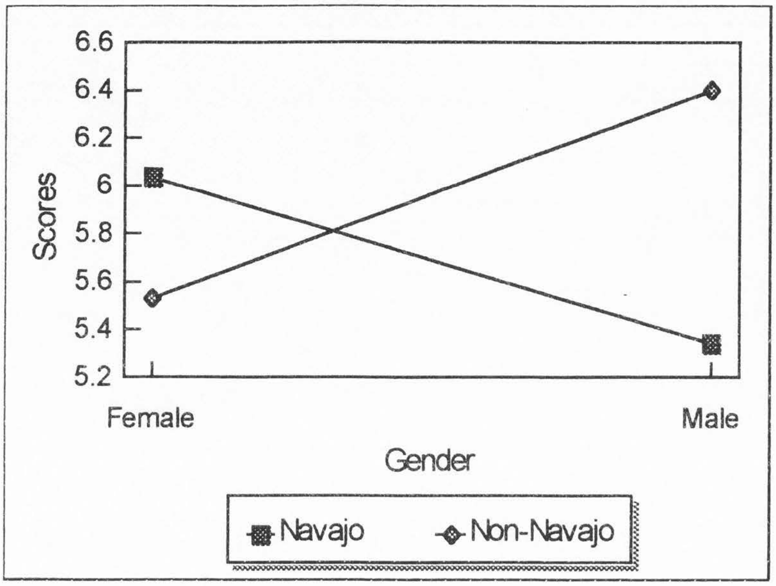


Figure 9. Mean scores by race and gender, Blocks, timed.

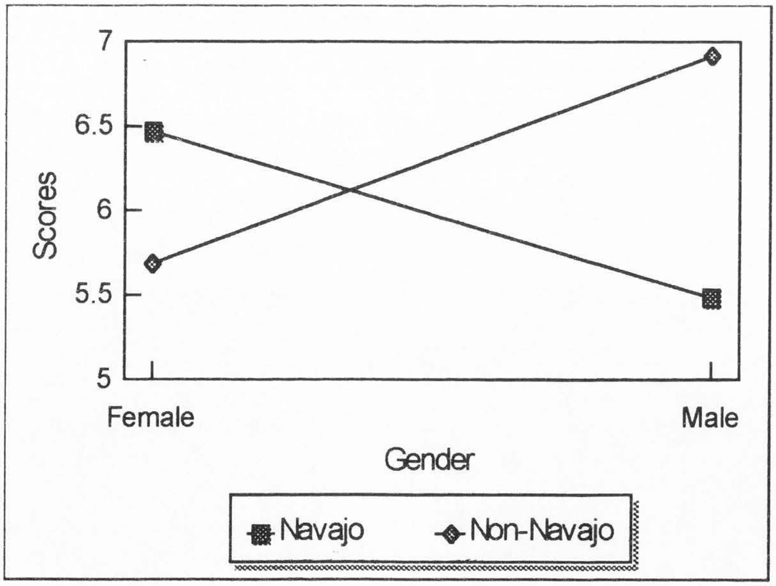


Figure 10. Mean scores by race and gender, Blocks, extended time.

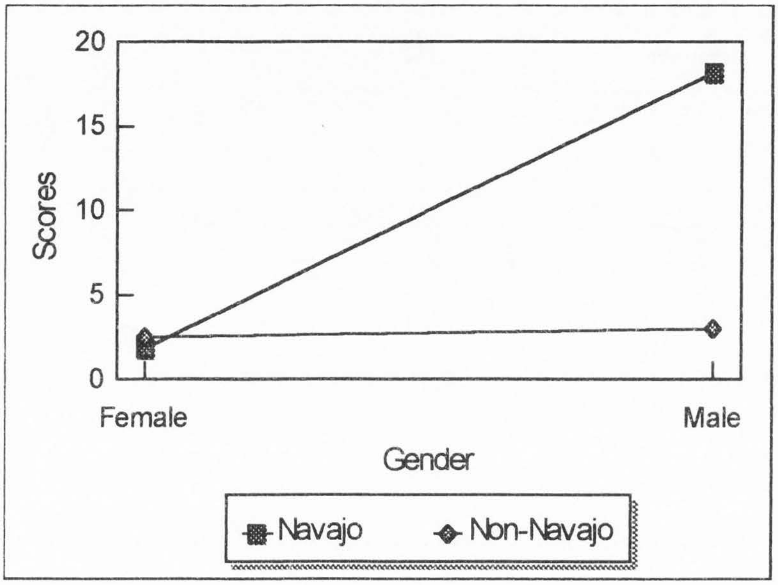


Figure 11. Mean scores by race and gender, Sticks, Jars, and Poles Test.

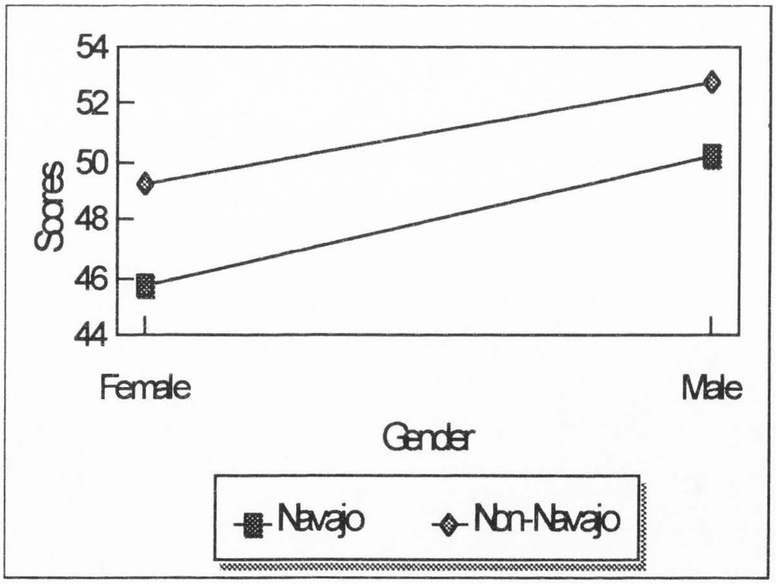


Figure 12. Mean scores by race and gender, Total score, timed.

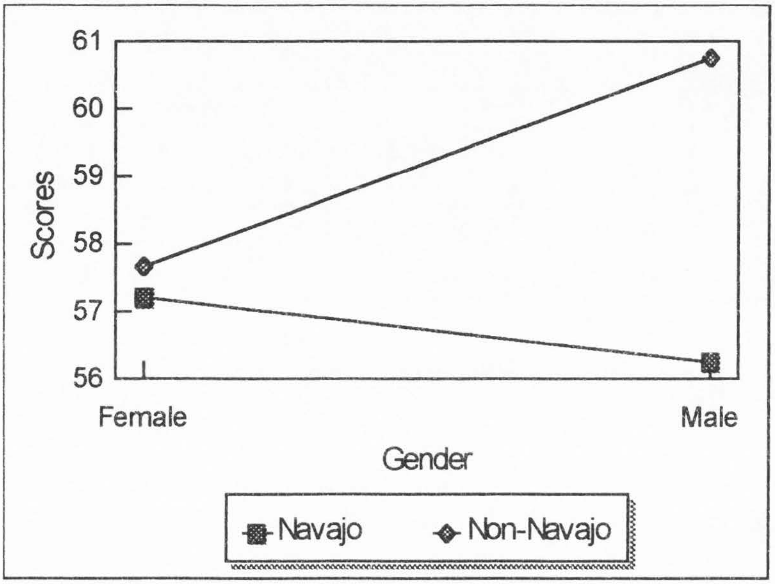


Figure 13. Mean scores by race and gender, Total score, extended time.

No significant interaction effects were found for the Flags test, but Scheffe's method of analysis of group means revealed significant differences in mean scores of two groups, with Navajo Indian girls scoring lower than non-Navajo boys. No other significant differences were found.

3d. H_o: There will be no relationship between gender and race on mean total scores (extended time). No interaction effects were found between race and gender on the total score extended time. Hypothesis 1h is not rejected (see Table 7, Figure 13). A Scheffe's method revealed no significant differences at the 0.05 level between any of the four mean total scores for groups formed by race and gender delineations.

4. H_0: There will be only one spatial factor found in either group for first (timed) and second (extended time) test results. Factor analysis on the timed tests using varimax rotation with three iterations revealed two factors in the Navajo Indian group with Sticks, Jars, and Poles; Hands; Spatial Relations; and Blocks loading on Factor 1, and Flags and Hidden Figures loading on Factor 2 (see Table 8, Figure 14). In the non-Navajo group, two factors were noted with Hidden Figures, Blocks, and Hands loading on Factor 1 and Flags, Spatial Relations, and Sticks, Jars, and Poles loading on Factor 2 (see Table 9, Figure 15). As can be seen in Figure 15, the tests seem to clump into a three-group formation, however, without associations significant to form three factors (see Tables 10, 11, 12, and 13).

The procedure was repeated using the same six tests with the scores for the extended time version of five tests five timed tests and Sticks, Jars, and Poles.

Analysis of the data suggested that membership in combined with the Sticks, Jars, and Poles test scores. Using data from the Navajo Indian subjects, Flags and Hidden Figures loaded on Factor 1, whereas Sticks, Jars, and Poles; Hands; Spatial Relations; and Blocks loaded on Factor 2 (see Table 14, Figure 16). In the non-Navajo group, Blocks, Hands, Spatial Relations, and Hidden Figures loaded on Factor 1, whereas Flags and Sticks, Jars, and Poles loaded

Table 8

Correlation Matrix for Navajo Indian Subjects, Six Tests, Timed

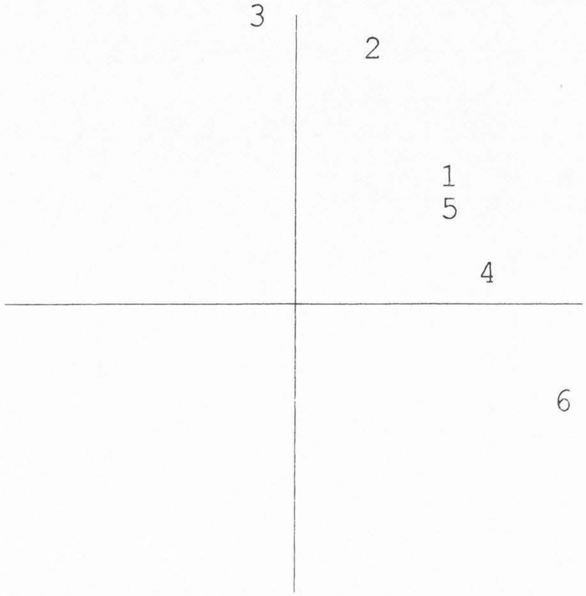
	Spatial Relations	Hidden Figures	Flags	Hands	Blocks	Sticks, Jars, and Poles
Spatial Relations	1.000					
Hidden Figures	.220	1.000				
Flags	.120	.331	1.000			
Hands	.159	.073	.131	1.000		
Blocks	.210	.088	.115	.109	1.000	
Sticks, Jars, and Poles	.154	.127	-.166	.251	.147	1.000

Table 9

Correlation Matrix for Non-Navajo Indian Subjects, Six Tests, Timed

	Spatial Relations	Hidden Figures	Flags	Hands	Blocks	Sticks, Jars, and Poles
Spatial Relations	1.000					
Hidden Figures	.184	1.000				
Flags	.221	.019	1.000			
Hands	.048	.163	.033	1.000		
Blocks	.344	.309	.257	.221	1.000	
Sticks, Jars, and Poles	.033	.018	.154	.008	.140	1.000

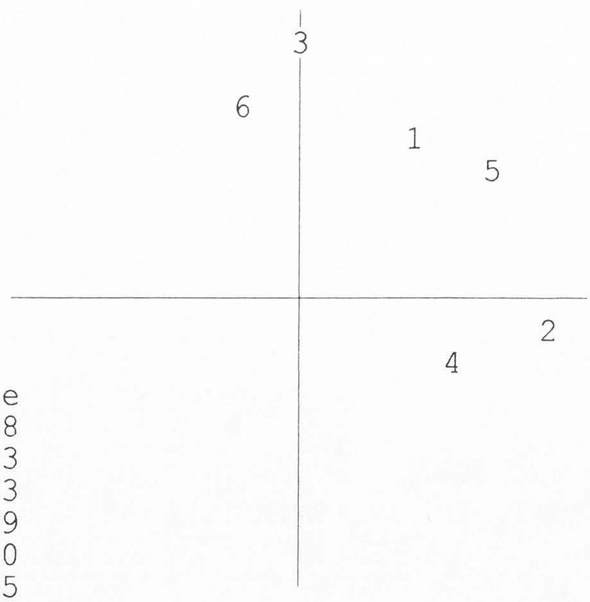
Horizontal Factor 1 Vertical Factor 2



Symbol	Var.	Coord.	
1	SpatR	.535	.342
2	HidFig	.241	.680
3	Flags	-.068	.848
4	Hands	.602	.080
5	Blocks	.484	.208
6	S,J,P	.766	-.283

Figure 14. Graph of factors, Navajo Indian subjects, timed.

Horizontal Factor 1 Vertical Factor 2



Symbol	Var	Coordinate	
1	SpatR	.432	.438
2	HidF	.726	-.023
3	Flags	.031	.753
4	Hands	.622	-.139
5	Blocks	.641	.470
6	S,J.P	-.146	.605

Figure 15. Graph of factors, non-Navajo subjects, timed.

Table 10

Factor Loadings, Navajo Indian, Timed Tests

	Factor 1	Factor 2
Sticks, Jars, and Poles	.7665	-.2830
Hands	.6022	.0798
Spatial Relations	.5346	.3419
Blocks	.4843	
Flags	-.0679	.8476
Hidden Figures	.2410	.6798

Table 11

Factor Loadings, Non-Navajo Indian, Timed Tests

	Factor 1	Factor 2
Hidden Figures	.7263	-.0229
Blocks	.6405	.4698
Hands	.6218	-.1386
Flags	.0311	.7531
Sticks, Jars, and Poles	-.1457	.6047
Spatial Relations	.4229	.4820

Table 12

Correlation Matrix for Navajo Indian Subjects, Six Tests, Extended Time

	Spatial Relations	Hidden Figures	Flags	Hands	Blocks	Sticks, Jars, and Poles
Spatial Relations	1.000					
Hidden Figures	.371	1.000				
Flags	.198	.334	1.000			
Hands	.176	.202	.155	1.000		
Blocks	.204	.082	.203	.149	1.000	
Sticks, Jars, and Poles	.210	.132	-.102	.215	.148	1.000

Table 13

Correlation Matrix for Non-Navajo Indian Subjects, Six Tests, Extended Time

	Spatial Relations	Hidden Figures	Flags	Hands	Blocks	Sticks, Jars, and Poles
Spatial Relations	1.000					
Hidden Figures	.319	1.000				
Flags	.307	.142	1.000			
Hands	.190	.102	.017	1.000		
Blocks	.381	.356	.177	.187	1.000	
Sticks, Jars, and Poles	.254	.208	.301	.040	.158	1.000

Table 14

Factor Loadings, Navajo Indian, Extended Time Tests

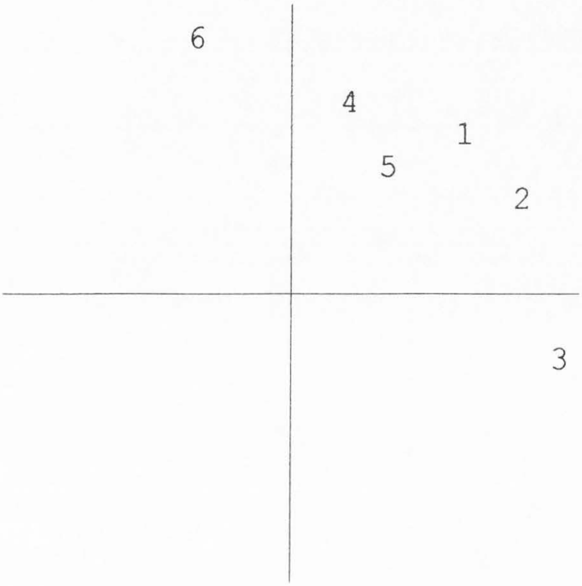
	Factor 1	Factor 2
Flags	.8376	-.1039
Hidden Figures	.6725	.2854
Sticks, Jars, and Poles	-.2298	.8357
Hands	.2227	.5572
Spatial Relations	.4746	.5021
Blocks	.2981	.3876

Table 15

Factor Loadings, Non-Navajo Indian, Extended Time Tests

	Factor 1	Factor 2
Blocks	.7217	.1789
Hands	.6631	-.3102
Spatial Relations	.6127	.4251
Hidden Figures	.5952	.2661
Flags	.0935	.7604
Sticks, Jars, and Poles	.1208	.7230

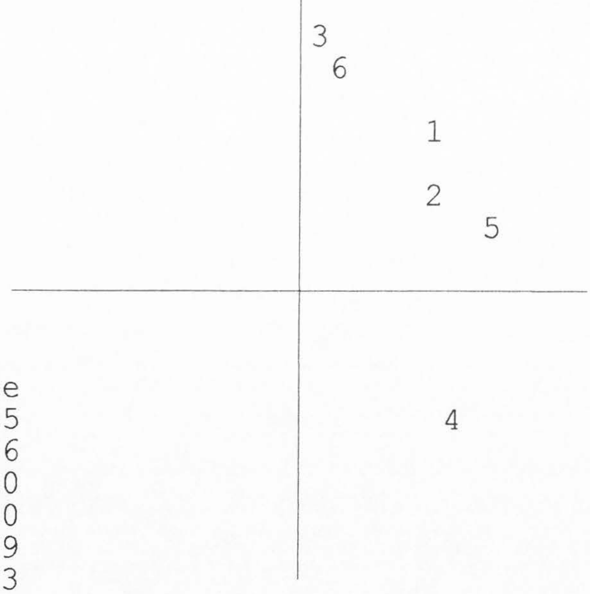
Horizontal Factor 1   Vertical Factor 2



Symbol	Var.	Coord.	
1	SpatR	.475	.502
2	HidFig	.673	.285
3	Flags	.838	-.104
4	Hands	.223	.557
5	Blocks	.298	.388
6	S,J,P	-.230	.836

Figure 16. Graph of factors, Navajo Indian subjects, extended time.

Horizontal Factor 1   Vertical Factor 2



Symbol	Var	Coordinate	
1	SpatR	.613	.425
2	HidF	.595	.266
3	Flags	.094	.760
4	Hands	.663	-.310
5	Blocks	.722	.179
6	S,J,P	.121	.723

Figure 17. Graph of factors, non-Navajo subjects, extended time.

on Factor 2. Therefore, Hypothesis 4 is rejected for both groups under both conditions (see Table 15, Figure 17).

5. H_0: If separate factors exist, the Navajo Indian and non-Navajo children will have similar factor structures.

Factor analysis demonstrated two factors for both groups, though the structures appeared to differ, based on timed or extended time scores. Under both conditions, in spite of the scores from both groups forming two factors, the actual structures were different. Therefore, this hypothesis is rejected for both cases.

6. H_0: There will be no differences in mean scores on each factor between the Navajo Indian and non-Navajo children, assuming Hypothesis 5 is correct.

Because the factor structures were different for each group, this hypothesis cannot be tested.

7. H_0: Group membership will not be predicted using these data.

7a. H_0: Group membership, as defined by Navajo Indian and non-Navajo, will not be determined using scores from either group could be significantly predicted using a discriminant function analysis with scores from Sticks, Jars, and Poles; Flags; Hidden Figures; Spatial Relations; and Blocks. Hands was not found to contribute significantly to the predictive ability of the function. The best predictors were found to be Sticks, Jars, and Poles and Flags, which both had significant F values (p <.05). The discriminate function correctly classified 65.73% of the total cases (see Table 16), which is greater than chance at 50.0%. A chi-square analysis also demonstrated that the group means of the function are significantly different ($\chi^2_{(5)} = 40.57$, $p < .05$). However, examination of the eigenvalue and Wilks lambda ($\alpha = .85$) indicated that a relatively modest proportion of the variance is explained by differences between groups compared to within-group differences. Hypothesis 7a is rejected on the basis of the predictability of these tests but will be discussed in more detail.

7b. H_0: Group membership, as defined by Navajo Indian and non-Navajo, will not be determined using scores from five extended time tests and Sticks, Jars, and Poles.

Using extended time test scores for five instruments, significant prediction of groups membership was determined

Table 16

Predicted Group Membership Based on Discriminate Function Analysis Using Timed Test Scores

Actual group	Cases	Predicted group membership	
		Navajo	Non-Navajo
Navajo	124	87	37
		70.2%	29.8%
Non-Navajo	124	48	76
		38.7%	61.3%

Note. Percentage of "grouped" cases correctly classified: 65.73%.

using three instruments: Sticks, Jars, and Poles; Flags; and Hands. Sticks, Jars, and Poles and Flags were the best predictors of group membership. A discriminate function utilizing these three measures correctly classified 63.3% of the "grouped" cases (see Table 17) compared to chance grouping of 50.0%. A chi-square test with 3 degrees of freedom demonstrated significant differences in the means of the discriminate function ($\chi^2_{(3)}$ = 27.45, p <.05). Further evaluation using the eigenvalue and Wilks lambda (α = .89) suggested that a moderate proportion of the variance is explained by within-group differences rather than between-group differences, as would be hoped for a clear prediction process. However, Hypothesis 7b will be rejected on the basis of the predictive ability greater than chance.

7c. H_0: Group membership, as defined by Navajo Indian/non-Navajo and male/female, will not be determined

Table 17

Predicted Group Membership Based on Discriminate Function Analysis Using Extended Time Test Scores

Actual group	Cases	Predicted group membership	
		Navajo	Non-Navajo
Navajo	124	83	41
		66.9%	33.1%
Non-Navajo	124	74	50
		59.7%	40.3%

Note. Percentage of "grouped" cases correctly classified: 63.31%.

Indian/non-Navajo and male/female, will not be determined using scores from five timed tests and Sticks, Jars, and Poles. A discriminate function to predict group membership included Flags; Sticks, Jars, and Poles; Hands; Blocks; and Hidden Figures (see Table 18). Spatial Relations was not found to account for significant variance in the function and was not included. With the four groups, 41.53% of the cases were correctly classified compared to a chance of 25%. Examination of classification percentages suggested the function correctly predicted group membership for the non-Navajo females at a less than chance rate while predicting correct group membership for Navajo Indian females and non-

Table 18

Predicted Group Membership for Four Groups Determined by Race and Gender Using Timed Tests and Sticks, Jars, and Poles Test

Actual group	Cases	Predicted group membership			
		Navajo female	Navajo male	Non-Navajo female	Non-Navajo male
Navajo female	81	46	14	13	8
		56.8%	17.3%	16.0%	9.9%
Navajo male	43	13	17	6	7
		30.2%	39.5%	14.0%	16.3%
Non-Navajo female	79	17	22	16	24
		21.5%	27.8%	20.3%	30.4%
Non-Navajo male	45	8	9	4	24
		17.8%	20.0%	8.9%	53.3%

Note. Percentage of "grouped" cases correctly classified: 41.53%.

Navajo males at a greater than chance rate. Because four groups were used for the prediction, three functions were identified. The first function provided the greatest predictability and is the basis of the following remarks. Analysis using chi-square with 15 degrees of freedom indicated significant differences in the means of the functions ($\chi^2_{(15)}$ = 68.91). However, evaluation of the eigenvalue (.2325) and Wilks lambda (α = .75) indicated only a moderate proportion of variance was accounted for by between-group differences, with the remaining proportion being generated by within-group differences. Hypothesis 7c is rejected.

7d. H_o: Group membership, as defined by Navajo Indian/non-Navajo and male/female, will not be determined using scores from five extended timed tests and Sticks, Jars, and Poles.

Sticks, Jars, and Poles; Hands; Blocks; and Flags were found to account for significant variance in predicting group membership using four groups. The discriminate function correctly classified 39.52% of "grouped" cases (see Table 19), which is greater than chance at 25%. Spatial Relations and Hidden Figures did not account for significant variance in the functions. The function again was successful at approximately a chance level in correctly predicting group membership for non-Navajo females. The greatest percentage of predictability was seen for non-

Navajo males, followed by Navajo females, and then Navajo males—all of which were at a greater than chance level. Chi-square with 12 degrees of freedom indicated that the means of the functions were significantly different ($\chi^2_{(12)}$ = 42.99, p <.05). The eigenvalue for the first function (.15) and the Wilks lambda (α = .84) suggested only modest proportions of variance were accounted for by between-group differences. Hypothesis 7d is rejected, however, on the basis of the discriminate function.

8. H_0: Analysis of tests by item will demonstrate no significant differences in scoring patterns between Navajos and non-Navajos on any instrument. A cross-tabulation

Table 19

Predicted Group Membership for Four Groups Determined by Race and Gender Using Five Extended Time Tests and Sticks, Jars, and Poles Test

Actual group	Cases	Predicted group membership			
		Navajo female	Navajo male	Non-Navajo female	Non-Navajo male
Navajo female	81	34	23	15	9
		42.0%	28.4%	18.5%	11.1%
Navajo male	43	9	17	9	8
		20.9%	39.5%	20.9%	18.6%
Non-Navajo female	79	18	16	22	23
		22.8%	20.3%	27.8%	29.1%
Non-Navajo male	45	6	7	7	25
		13.3%	15.6%	15.6%	55.6%

Note. Percentage of "grouped" cases correctly classified: 39.52%.

analysis of each instrument by item was conducted using a Pearson chi-square to determine independence of cells and a phi coefficient to imply strength of relationship. Examining the results of this procedure, it was suggested that on at least one item within each test, cells were independent between the two groups, which could be seen to indicate significantly different rates of answering the item correctly for each group.

On the Spatial Relations test, cells were deemed significantly independent on item 7 ($\chi^2_{(1)} = 4.72$, $p < .05$) and item 9 ($\chi^2_{(1)} = 4.69$, $p < .05$). Comparing percentage correct, Navajo Indian subjects had a higher percentage on item 7 and non-Navajos on item 9. Numbers 12 and 21 approached independence (see Table 20). The phi coefficient for both numbers 7 and 9 indicated a significant association between group membership and score on the item ($p < .05$).

Independence of cells was demonstrated on five items of the Flags test: numbers 6 ($\chi^2_{(1)} = 6.75$, $p < .05$), 8 ($\chi^2_{(1)} = -.154$, $p < .05$), 22 ($\chi^2_{(1)} = 9.27$, $p < .05$), 23 ($\chi^2_{(1)} = 6.15$, $p < .05$), and 24 ($\chi^2_{(1)} = 5.51$, $p < .05$) (see Table 21). Non-Navajo children had a higher rate of correct answers on all five items. The scores of numbers 7, 9, and 21 approached significance. The phi coefficients for numbers 6, 8, 22, 23, and 24 all suggested an association between group membership and score on the item.

For the Hands test, results of chi-square analysis

Table 20

Percentage of Subjects Answering Each Item Correctly by Racial Groups, Spatial Relations Test

Item	Navajo		Non-Navajo			
	Count	Percentage correct	Count	Percentage correct	Phi	Sig.
1	120	96.8	118	95.2	.04	
2	113	91.1	114	91.9	-.01	
3	93	75.0	98	83.1	-.10	
4	96	77.4	100	80.6	-.04	
5	118	95.2	119	96.0	-.02	
6	113	91.1	113	91.1	.00	
7	115	92.7	104	83.9	.14	$p <.08$
8	94	75.8	101	81.5	-.07	
9	84	67.7	99	79.8	-.14	$p <.01$
10	98	79.0	96	77.4	.02	
11	99	79.8	103	83.1	-.04	
12	104	83.9	113	91.1	-.11	$p =.08$
13	104	83.9	104	83.9	.00	
14	92	74.2	94	75.8	-.02	
15	87	70.2	84	67.7	.02	
16	96	77.4	100	80.6	-.04	
17	67	54.0	71	57.3	-.03	
18	67	54.0	56	45.2	.08	
19	56	45.2	56	45.2	.00	
20	33	26.6	45	36.3	-.10	
21	41	33.1	55	44.4	-.12	$p =.06$
22	42	33.9	47	37.9	-.04	
23	67	54.0	68	54.8	-.01	
24	24	19.4	30	24.2	-.06	
25	25	20.2	19	15.3	.06	
26	40	32.3	38	30.6	.02	
27	26	21.0	30	24.2	-.04	

Table 21

Percentage of Subjects Answering Each Item Correctly by Racial Groups, Flags Test

Item	Navajo		Non-Navajo			
	Count	Percentage correct	Count	Percentage correct	Phi	Sig.
1	72	58.1	79	63.7	-.06	
2	76	61.3	78	62.9	-.02	
3	76	61.3	78	62.9	-.02	
4	81	65.3	82	66.9	-.02	
5	85	68.5	85	68.5	.00	
6	88	71.0	105	84.7	-.16	p <.05
7	64	51.6	78	62.9	-.11	p = .07
8	58	46.8	77	62.1	-.15	p <.05
9	59	47.6	73	58.9	-.11	p = .07
10	60	48.4	65	52.4	-.04	
11	73	58.9	85	68.5	-.10	
12	57	46.0	70	56.5	-.10	
13	72	58.1	70	56.5	.02	
14	72	58.1	84	67.7	-.10	
15	88	71.0	85	68.5	.03	
16	74	59.7	78	62.9	-.03	
17	80	64.5	80	64.5	.00	
18	91	73.4	99	79.8	-.08	
19	83	66.9	88	71.0	-.04	
20	79	63.7	83	66.9	-.03	
21	69	55.6	83	66.9	-.12	p = .07
22	68	54.8	91	73.4	-.19	p <.05
23	77	62.1	95	76.6	-.16	p <.05
24	67	54.0	85	68.5	-.15	p <.05

suggested four items: 2 ($\chi^2_{(1)}$ = 7.12, p <.05), 6 ($\chi^2_{(1)}$ = .136, p <.05), 11 ($\chi^2_{(1)}$ = 8.19, p <.05), and 13 ($\chi^2_{(1)}$ = 5.69,p <.05) had independent cells. Navajo subjects had a higher percentage correct on numbers 2, 6, and 11. On number 13, non-Navajo subjects had a higher percentage of correct answers. Number 10 approached independence (see Table 22). Phi coefficients similarly indicated an association between score and group membership for these items.

On the Sticks, Jars, and Poles test, chi-square analysis suggested cell independence on four of the six items: 1 ($\chi^2_{(1)}$ = 21.97, p <.05), 2 ($\chi^2_{(1)}$ = 5.00, p <.05), 4 ($\chi^2_{(1)}$ = 9.38, p <.05), and 6 ($\chi^2_{(1)}$ = 12.16, p <.05). Non-Navajo children had a higher percentage of correct answers for all of these items, leaving two questions on which both groups answered correctly at approximately the same rate (see Table 23). Phi coefficients for all items implied a significant association between race and score on the item.

On the Blocks test, one item (16) was shown to have independence of cells: ($\chi^2_{(1)}$ = 4.30, p <.05). Non-Navajo students answered number 16 correctly at a higher rate than Navajo children (see Table 24). Corresponding phi coefficients suggested a significant association between group membership and score on these items.

Chi-square analysis for the Hidden Figures test demonstrated cell independence for two items: 11 ($\chi^2_{(1)}$ =

6.80, $p < .05$) and 12 ($\chi^2_{(1)} = 4.60$, $p < .05$) (see Table 25). Navajo Indian subjects had a higher percentage correct for both of these items. Examination of phi coefficient suggested a significant association between score and group membership.

Table 22

Percentage of Subjects Answering Each Item Correctly by Racial Groups, Hands Test

Item	Navajo		Non-Navajo			
	Count	Percentage correct	Count	Percentage correct	Phi	Sig.
1	66	53.2	64	51.6	.02	
2	103	83.1	85	68.5	.17	$p < .05$
3	88	71.0	94	75.8	-.05	
4	101	81.5	91	73.4	.10	
5	88	71.0	89	71.8	-.01	
6	108	87.1	95	76.6	.14	$p < .05$
7	88	71.0	93	75.0	-.05	
8	97	78.2	90	72.6	.06	
9	93	75.0	88	71.0	.05	
10	97	78.2	85	68.5	.06	$p = .08$
11	95	76.6	74	59.7	.18	$p < .05$
12	84	67.7	86	69.4	-.02	
13	49	39.5	66	53.2	-.14	$p < .05$
14	59	47.6	67	54.0	-.06	
15	33	26.6	45	36.3	-.10	
16	89	71.8	86	69.4	.03	

Table 23

Percentage of Subjects Answering Each Item Correctly by Racial Groups, Sticks, Jars, and Poles Test

Item	Navajo		Non-Navajo			
	Count	Percentage correct	Count	Percentage correct	Phi	Sig.
1	5	4.0	31	25.0	-.30	$p < .05$
2	22	29.5	37	29.8	-.14	$p < .05$
3	32	25.8	42	33.9	-.09	
4	56	45.2	80	64.5	-.19	$p < .05$
5	64	51.6	73	58.9	-.07	
6	36	29.0	63	50.8	-.22	$p < .05$

Table 24

Percentage of Subjects Answering Each Item Correctly by Racial Groups, Blocks Test

Item	Navajo		Non-Navajo			
	Count	Percentage correct	Count	Percentage correct	Phi	Sig.
1	117	94.4	118	95.2	-.02	
2	76	61.3	73	58.9	.02	
3	65	52.4	64	50.8	.02	
4	54	43.5	63	50.8	-.07	
5	84	67.7	75	60.5	.07	
6	45	36.3	50	40.3	-.04	
7	66	53.2	63	50.8	.02	
8	37	29.8	39	31.5	-.02	
9	58	46.8	58	46.8	.00	
10	22	16.1	24	19.4	-.04	
11	37	29.8	42	33.9	-.04	
12	21	16.9	25	20.2	-.04	
13	22	17.7	19	15.3	.03	
14	13	10.5	13	10.5	.00	
15	10	8.1	4	3.2	.10	
16	8	6.5	18	14.5	-.13	$p < .05$
17	4	3.2	5	4.0	-.02	
18	21	17.1	13	10.6	.09	

Table 25

Percentage of Subjects Answering Each Item Correctly by Racial Groups, Hidden Figures Test

Item	Navajo		Non-Navajo			
	Count	Percentage correct	Count	Percentage correct	Phi	Sig.
1	110	88.7	116	93.5	-.08	
2	77	62.1	79	63.7	-.02	
3	42	33.9	51	41.1	-.07	
4	46	37.1	56	45.2	-.08	
5	89	71.8	94	75.8	-.05	
6	112	90.3	110	88.7	.03	
7	94	75.8	97	78.2	-.03	
8	74	59.7	82	66.1	-.07	
9	57	46.0	70	56.5	-.10	
10	81	65.3	71	57.3	.08	
11	48	38.7	29	23.4	.17	$p < .05$
12	41	33.1	26	21.0	.14	$p < .05$
13	86	69.4	88	71.0	-.02	
14	89	71.8	89	70.8	.00	
15	45	47.5	50	40.3	-.04	

CHAPTER V

DISCUSSION

Overview

The purpose of this study was to investigate whether claims of differences in cognitive abilities between Navajo Indian children and non-Navajo children seemed accurate, with an emphasis on spatial abilities. Previous research has suggested that American Indians have stronger spatial skills than non-Navajo children. In this chapter, the results of the research are discussed within the framework of the original questions to explore the relative meaning of the results, as well as how they are related to each other.

Interpretation

The investigation started with a comparison of scores between the genders because history has suggested that they differ in their spatial ability levels. Differences were found between genders on the Flags test in the timed condition but not in the extended time condition. Since Flags is a test of rotational ability, these results suggest disparity between males and females on rotational ability consistent with that noted by other authors with adults (Goldstein et al., 1990; Lohman, 1986; Tapley & Bryden, 1977). In addition, the degree of dissimilarity changes as the task moves from timed to extended time results, indicating that females may be able to complete the task with equal accuracy but require more time. Examination of alpha statistics to measure reliability also demonstrated interesting patterns with this particular instrument. The alpha levels of the Navajo Indian males and both non-Navajo groups clustered around .80, whereas the alpha level of the Navajo Indian females was .69 (see Table 26). This difference suggests that the items were possibly approached differently by this group of students or provided a distinct challenge to this particular group.

Computational analysis of rotational tasks comparing males and females has suggested that a female's speed of rotation is slower than a male's (Lohman, 1986; Tapley & Bryden, 1977) and that these results are consistent with this hypothesis. However, the solution does not seem to be that simple when examined in greater detail. Tapley and Bryden (1977) suggested that the rate of rotation has a greater relationship to use of visual imagery in men than it does in women and that women may use more verbal mediation when solving rotational problems. They believed that this is an important part of the process; however, the relationship noted in their work was not sufficient to explain all the differences recorded. They further intimated that the women's apparently slower speed of rotation could be affected as much by how many times they made comparisons between the base stimuli and the rotated

Table 26

Alpha Coefficients for Four Groups by Race and Gender, Each of Six Instruments

	Navajo		Non-Navajo	
Test	Male	Female	Male	Female
Spatial Relations	.72	.69	.82	.74
Flags	.84	.69	.82	.80
Hidden Figures	.69	.64	.65	.62
Blocks	.77	.82	.87	.78
Hands	.76	.63	.76	.54
Sticks, Jars, and Poles	.50	.52	.66	.25

one for each problem and the process through which they confirmed "same" or "different." Newcombe (1982) also hypothesized that women typically may use a more verbal-analytic strategy than men to solve rotational problems. In further exploring this area, Bryden (1979) devised the idea that, rather than having different specific rotational strategies, women may have different strategies for the allocation of attention, the order of reporting, and the decision-making process whether they report answers to items about which they are uncertain. Goldstein et al. (1990) stated this idea more boldly by suggesting that the differences are not due so much to pure cognitive ability differences but more to confidence levels about answering, subsequent speed of answering, and a lack of familiarity with tasks. The apparent gender differences disappeared when the tasks were not timed (Goldstein et al., 1990), as they did in this study. In their research results, they also found that when the ratio of number right to number attempted (as opposed to raw number right) was compared across genders, gender differences again seemed to dissipate. Thus, because sex-role-typing and gender-related self-esteem issues often develop earlier than believed, the differences seen in this study (as with those seen previously) may be because of many factors separate from basic cognitive differences.

The same pattern occurred in the total score in which a significant difference was noted between the groups in the timed condition but not in the extended time. Thus, whatever strategy females use to complete tasks or whatever their mind-set about answering, their accuracy seems to be equivalent if given additional time.

The second question asked whether there appeared to be any differences between the two racial groups on the measures of spatial abilities (individually or together, timed, and extended time). The results of this study demonstrated that differences were found between the groups on two tests (Flags and Hidden Figures) when the test situation was timed and on the Flags test when the students were given more time. These results suggest that (a) Navajo children may, in general, perform better when not pressured with time constraints, and (b) both Flags and Hidden Figures may be conjectured to involve rotational ability and, similar to the comparisons between genders, may have some difference in speed of rotation or another component of the task between the Navajo Indian and non-Navajo groups. Again, if this were to be explored in detail, it is likely that differences could be found in strategies. These strategies may include previously noted areas such as allocation of attention, number of comparisons, order of reporting, decision-making processes, or even unexplored areas. As suggested with gender differences, cultural or personality factors could exist that affect the choice of strategy, utilization of various strategies, or answering process.

If McShane and Berry (1988) and Kleinfeld (1971) are correct in their suggestion that Alaskan Natives' apparent strengths in visual-spatial and spatial-orientation abilities are the result of survival mechanisms, it is likely that those abilities can be broken down to components that may or may not differ from non-Alaskan natives. Similarly, the Navajo children tested may have a series of strategies that have been developed through a combination of genetics and learning that may be highly adaptive for their living style but also may be different from non-Navajos and not particularly adaptive for the tasks used in this study and others like them. If this was the case, it might then be conjectured that, should the tasks be adapted for their strategies or vice versa, the comparisons between groups might demonstrate entirely different results.

Kleinfeld (1973) concluded that the presence or absence of equivalent experience and education could have an effect on the scores received by Alaskan natives on tests, especially if those tests were educationally based. Also, Berry et al. (1992) believed that culture-fair tests "are fiction" (p. 111), and, using unfamiliar tests and stimuli with culturally different groups, could affect the test results. These particular tests were selected for their low verbal content and apparent universality of the stimuli, but it is possible that these selection criteria were incorrect. Possibly, the two groups do not have equivalent educational experience and/or their level of familiarity or comfort with these tasks differs for many reasons, including the availability and use of computer and video games. This reasoning also may explain some of the gender differences that are discussed in this chapter.

Significant differences also were noted on the Sticks, Jars, and Poles task, with the non-Navajo children performing better than the Navajo children. However, this task had few items and is related to Piaget's stages of development from preoperational to concrete operational. Piaget hypothesized that the change occurred by age 9 (Weiten, 1989). However, E. Johnson (personal communication, May 1990) suggested that these skills are developed over a range of ages, with fewer than 60% having the skill by age 18. Since the proposed age of acquisition is at the older end of the ages of the current subjects, differences in scores could be related to problems with the instrument and/or maturational differences between the two groups rather than concrete ability differences. Alpha coefficient comparisons also indicated a striking difference between groups on this test, with non-Navajo females showing the lowest coefficient (see Table 26). This finding, again, may symbolize particular difficulties with this type of task for this group or an idiosyncratic approach to this task or to tasks in general.

A significant difference was found between the two groups on the total mean score of five tests that were timed: non-Navajos scoring higher than Navajos. Using the mean scores of the same five tests with extended timing, the scores were no longer significantly different. This difference seems, again, to be a strong statement for allowing extended time conditions with Navajos when assessing cognitive abilities in order to obtain a more accurate measure of their abilities rather than their reaction to timing. Some level of timing is important when measuring many cognitive abilities, particularly spatial abilities. In order to push for certain strategies, a true untimed condition is not possible. The range of factors potentially affecting cognitive performance is large and often complicated without even considering basic differences in abilities. Thus, the use of extended time conditions seems to be the most reasonable and equitable.

Further analysis revealed several significant interactions between race and gender. Closer examination suggested that Navajo Indian girls' scores, particularly in the extended time condition, were sometimes higher than the Navajo Indian boys' and at times equal to or better than non-Navajo girls' scores. Several hypotheses were considered, all of which deserve further attention. First, if differences in spatial ability are related to sex-role typing, there may be less pressure on girls in early elementary school on the reservation to conform to traditional female sex roles. Second, possibly if self-esteem and confidence levels are significant factors in successful completion of some of these tasks, perhaps at ages 7 to 9, Navajo Indian girls have maintained a higher level of self-esteem in school, as has been hypothesized for all girls of elementary age.

The first significant point of interest about the factor analysis is that, unlike some previous research, two factors, rather than three as initially suggested, were found in both groups. The factors that formed were also of different structures between the two groups for timed and extended time conditions. Several reasons could account for this finding. First, while factor analysis can be conducted with a small number of variables, the number in this study may not have been sufficient for three distinct groups to have formed. This finding is a particular problem with the now greater understanding of the functioning and limitations of the Sticks, Jars, and Poles test. Interestingly, however, in the non-Navajo group (timed), there seemed to be a drawing toward identification of a third factor that the addition of more variables might push. In looking at the instruments graph (see Figure 15), the suggested pairings are not consistent with the original pairings made for proposed factors in designing this study. Any thoughts drawn from this finding must be considered conjecture, but this also seems to provide support for the notion that, with this group of students, these tests are not measuring the qualities that were originally hypothesized. Some of these instruments were selected based on fairly strong research results that indicated they measure certain qualities. Other instruments were selected based on similarities to tests that appeared to measure identified abilities. Also, it must be remembered that this was a fairly young sample. Scores from these same tests designed for older children or adults may display a different factor structure, including three factors with an older sample. As for this sample, these choices of tests may have been faulty, or these tests, for whatever reason, may have responded differently with this particular sample. Whether that is a problem with the "conclusion-makers" or with the instruments remains to be seen.

Also, the current results suggested that, at least in some conditions, these tests are not exhibiting the same types of responses between the two groups. This finding is evident in the results of the ANOVA, factor analysis, and item analysis. Some of these differences affected the manner in which the scores factored into groups. Another curiosity is the different factor structures identified, as the scores used changed from timed to extended time. The apparent pattern of equalizing scores on the tests had a major effect on the configuration of factors with the non-Navajo children. This change may be related to possible differences, as noted earlier, in strategies or approaches to the test material by the students. This change might be because of what skills the tests actually measure when subjects are given limited and unlimited time to finish. At this point, these thoughts continue to be mere conjecture, as better answers would take a more in-depth examination of processes involved. As a start, it is worthy to note that, even with apparent differences in results between the two groups, had there been a greater number of instruments involved in the factor analysis, possibly the structures may have been similar and/or three factors might have been identified.

Another method of examining the data was through discriminate analysis to determine if group membership could be predicted accurately using the scores from these instruments. This procedure seemed to demonstrate that the groups varied sufficiently in their scores on these instruments to predict membership using five of the six instruments (four timed and Sticks, Jars, and Poles). However, with a prediction ratio of 65.73%, ample room is available for misclassification. In addition, in spite of the 65.73% prediction accuracy, evidence suggested that much of the variance came from differences in scores within each group rather than from between. A proportion such as this decreases the accuracy with which one could classify new cases into groups and increases the error rate. Even though it seems possible that the instruments are more accurate at predicting group membership for Navajo Indians than non-Navajos, the potential error rate is still high. The same pattern holds when using the best predictors among scores from extended time tests. The only apparently consistent discriminator for the two groups is Sticks, Jars, and Poles, but, as discussed elsewhere in this dissertation, there appear to be inherent weaknesses in this instrument (at least in these groups).

Item analysis suggests, in addition, a different pattern of responding to some test items between the two groups. Some of the differences, approximately 5%, in percentage correct between groups are because of chance. In accordance with this finding, it would seem intuitive to find item differences at the ends of the tests on which significant total differences were present, assuming the test was designed as a power test. However, the differences found in the present study did not necessarily follow a consistent pattern for an instrument of increasing difficulty. Rather, the items in which number scoring correctly was significantly different had a random sense to them, at least for Hands, Spatial Relations, and some of the Flags items.

This possible difference in pattern of correct answers is reminiscent of Chrisjohn and Peter's (1986) suggestions that apparent differences in scores between groups may be related to differences in patterns of correct answers on an instrument; that is, the total score is not an accurate source of comparison. However, in this case, the differences are not consistent across the groups; that is, in some cases, the Navajo children answered an item correctly to a greater degree than non-Navajos, whereas, on some items, the pattern was reversed. Curiously, on Hidden Figures, one of the tests, in which significant differences were present in the timed version but not the extended time version, the Navajo students answered the higher percentage correct on two items. These items were at the end, however. They were probably only counted for the extended time comparison, suggesting that the students understood the task but did not complete as many items as the non-Navajo students during the time limit. Hidden Figures is one instrument in which, had the ratio of number correct to number attempted been computed, the results may have been quite different (at least for scores for the timed version). It must be expected that a small percentage of items would have different response rates only by chance. However, the number of items across all tests was greater than 5%, suggesting that some of the differences were caused by reasons other than chance. Also, the tests with the apparent differences in patterns were often those with somewhat curious results in other analyses, as previously noted.

In many ways, these are not the results expected when this dissertation was proposed; however, the data gathered and analyzed have proposed many interesting problems. On the surface, it seems that Navajo Indians' and females' scores improve when given adequate time to complete the task, but many underlying issues seem to exist as well. For whatever reason, the tests selected for this dissertation do not seem to measure what was originally suggested (at least for these two groups of subjects). In addition, the tests do not seem to measure consistently the same abilities in each group, even though the differences may occur in actual ability or strategy, approach to tasks, confidence, willingness to take risks, familiarity with the type of tasks, or developmental stage. As a beginning, it might be recommended that Navajo Indians and females be allowed to work extended time. Ultimately, it may be of greater importance to develop a better understanding of underlying processes to assess strengths to be capitalized upon and what skills may need to be developed over time.

CHAPTER VI

SUMMARY AND CONCLUSIONS

Summary

The purpose of this study was to clarify conflicting concerns about whether apparent differences in cognitive ability between American Indians and non-Navajos exist. Earlier research with a variety of instruments has left strong evidence on both sides of the debate. Prior research results demonstrate that American Indian children tend to perform less well on instruments with a high verbal loading and better on measures that use visuospatial abilities. There are numerous theories about why this may occur, and there is a large group of investigators who believe these differences are related (at least in part) to lower levels of school achievement by American Indians than by Anglo American students. Eminent researchers claim this perspective is racist and merely another way of keeping the American Indian at the level of second-class citizens. Others who acknowledge the existence of differences among several different groups (including American Indians, African Americans, Anglo Americans, Hispanic Americans, and Asian/Pacific Islander Americans) stress the importance of viewing the disparities as differences, not better and worse or higher and lower.

In the field of spatial ability research, the debate starts with the basic definition of spatial ability and extends to how it is manifested (whether it is a singular entity or whether there are several types of spatial abilities that can be identified through factor analysis). The conclusions differ from person to person, but the weight seems to fall on the side of qualitative discrepancies in abilities that can be factor analyzed. In addition, there is heated discussion about the presence of differences between the genders and, if this difference does exist, at what point it occurs. Variations in performances have been noted in early grade school but seem more likely to appear around the age of puberty and increase throughout high school. There are also many theories about why this occurs, ranging from purely biological through social-learning theories.

Most research conducted with American Indian children seems to have used a divergent group of instruments with questionable loading of spatial abilities, and it has not been examined from a factor perspective. The present study was designed to fill in some gaps and to take this type of research in a slightly different direction.

The results of the study seem to vary from what might be anticipated based on prior research studies. In this particular study, the Navajo students did not score as well as the non-Navajo students in some instances and never scored significantly better. This finding is not a cutoff point, however. There are several pieces of important information yet to be examined. Both the Navajos' and the females' performances tended to be enhanced when the time period was extended. This change from timed to extended time was so noticeable in the Navajo Indian group that the Navajo Indian females scored higher than the Navajo Indian males on two tests, which is a pattern not seen with the non-Navajo group and one that is not typical in gender research of spatial abilities. However, since the students were aware that they were being timed, neither group experienced the total freedom of a true untimed condition under which even more variable results may have been found. However, within the observation of changes between the two conditions, information suggests that on several tests gender differences had an impact on the overall disparity between groups.

This effect can most readily be seen on Flags, Blocks, and Hands. The Navajo Indian girls scored the lowest on Flags in both conditions (see Table 27), the non-Navajo males had the highest scores, and the non-Navajo females and Navajo Indian males were in the middle. On Blocks, the highest was, again, non-Navajo males, with Navajo Indian males scoring the lowest. Navajo Indian females received the second highest score and non-Navajos the third. On Hands, however, the Navajo Indian males scored highest and second highest, which is in concert with the non-Navajo

Table 27

Rank Ordering of Groups, Race, and Gender by Mean Scores Timed and Extended Time*

	Navajo		Non-Navajo	
Test	Male	Female	Male	Female
Spatial Relations, timed	2	3	1	4
Spatial Relations, untimed	4	2	1	3
Flags, timed	2	4	1	3
Flags, untimed	3	4	1	2
Hidden Figures, timed	4	3	2	1
Hidden Figures, untimed	4	3	1	2
Blocks, timed	4	2	1	2
Blocks, untimed	4	2	1	2
Hands, timed	1	4	3	2
Hands, untimed	2	3	4	1
Sticks, Jars, and Poles	3	4	1	2

*Differences between groups as rank ordered are not necessarily significant at a $p<.05$ level.

females, whereas the Navajo Indian females and non-Navajo males vied for third and fourth.

Without more in-depth analysis, it is impossible to determine the cause of these disparities. First, however, one might conjecture that there is a relative difference in familiarity with task. All boys are aware of and use their hands, but possibly an urban non-Navajo boy does not consider or use his hands in the same way with the same meaning or level of importance as a Navajo Indian boy living on a reservation. Possibly an Indian boy is more adept at visualizing in space something that has meaning to him rather than an object or set of objects that has no specific relation to him or his life. Because the children were not only from two different racial groups but also contrasted in urban-rural living, familiarity with task may have had an even greater effect than is immediately apparent because of the differing levels of availability, such as computer and video games. These games often focus on spatial relations and utilizing nonmeaningful objects to achieve a goal.

Second, there may be a difference in the use of strategies. Information that has been applied to gender research relating to the repertoire of strategies that may be available to females compared to males may be applicable. It seems reasonable that Navajo Indian children learn cognitive strategies related to tasks in their world or to methods of teaching prior to formal schooling just as non-Navajo children might. Because the respective environments may be different and create varying demands on the children at the micro level, problem-solving strategies also may be different. These strategies may or may not be easily translated to educational or unfamiliar tasks.

The concept of strategies has no relationship to level of intelligence or basic cognitive ability. However, they do relate strongly to how individuals solve problems and whether the approaches are based in culture or environment.

In keeping with earlier research results, the existence of different types of spatial skills seemed to be demonstrated. This statement must quickly be qualified, however. In computing the factor analysis, a small number of instruments were used, and one of those (Sticks, Jars, and Poles) was of questionable reliability. Additional instruments could be used to more fully answer this question. However, with the results obtained, there appears to be some divergence in what is being measured, such as more than one type of spatial ability. The differences in factor loading between the two groups and the evidence suggesting the Navajo Indians' factor structures remain the same, whereas the non-Navajos' do not, also implies a difference in approach to or handling of the problems or variations in strategies. The factor loadings of the non-Navajo group more closely resembled those predicted at the beginning of the present study than the Navajo Indian subjects. If the non-Navajo students approached the tasks in a manner similar to the groups tested when the factors were identified, the structure might be expected to be similar. Concurrently, if the Navajo Indian group used different approaches or strategies, it might explain the apparent difference in factor structure. No suggestion was found in the review of literature that any subjects in the factor analysis research were minorities; thus, there is no basis for comparison at this point. Whatever strategies the

Navajo Indian group may be using, they seem to be consistent across conditions because their factor structure remains the same and the non-Navajo group does not.

In further analysis, the differences in scores between groups provided some predictive ability using varied selections of the measures. The facility of this measure varied from group-to-group, with non-Navajo males and Navajo Indian females providing the strongest predictive ratios. These discrepancies, again, may be caused by varying strategies, perceptions, or response styles in the groups. Male and female, Navajo and non-Navajo seemed to be consistent with other differences noted throughout the present study.

Differences in strategies have been highlighted as one hypothesis to explain some of the dissimilarities found in the present study. This finding is not to minimize the array of other factors that can contribute to the performance of a child on a cognitive test. However, little prior evidence was found to suggest that data comparing these two racial groups have been analyzed at the strategy level, though many theories suppose differences occur. One finding that seems clear in this collection of data is that even though group differences seem to exist, individual differences within groups also are important. Predictive ability was limited because of within-group variance, patterns of mean scores varied across gender and racial groups in different conditions, and, at times, some females achieved scores closer to a cross-gender or cross-racial group than to their own group. These results seem to point strongly to the importance of assessing abilities, strategies, and styles at an individual level, as much as or more than at the group level.

Limitations of the Current Study

The results of this research study can only be used to draw hypotheses about a select group of American Indian students, namely 7- to 9-year-old English-speaking Navajo students from the Shiprock area of the Navajo reservation. Since Navajos have a fairly distinct cultural and environmental lifestyle, it would be extremely tenuous, if not dangerous, to attempt to generalize these results outside the bounds of this group or even to groups that live in the same geographical area. Also, this study used materials that were designed to measure nonverbal spatial abilities and, at face value, appear to have minimal cultural bias. However, the last instrument (Sticks, Poles, and Jars) had a limited number of items and was supported by less research data than the other five instruments, leaving greater hesitance to draw conclusions heavily weighted by this instrument. Factor analysis was conducted using only six instruments. If more instruments had been used, the results may have been the same or they may have been quite different.

In addition, there were methodological difficulties in collecting accurate data for the timed condition. Although the majority of students was responsive to the examiner and the guidelines established for the session, some students were not (similar to a class with a substitute teacher), thus contaminating the timed data set. All the results were analyzed with this fact in mind; however, it is worthy of additional note as a limitation of this particular study.

Future Research

Many avenues of exploration are left open to the researcher or educator with continued interest in this field. Immediately, of course, is the continuation of this particular project with one or more variations such as (a) comparing English and non-English-speaking Navajo students and (b) comparing non-English-speaking Navajo students with non-Navajo students, including a rural/urban designation as a variable, utilizing the same technique with different tribal groups, and comparing between groups or between a tribal group and a non-Navajo group. Also, it might be helpful to include simultaneously measures of verbal abilities with which to make comparisons. In addition, following McShane and Plas's (1982a) suggestion and assessing acculturation level using a validated instrument also could provide better defined information.

At an entirely different level, componential analysis of strategies could be approached to open a new field of information. In recent years, the idea of analyzing the steps of a cognitive process has taken on new import, as differences seem to occur at a micro level rather than at a macro level. Little of this work seems to have emerged in the field of cross-cultural investigations, although the area of learning style seems to be a gross approach to this same issue. McShane and Berry (1988) and Kleinfeld (1970) presented evidence suggesting that some North American Indians demonstrate relative strength in visual-spatial and spatial-orientation abilities. This strength is related to survival needs for their particular environment. Spatial abilities possibly are the gross representation of a series or system of microabilities, perceptions, or approaches to problem solving. These abilities continue to be passed on through genetics, interpersonal learning processes, cultural norms, or any of a variety of paths. They remain adaptive either for some tasks or as a cultural norm, but they may not be highly effective or readily accepted for other tasks or environments such as those presented by traditional academic settings.

McCarty et al. (1991) stated:

> While learning "style" as performance is fairly well-defined, learning style as a set of processes generating the performance is often obscure, or so general as to be useless, if not deleterious, in

> informing instructional practice. (p. 44)

They hypothesized that the children in their study brought

> certain predilections which can lead to the kinds of performances referred to as a "style. . . ." These predilections are a function of a complex set of integrated out-of-school learning experiences that are rationalized and guided by a Navajo theory of cognitive and personal development. (p. 44)

Krywaniuk and Das (1976), with American Indians, and Bryden and Tapley (1977) and Newcombe (1982), with gender differences, also suggested that American Indians and non-Navajos may use different strategies to accomplish similar tasks. Some of the strategies are generally more efficient or more efficient for certain tasks than others. As with gender differences, it is also likely that the strategies are not purely cognitively based but are some intricate weaving of cognitive, personal, and cultural learning factors. Thus, again, the strategies need to be assessed, as clearly as possible, at a purely cognitive level and at a sociocultural level. Some evidence exists that strategies can be taught successfully (Krywaniuk & Das, 1976; Newcombe, 1982), but the current form and level of efficiency of the strategies need to be assessed first. In this model, as in many models, it is of paramount importance to recognize the strengths of a particular strategy and, if possible, utilize that strength to teach new strategies rather than labeling long-used strategies as "good" or "bad."

As for addressing some of the shortcomings of this design or utilizing some of the suppositions coming from the results of this study, many more paths of exploration are opened as well. Two suggestions, both related to the examiner, come to mind. The most obvious of these suggestions is to use an American Indian examiner for the American Indian students, as originally proposed, or to use both an American Indian and an Anglo examiner for all data collection to control for administrative differences as a variable. Jensen (1974) did not find significant differences in scores of African American and Anglo American students on several tests of cognitive abilities related to race of the examiner. However, as Chrisjohn et al. (1988) pointed out, local testers

> would be more sensitive to language and cultural issues than testers from outside the reserve, thereby reducing errors associated with the social situation of testing. (p. 276)

Again, if previously stated suppositions concerning confidence levels and willingness to provide answers when unsure are accurate, the presence of a same-race/tribe examiner could provide a sense of safety for taking a greater risk, which again could have an impact on the level of performance. Second, more accurate results might be obtained if the examiner is also a person in a position of authority with the children, either a teacher or well-known administrator. If this is not possible, a teacher or teacher's aide could be present during the testing to help eliminate the "substitute-teacher" effect noted with the timed version of this study.

Next, it might be of interest to explore not only raw number of answers correct but the ratio of number correct to number attempted in order to determine if race differences disappeared as gender differences disappeared in the Goldstein et al. (1990) work. This area gives birth to numerous questions about all previous cognitive ability research with American Indians, such as the following: Would the magnitude of differences change if this ratio were used rather than raw or standardized scores, and, if the range of differences was altered, to what degree is that happening? If changes in results were found in past research, what are the implications for currently used conclusions and for future research? Again, if this does have an effect on apparent differences, what might be the relationship with strategies and approaches to test material as previously suggested?

Since Navajo girls scored as well as or higher than Navajo boys in some instances, a cross-sectional or longitudinal study could be undertaken to explore whether these differences remain, increase, or decrease as the children age. This investigation might be conducted in the company of self-esteem research in order to determine if there is a direct relationship between changes in self-esteem over time and relative performance on tests.

This area of study is not an easy one because of the complex juxtaposition of issues that contribute to the problem. However, it seems to remain a vital area not only for American Indians but for other groups that are misrepresented in the cognitive science world. As one becomes more mechanized, so must one's thinking and understanding of human cognitive functions. Thus, future research in this area is endless.

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APPENDICES

APPENDIX A. TEST INSTRUMENTS

Note. From "Developmental Patterns of Spatial Ability: An Early Sex Difference," by E. S. Johnson and A. C. Meade, 1987, Child Development, 58, pp. 741-749.

SPATIAL BATTERY

LOWER LEVEL C

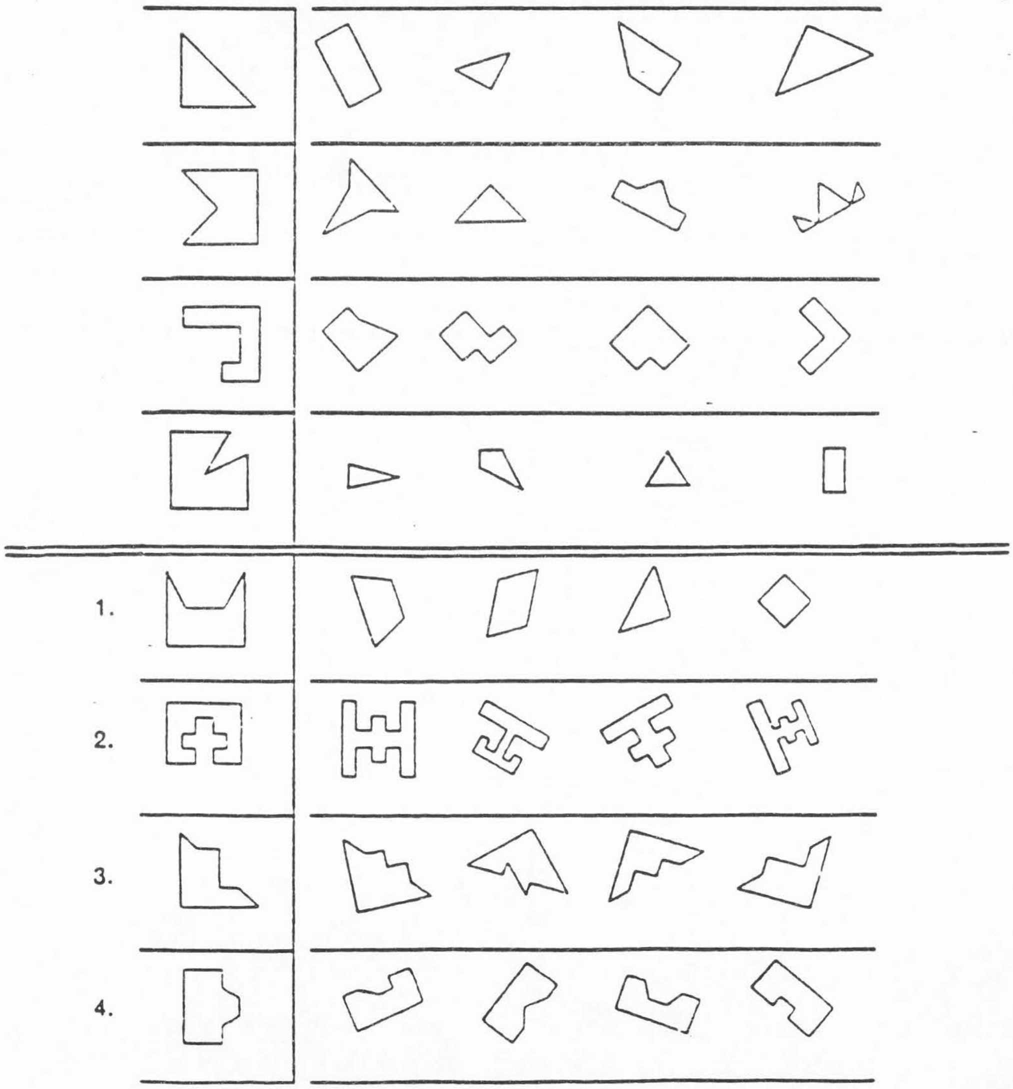
Danville City Schools

MY NAME IS ______________________ I AM IN GRADE ________

Adapted from the SRA test of Primary Mental Abilities with permission of Thelma Thurstone

EDWARD JOHNSON & ANN MEA
UNIVERSITY OF NORTH CAROL

SPATIAL RELATIONS



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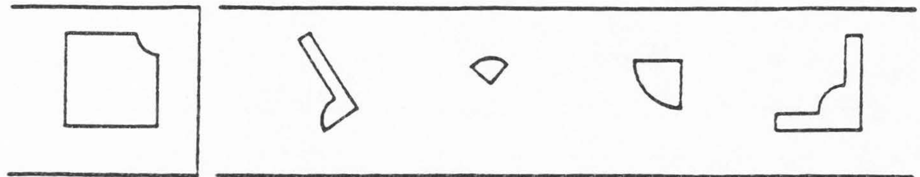

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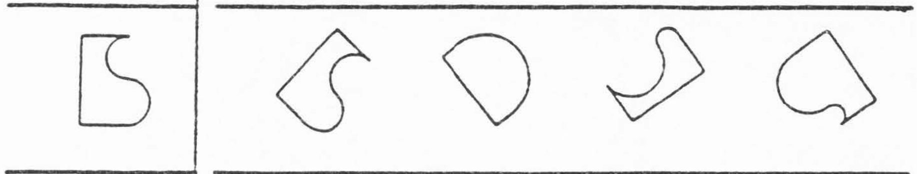

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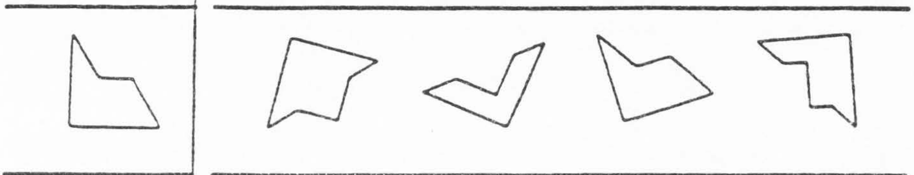

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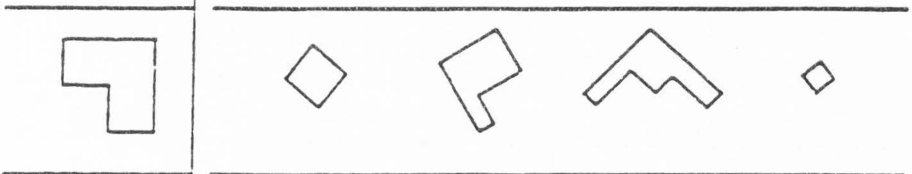

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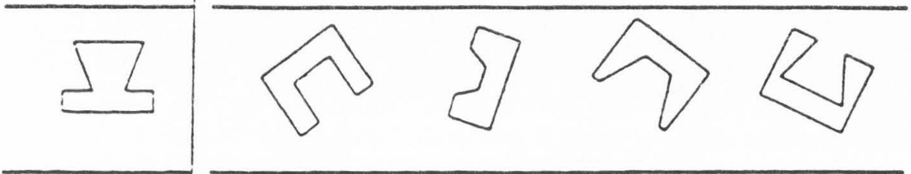

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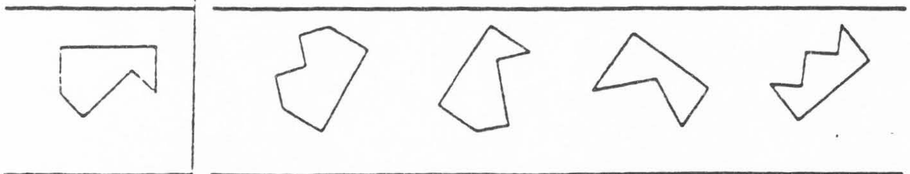

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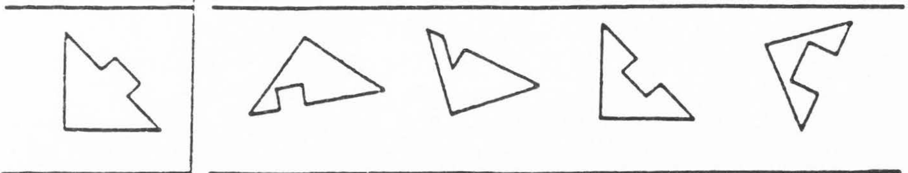

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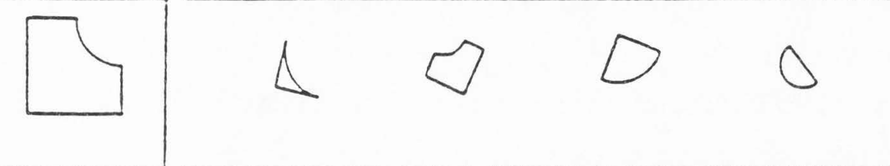
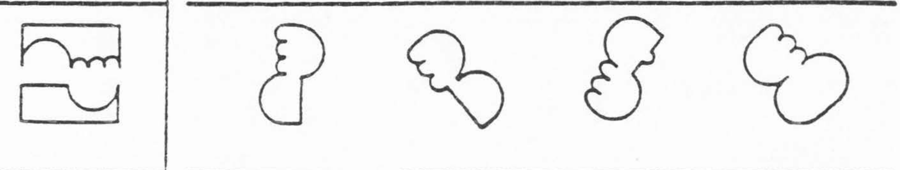
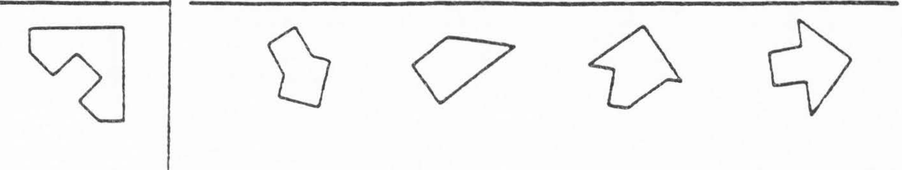
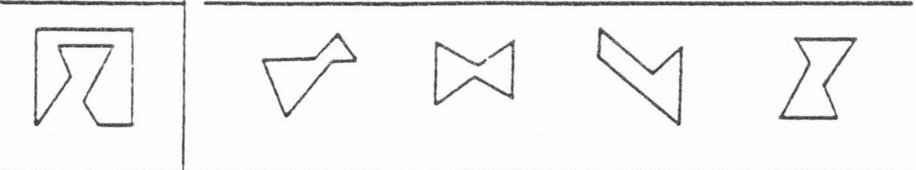
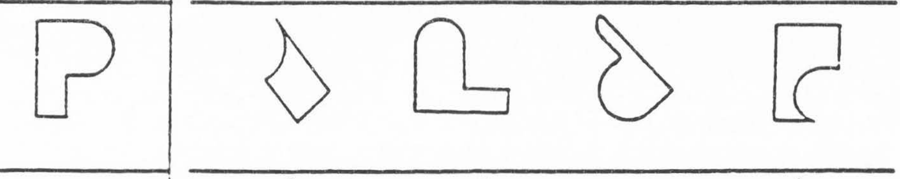
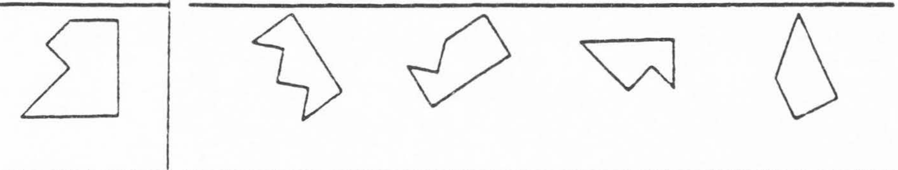
13. 

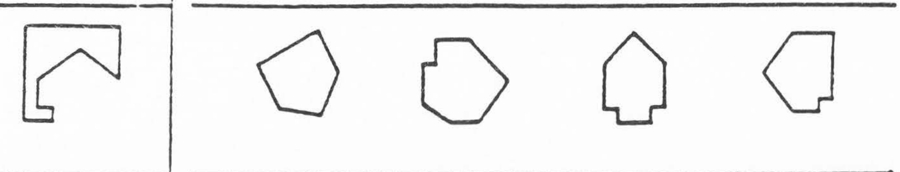
14. 

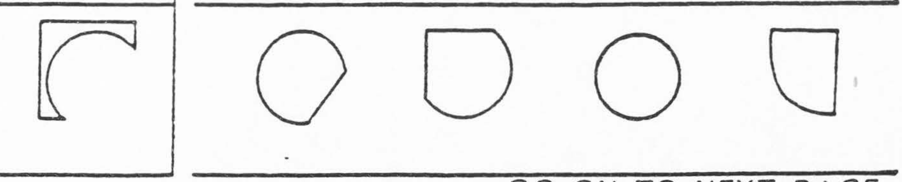
15. 

16. 

17. 

18. 

19. 

20. 

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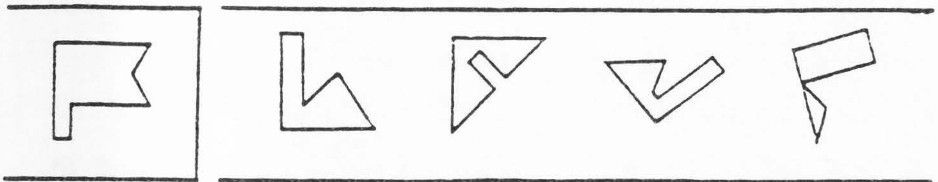
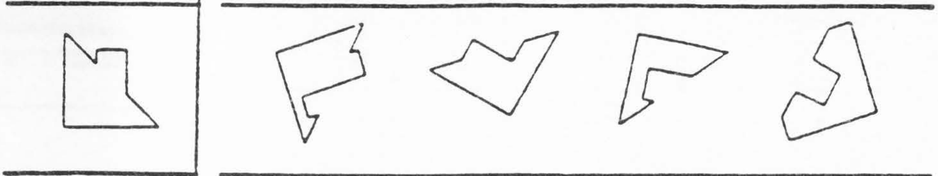
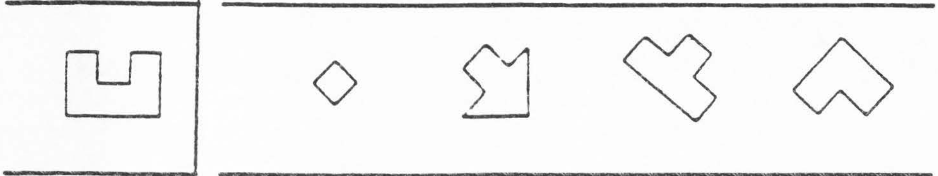
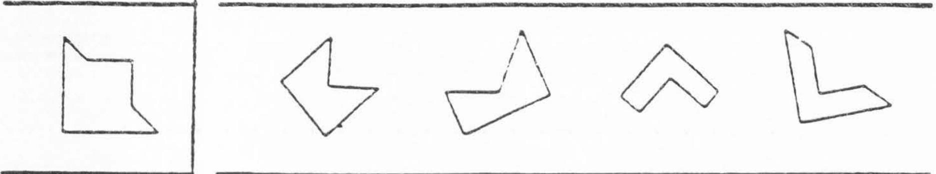
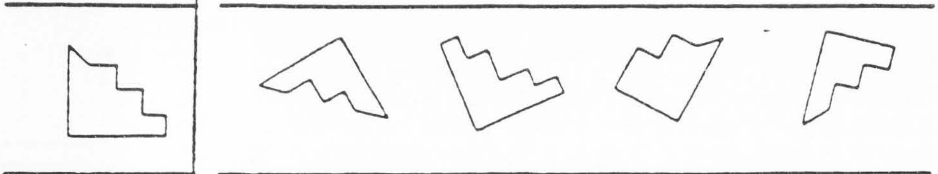
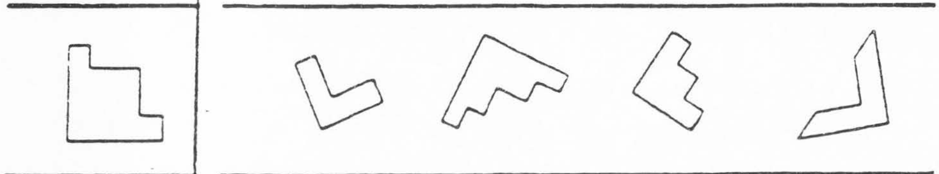
21. 

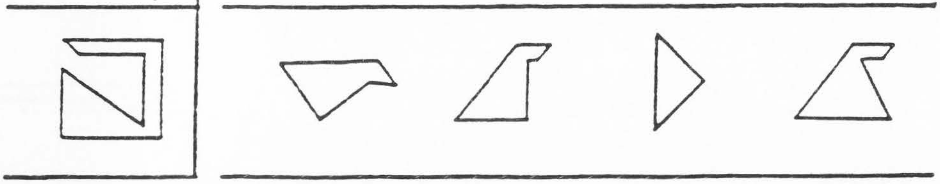
22. 

23. 

24. 

25. 

26. 

27. 

STOP.

SPATIAL BATTERY

LOWER LEVEL E

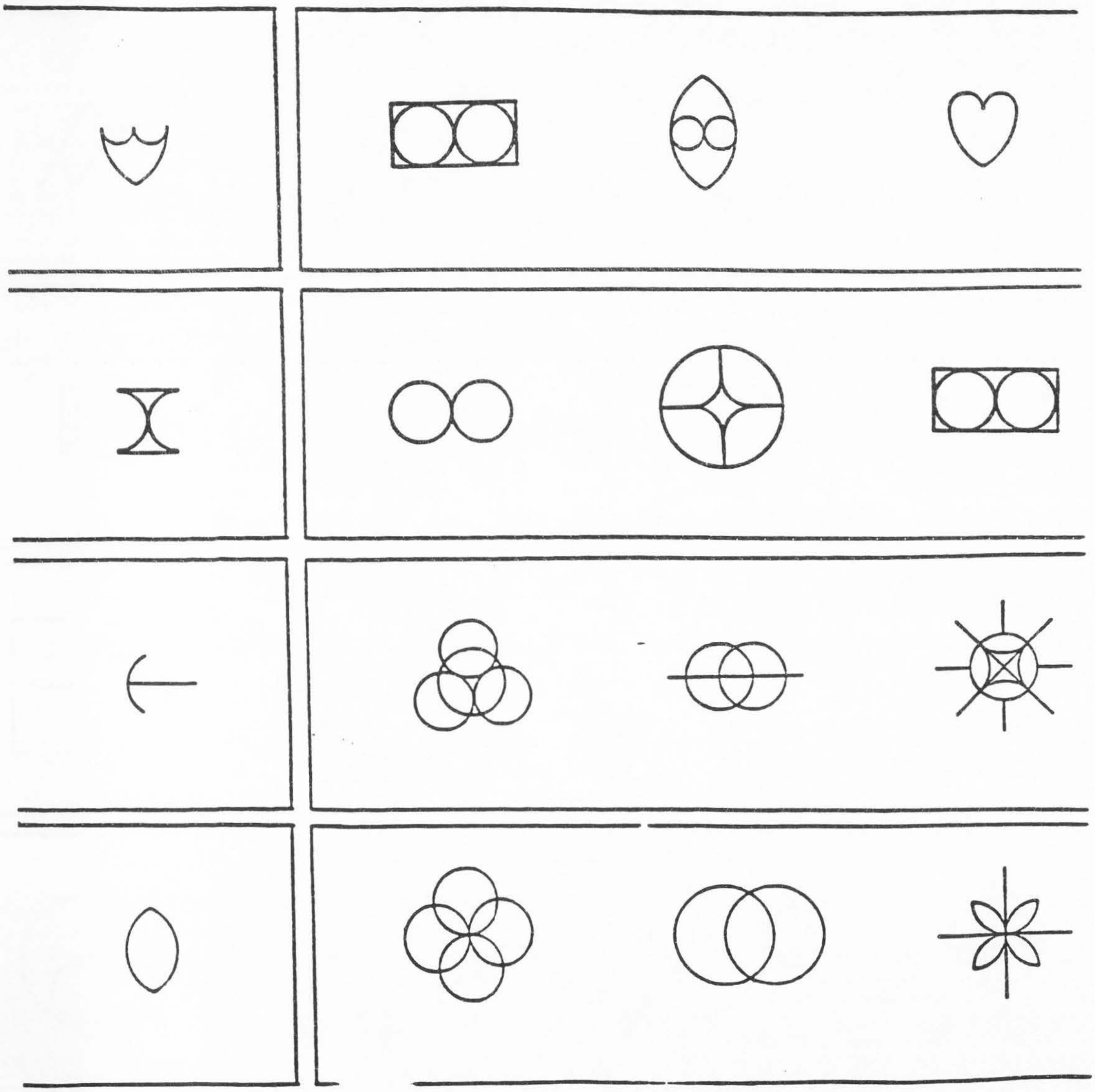
Danville City Schools

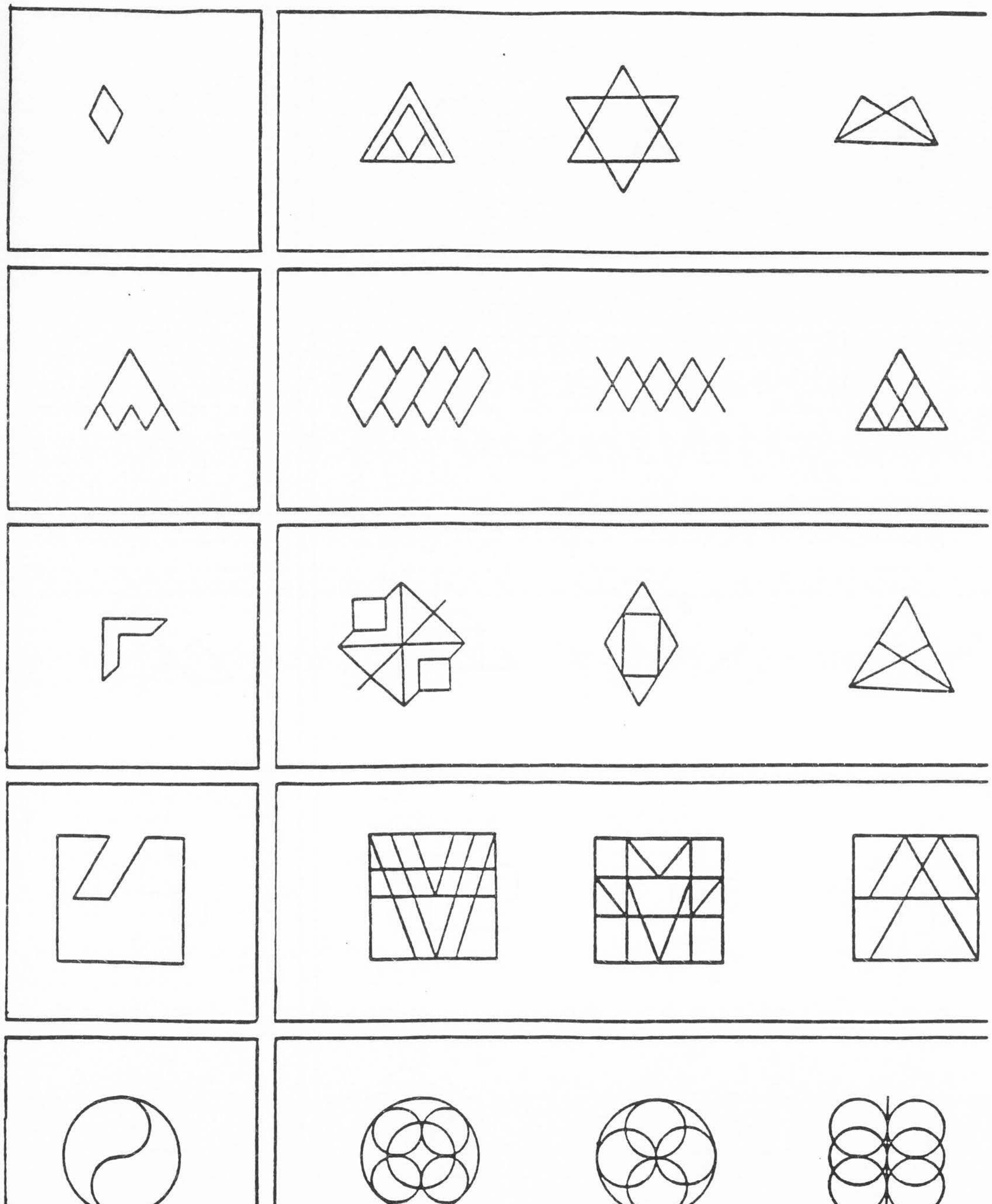
MY NAME IS ______________________ I AM IN GRADE ________

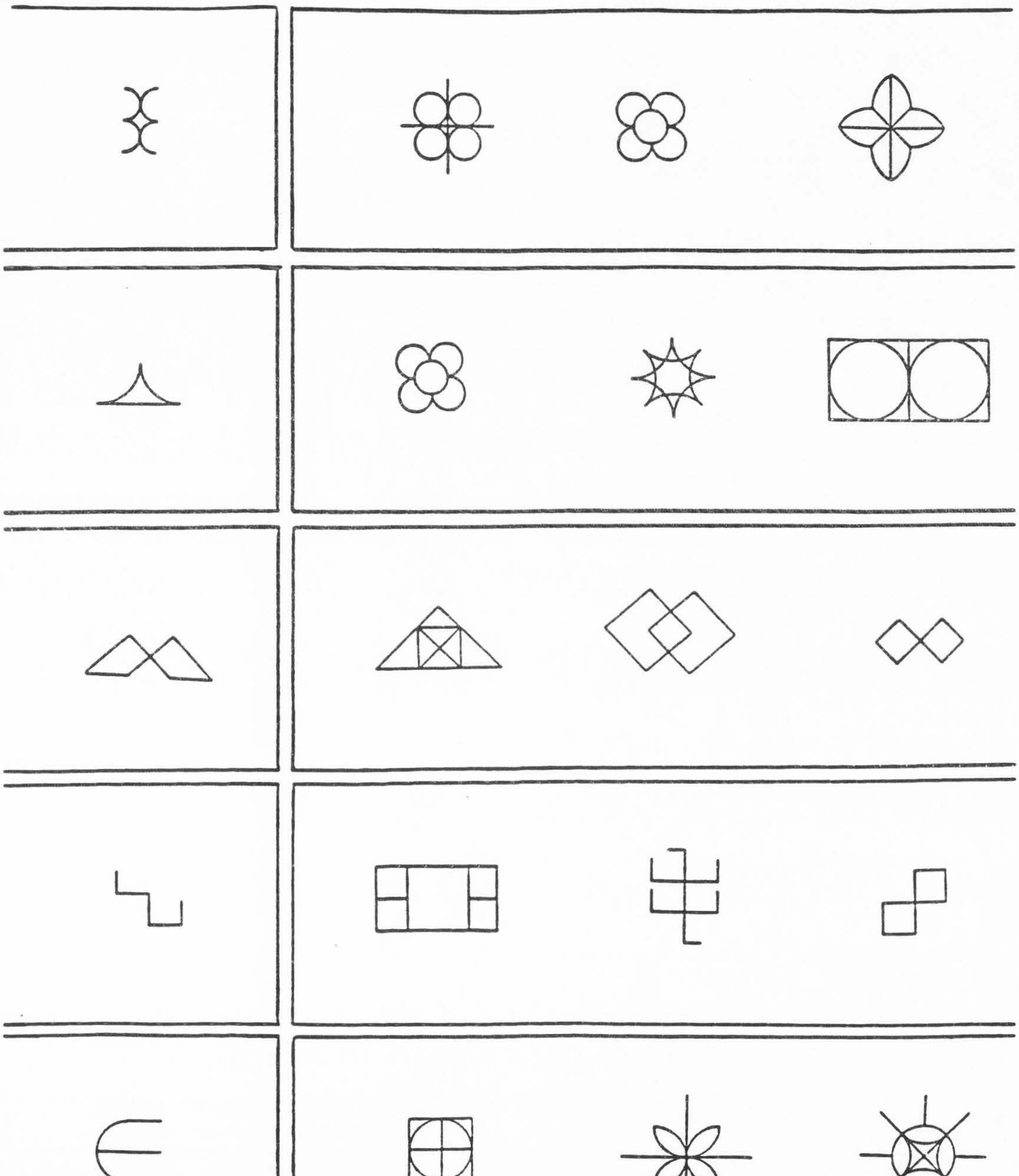
Adapted from a test by
by L. L. Thurstone.

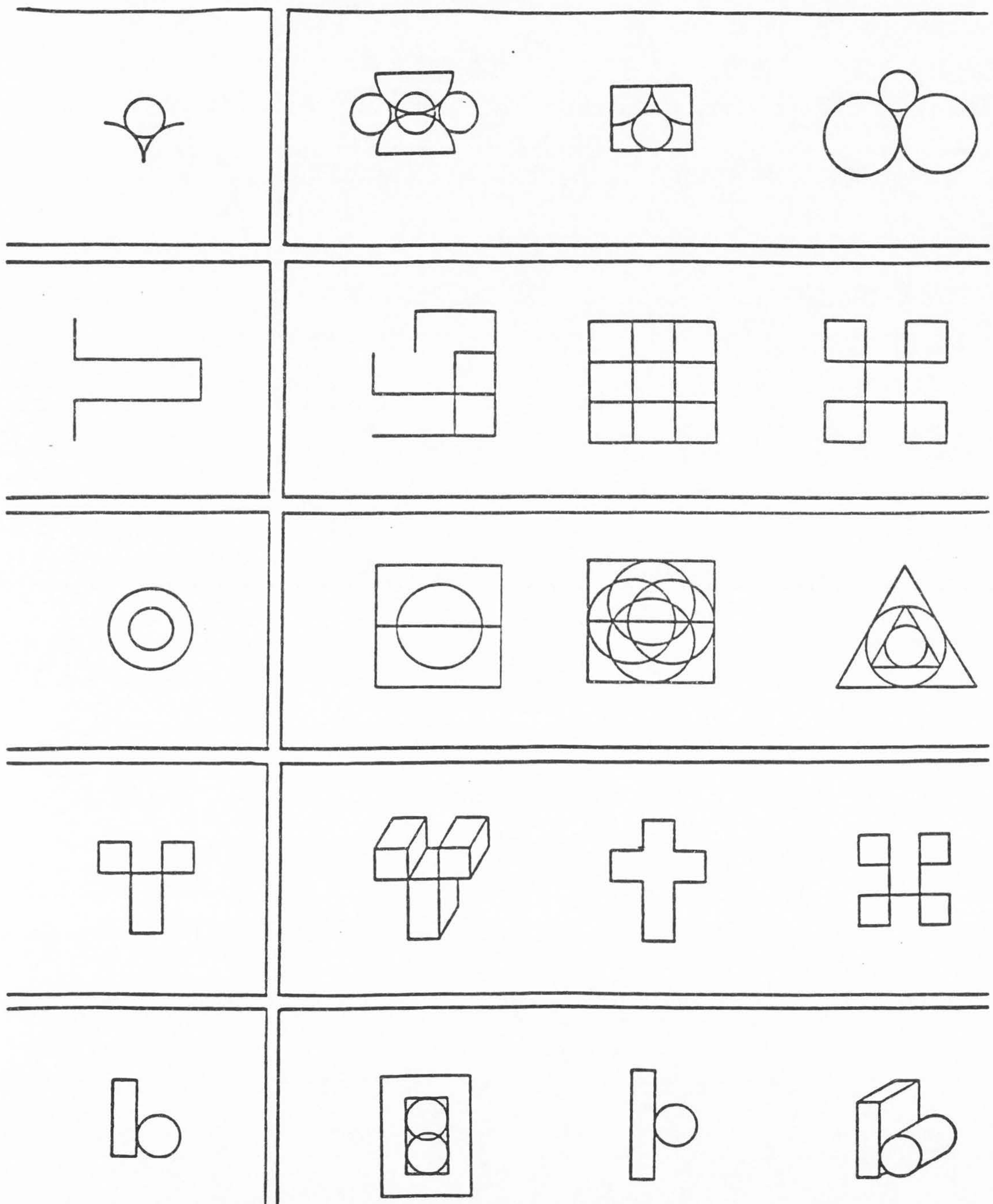
HIDDEN FIGURES

EDWARD JOHNSON & ANN M
UNIVERSITY OF NORTH CAR









SPATIAL BATTERY

LOWER LEVEL A

Danville City Schools

MY NAME IS ____________________ I AM IN GRADE __________

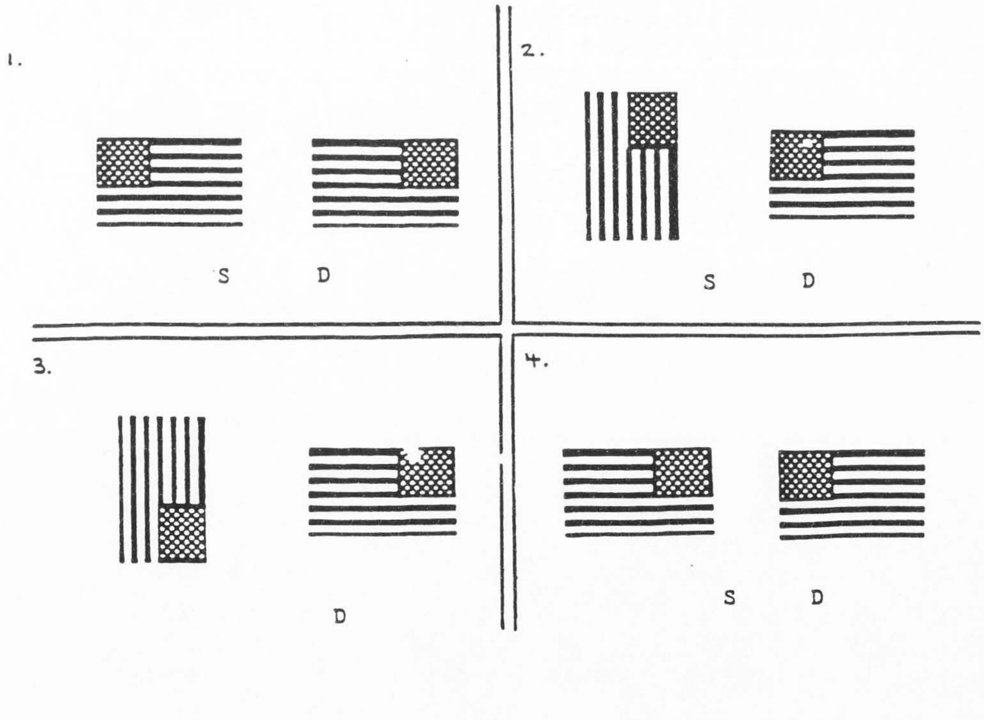
MY TEACHER IS ____________________ I AM A: BOY GIRL

MY SCHOOL IS ____________________

Adapted from a test by L. L. Thurstone.

EDWARD JOHNSON & ANN ME.
UNIVERSITY OF NORTH CARO.

FLAGS



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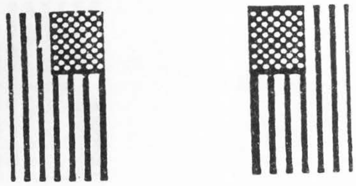

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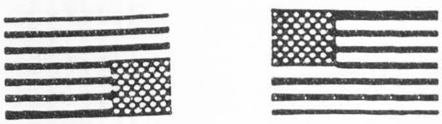

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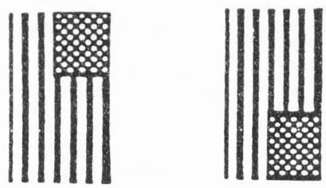

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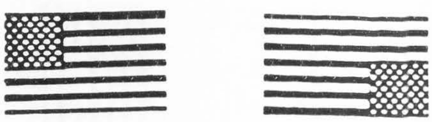

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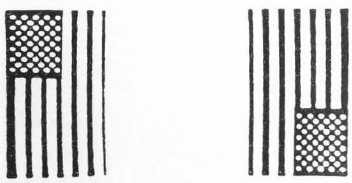

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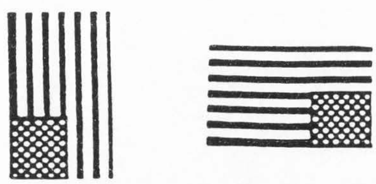

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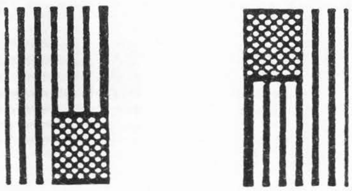

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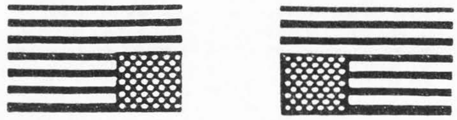

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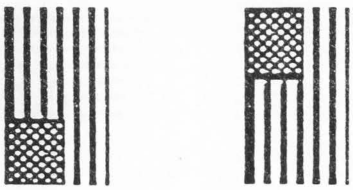

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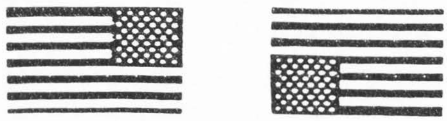

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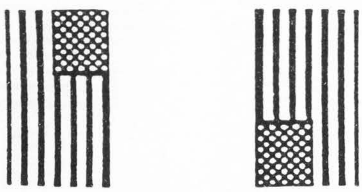

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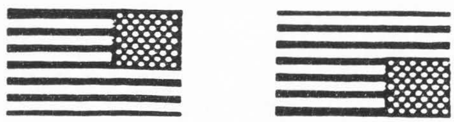

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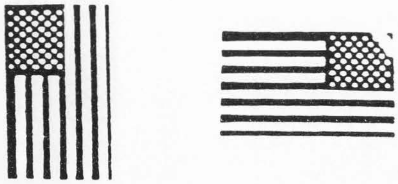

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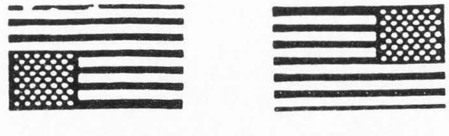

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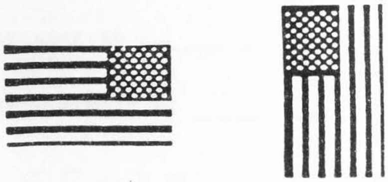

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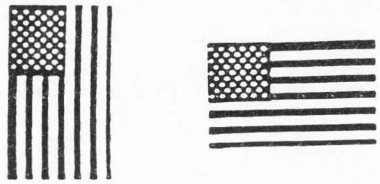

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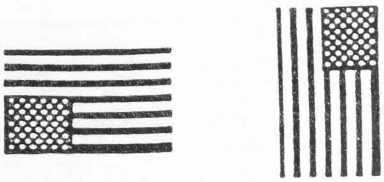

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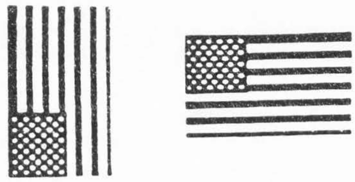

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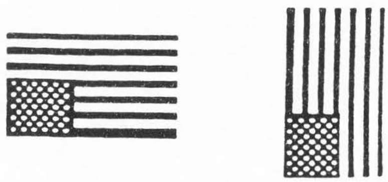

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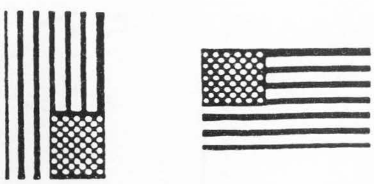

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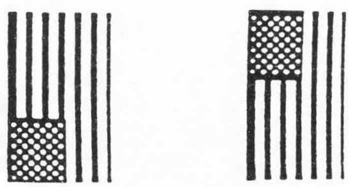

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SPATIAL BATTERY

LOWER LEVEL B

Danville City Schools

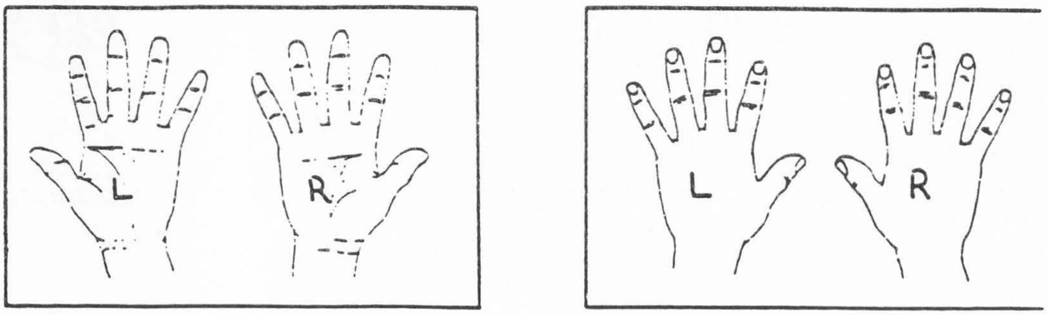
MY NAME IS ______________________________ I AM IN GRADE __________

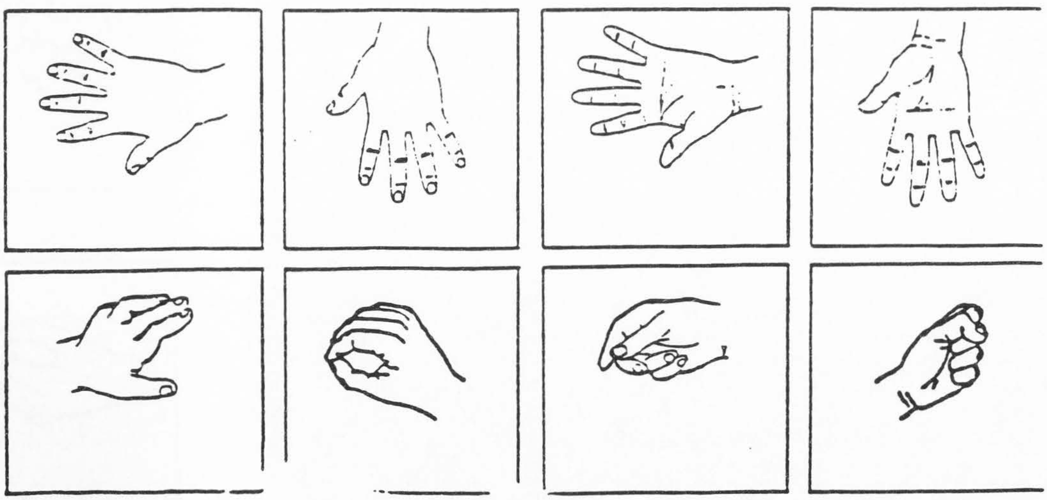
MY BIRTHDAY IS ______________________________ I AM ________ YEARS OLD

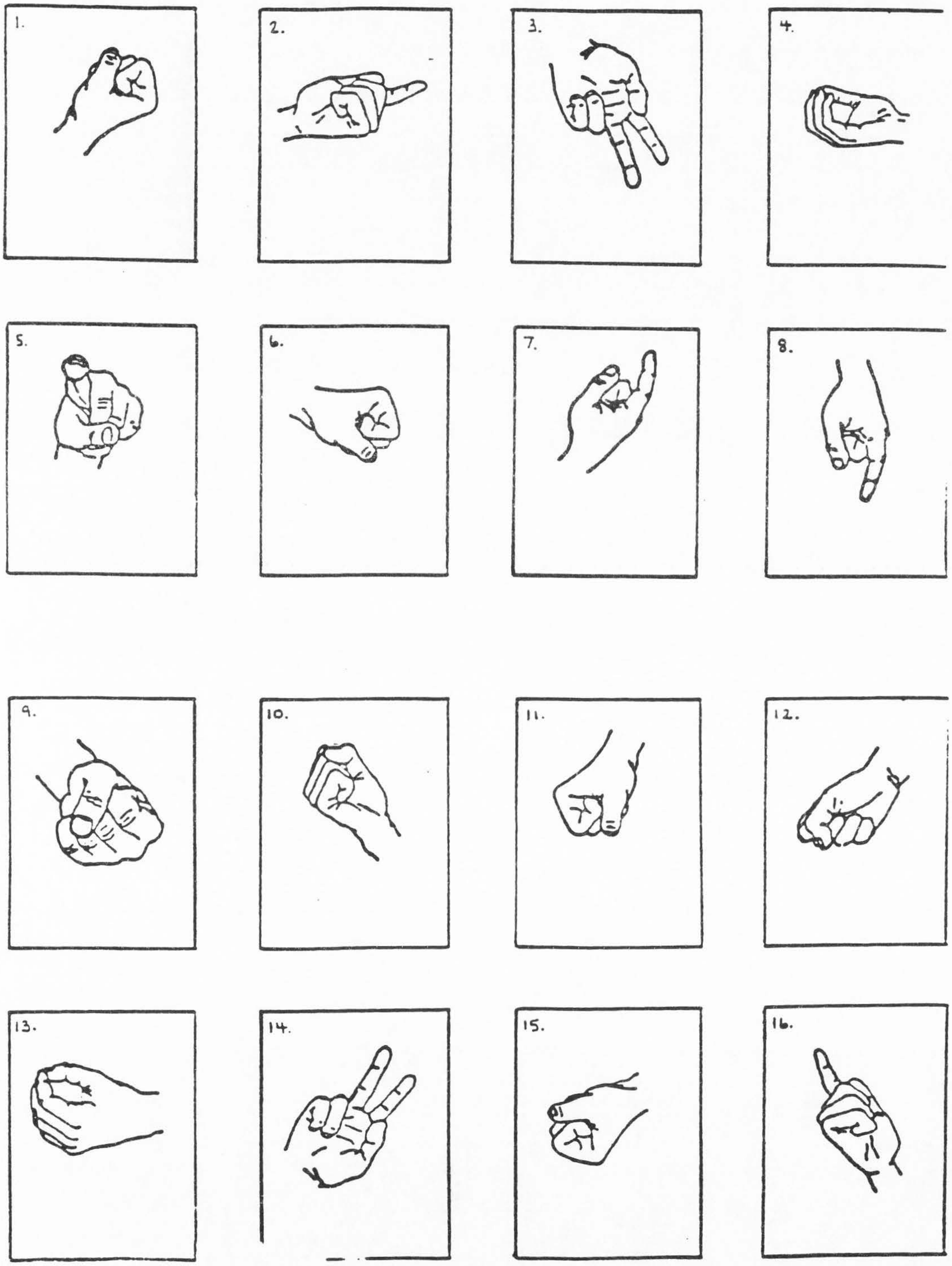
I WRITE WITH MY   LEFT HAND   RIGHT HAND

EDWARD JOHNSON & ANN MEA
UNIVERSITY OF NORTH CAROL

HANDS



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SPATIAL BATTERY

LOWER LEVEL D

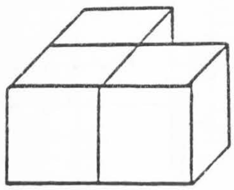
Danville City Schools

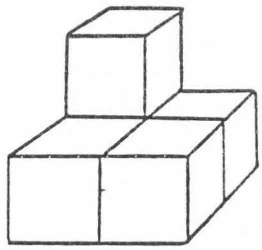
MY NAME IS ______________________________ I AM IN GRADE ________

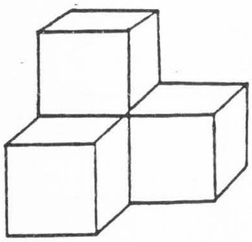
MY BIRTHDAY IS ___________________________ I AM ________ YEARS OLD

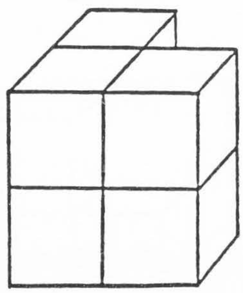
EDWARD JOHNSON & ANN MEADE
UNIVERSITY OF NORTH CAROLINA

BLOCK COUNTING









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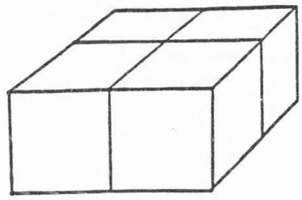

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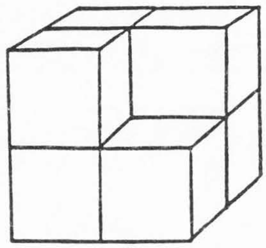

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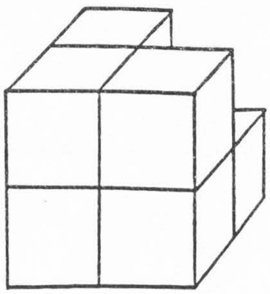

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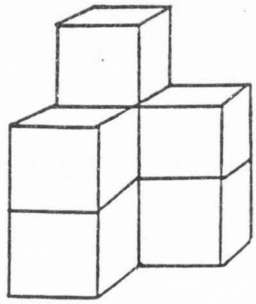

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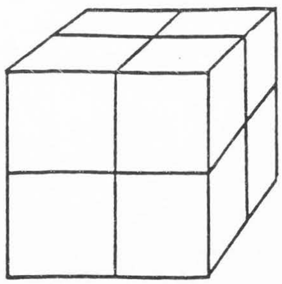

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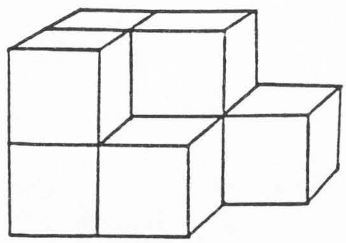

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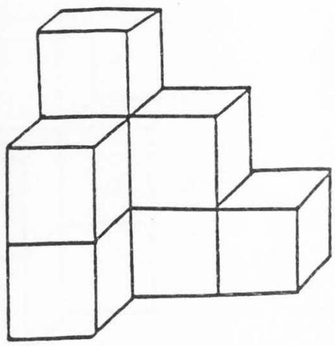

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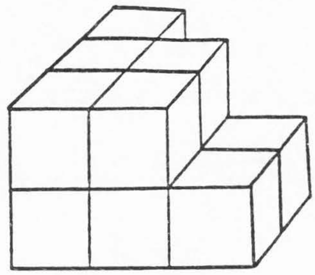

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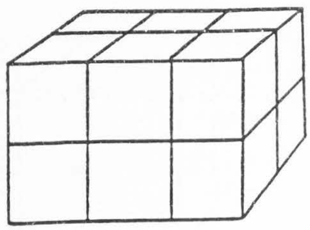

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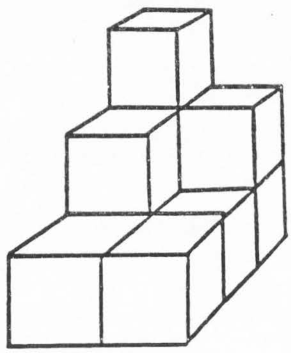

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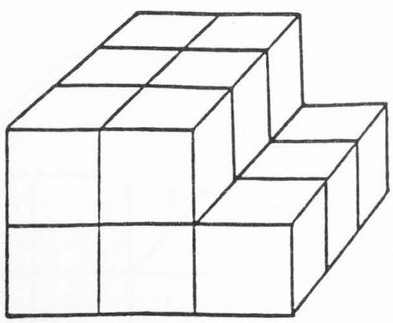

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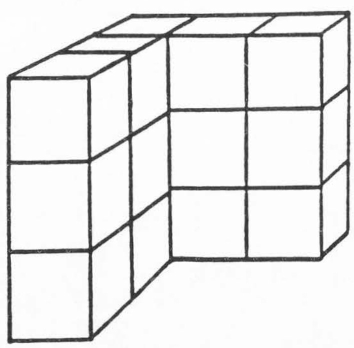

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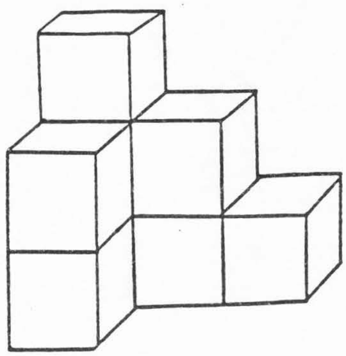

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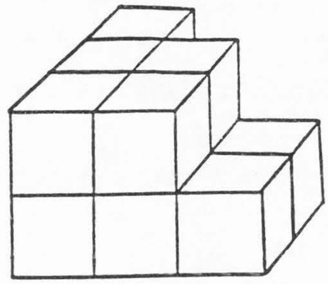

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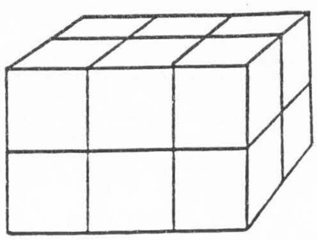

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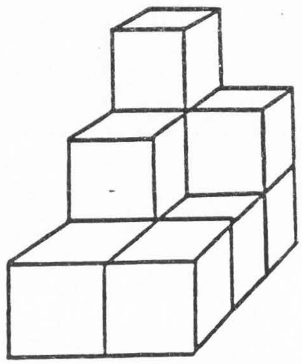

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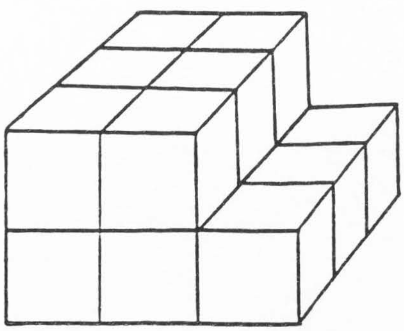

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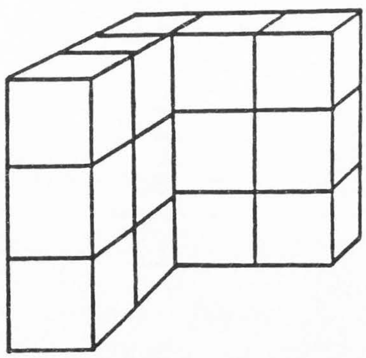

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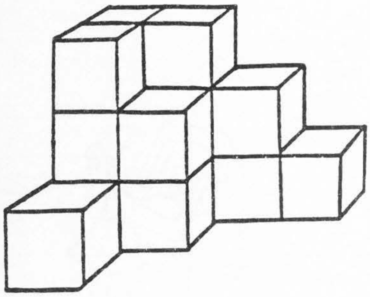

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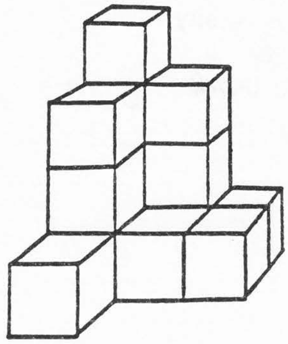

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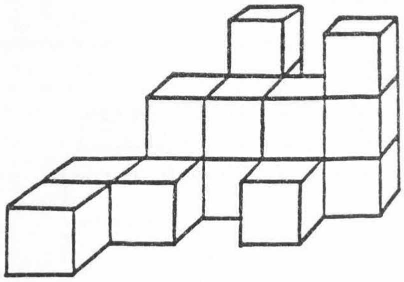

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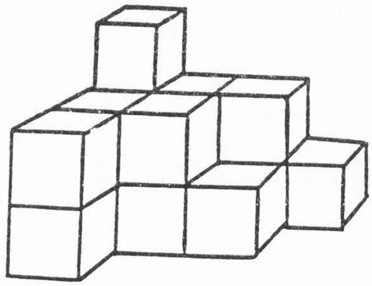

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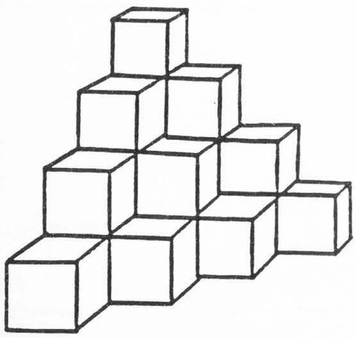

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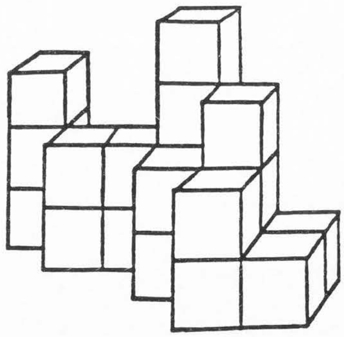

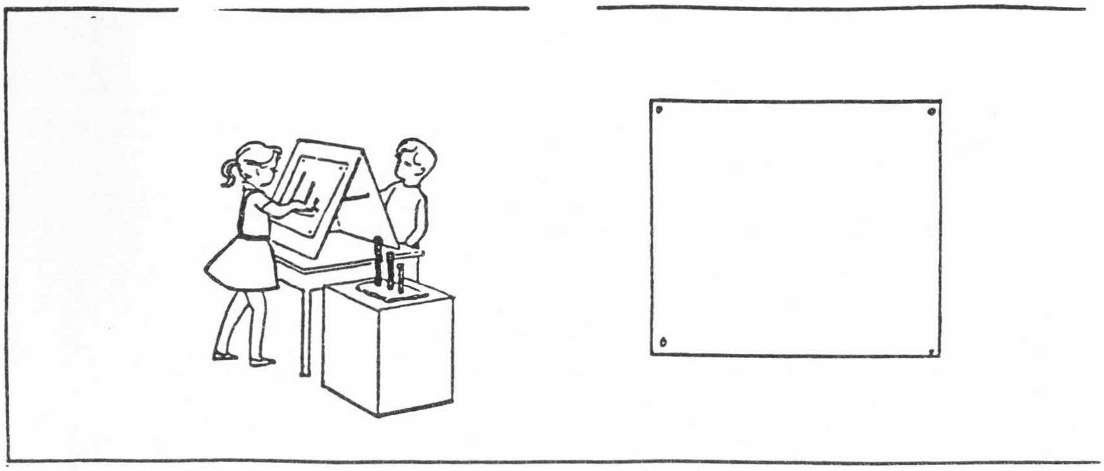

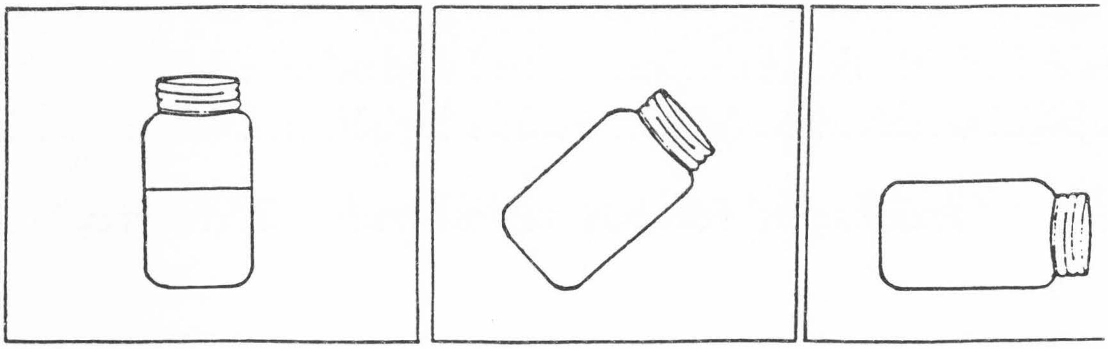

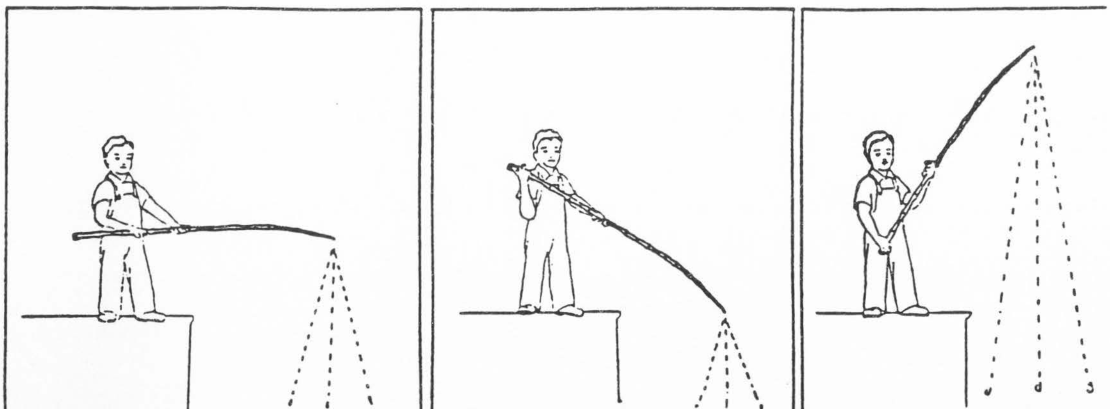

APPENDIX B. INSTRUCTIONS FOR TEST INSTRUMENTS

Note. Adapted from "The JM Battery of Spatial Tests: Instructions for Administration" in "Developmental Patterns of Spatial Ability: An Early Sex Difference" by E. S. Johnson and A. C. Meade, 1987, Child Development, 58, pp. 741-749.

FLAGS:

Instructions: Using the four flags, demonstrate that some pairs are identical and some pairs are backwards. Show them various pairs side-by-side and have the class tell whether they are same or different. As you do this, present the flags in various positions. After the class decides on the answer, rotate the flags so that the class can see what the answer is.

Now hand out the tests and red pencils and have the class mark the four practice items on the first page. Remind them that "S" stands for same and "D" for different. Answers are made by circling the right alternative. Then go over the answers (1=D, 2=S, 3=S, and 4=D) and be sure that everyone understands what is to be done on each item. You may bring out the real flags again to clarify the answers to the practice problems.

Timed period: 2:00 exactly.

Additional red pencil time: Approximately 3 minutes. Be sure that everyone uses a red pencil. Remind students that they can go back and answer skipped items. Encourage everyone to mark an answer for each item.

HANDS:

Instructions: Begin by handing out the test booklets and red pencils. Hold out your hands, palms up, and have the class do likewise. Make sure that everyone knows which hand is left and which is right. Then have students turn their hands over, thumbs together. Point out that, in the drawings on the front page, the fingernails, knuckles, etc., are drawn in. These can be clues as to whether the hand is drawn palm up or palm down.

Next, have students try the eight practice items on the front page. They may look at their own hands, but they may not turn the page around. They should write "L" or "R" in each box. When everyone is through, go over the answers (top row: R, L, L, R; second row: L, R, R, L). Don't let anyone turn the page until you give the signal.

Timed period: 2:00 exactly.

Additional red pencil time: Approximately 2 minutes.

SPATIAL RELATIONS:

Instructions: Hand out the test booklets. Tell the class that these puzzles are about squares. (In order to be sure the children knew what squares were, they were shown paper cutouts of triangles, rectangles, and squares.) In each item, a piece has been cut out of the square at the left. The missing piece is one of the four on the right. Have everyone try practice problem 1. Explain (perhaps using the blackboard) that the fourth alternative is the right answer. Have them put a circle around this one.

Then have everyone do the next three practice problems (but don't go below the double line). The answers to these are alternatives 2, 3, and 2. Be sure that everyone sees that these answers are correct. It might help to say that these problems are like trying to find the right piece in a puzzle (or use a familiar simile such as "Where's Waldo") to indicate this is a searching problem.

Timed period: 4:00 exactly.

Additional colored pencil time: Approximately 4 minutes.

BLOCK COUNTING:

Instructions: Do not hand out booklets yet. In this test, the problem is to count all the blocks in a stack. Use the two single blocks to show how the blocks can go together but be counted as two blocks. Using the block models of the four practice items, demonstrate how the blocks have been put together, but there are still 3, 4, 5, and 6 blocks in the different models. Emphasize that even though blocks are hidden in the different models, they are still to be counted.

Now hand out the booklets and tell the class that the pictures on the front are the same as the four models you just showed them. Have them mark their answers by writing the numbers beneath each picture. Check to see if everyone has written the correct answers. You are now ready to start the test. Warn the class that the items are difficult toward the end, but urge them to do their best.

Timed period: 4:00 exactly.

Additional colored pencil time: Approximately 4 minutes.

HIDDEN FIGURES:

Instructions: Hand out the booklets. At the left side of each item, a simple figure is shown in a box. Beside it, on the right, are three complex figures. Have students try the first problem. Then show them that the second alternative is correct by having them cover the top half of the figure with a finger. What shows is the simple figure they were supposed to find. Have everyone circle the correct answer.

Now have the class try the rest of the practice problems on page 1. The answers to the last three problems are alternatives 3, 2, and 2. Help everyone to see that these are the answers by showing how they can cover up portions of the correct answer to reveal the hidden figure. Or, you may wish to use the blackboard to make it clear.

Timed period: 3:00 exactly.

Additional colored pencil time: Approximately 4 minutes.

STICKS, JARS, AND POLES:

Instructions: This is an untimed page for which you have to read instructions for each of the three problems. Do this immediately after ROTATIONS if you wish.

STICKS: "The two children are both drawing a picture of the three sticks. See that the sticks are not the same length. You can see the girl's drawing. The boy is drawing the sticks just as he sees them. Make the boy's drawing in the box."

JARS: "Here are three jars. The first one is half full of water. Pretend that the other jars are also half full of water. Draw where the water will be in these jars."

POLES: "This boy is pretending he is fishing. He is standing on his front porch and his line almost touches the ground. How do you think the line will look? Look at the first picture. Trace your pencil down one of the dotted lines to show how the line will look. Now do it for the middle picture. . . . Now do it for the last picture." (Be sure that everyone traces only one line in each picture.)

APPENDIX C. PARENT LETTERS AND PARENT PERMISSION FORMS

Dear Parent,

I am a graduate student in the Psychology Department at Utah State University in Logan working on my doctorate.

I am in the process of conducting a research study on spatial abilities in children. There is a great deal of research suggesting that spatial abilities are linked to different skills and also that there are different types of spatial abilities. I am attempting to gather information that will explore the patterns of spatial abilities in different groups, in this case American Indian and non-Indian children. In order to do this, I need children who are in the second grade to take some tests that measure spatial abilities.

I understand that you might have a child in this age group and, therefore, ask for your help and your child in completing this study. The tests are all paper-and-pencil tests and will take each child approximately 45 minutes to 1 hour to complete. Before giving the child the tests, I will give them a demonstration of how to do some of them to help them understand. Each child will be given a small prize or candy bar at the end of the testing.

Please consider this, and, if you feel your child could participate, please sign the attached permission form and return it to me through the center. Thank you very much for your time and your help.

Respectfully,

Laurie Sullivan, MS

Parent Permission Form:
Spatial Ability Study

I ______________________________ give my permission to have my child participate in the study of patterns of spatial ability in children being conducted at ____________ school. This study is being conducted by Laurie Sullivan, MS, from Utah State University, who is working under the direction of William Dobson, PhD. The purpose of this study is to find out if there are different patterns of spatial abilities between different groups of students. Spatial ability skills have been linked to achievement in certain subjects, so it is important to know as much as possible about their patterns in different groups. I understand that my child will be tested after school.

I understand that my child will be asked to take several tests on spatial abilities. I understand that these tests are written educational-type tests and will in no way endanger or threaten harm to my child.

If I agree to allow my child to participate, I understand that all information will be held in strict confidence, available only to the researcher and her assistant. Nothing from this study will be reported that could identify my child or myself as individuals.

Also, I understand that I am free to withdraw my child, or my child is free to withdraw from this study at any time after signing this form with no penalty. If I decide not to let my child participate in any part of the study, I understand this will in no way affect the services my child receives at ______________________ school.

If you have any questions or wish to withdraw your child from the study at any time, contact me at the following numbers:

Laurie Sullivan, (801) 322-1001 or (801) 466-8946.

______________________________ ______________

Parent or Guardian Date

VITA

Laurie Sullivan-Sakaeda
1134 East Browning Ave.
Salt Lake City, UT 84105
(801) 487-2909

EDUCATION:

DOCTORAL STUDENT IN PSYCHOLOGY, Utah State University, Logan, Utah, Professional-Scientific program, with an emphasis in Clinical Psychology. Recipient of College of Education Graduate Fellowship, 1986-87. Studies include clinical training and practice, participation in neuropsychological research, grant writing, and neuropsychological assessment.

MASTER OF SCIENCE IN PSYCHOLOGY, California State College, Bakersfield, California, 1983. Studies included child and adult psychopathology, and techniques of objective, projective and intelligence testing.

BACHELOR OF SCIENCE IN BIOLOGY, MATHEMATICS MINOR, University of Wisconsin, River Falls, Wisconsin.

WORK EXPERIENCE:

Therapy and Assessment:

August, 1994 to Present. THERAPIST, Center For Transpersonal Therapy/Addictions Recovery Program, Salt Lake City, Utah. Engage in individual therapy and conduct Psych/Social interviews with addicts who are primarily HIV positive. Supervised by Denise Bolenes, PhD.

July, 1994 to Present. GROUP THERAPIST, Serve as primary therapist for the women's therapy group in the adult facility. Supervised by John Hardy, PhD.

October, 1992 to June, 1994. PSYCHOLOGICAL ASSISTANT, Odyssey House of Utah, Salt Lake City, Utah. Provide consultation through assessment of adult residents, group and individual psychotherapy and research. Current research includes demographic description of adolescent and adult population, as well as follow-up study of people who left treatment for any reason. Supervised by John Hardy, PhD

October, 1992 to Present. ASSISTANT COORDINATOR, ASSESSMENT PRACTICUM, Valley Mental Health, Salt Lake City, Utah. Help coordinate an interagency program between the University of Utah Psychology Department and various facets of the Valley Mental Health system to provide psychological assessment to the Mental Health system as a training program for Clinical Psychology students. Supervised by Margaret Morris, PhD

September, 1991 to September, 1992. PSYCHOLOGY INTERN, Valley Mental Health, Salt Lake City, Utah. Worked in two outpatient units providing psychological assessment and psychotherapy for adult, adolescent, and child clients. Provided psychological assessments on a consulting basis for treatment teams at the University of Utah hospital psychiatric units. Worked at the Children's Behavior Therapy Unit providing group therapy and psychological assessment to behavior disordered children and consulted with the teachers in the Autistic Preschool

Experience (con't)

Program. Also worked through the Forensics Unit in cognitive restructuring groups at the unit, in the Mentally Ill Offenders Program at the Orange Street facility, and at the Utah State Prison. In addition, I provided psychological assessment of offenders. Batteries included MMPI 1 & 2, MCMI II, projective personality testing, intelligence testing, and neuropsychological screening. Supervised by Nancey Cohn, PhD.

August, 1990 to August, 1991. PSYCHOLOGICAL CONSULTANT, Odyssey House of Utah, Salt Lake City, Utah. Psychological assessment of adult residents referred for drug and alcohol treatment. Batteries included MMPI, MCMI II, projective, intellectual, and neuropsychological instruments. Also involved in group therapy with segments of the residential population. Supervised by Nancy Parsons-Craft, PhD.

September, 1989 to May, 1990. PSYCHOLOGIST TRAINEE, Charter Summit Hospital, Midvale, Utah. Psychological assessment of adolescent and adult psychiatric inpatients. Batteries included objective, projective, intellectual and neuropsychological instruments. Supervised by John Hardy, PhD.

July, 1987 to August, 1991. THERAPIST, Center for Family Development, Salt Lake City, Utah. Therapist for group of people who were molested as children and for individual child and adult clients. Supervised by Nancy Parsons-Craft, PhD.

July, 1988 to August, 1989. PSYCHOLOGIST TRAINEE, Assessment Psychotherapy Associates, Salt Lake City, Utah. Psychological testing of children and adolescents which focus on neuropsychological assessment. Neuropsychological testing of geriatric patients on an inpatient and outpatient basis. Supervised by Janiece Pompa, PhD.

1983-1986. PSYCHOLOGIST I, Western Montana Regional Community Mental Health Center, Libby, Montana. Provided mental health services to a county of 20,000 people in a three-therapist satellite outpatient clinic in northwestern Montana. Sole provider of services to Eureka, Montana, a small community 67 miles north of Libby, for one and a half years. Services included individual, family and group therapy; psychological evaluations, including personality and intelligence testing, for a variety of county and state offices; community education, consultation with town and county personnel, and evaluations for involuntary commitments. A primary population served was adolescent victims of sexual abuse. The position involved providing 24 hour emergency on-call services on a rotating basis with the other therapists. Clinical supervisor: Lee Tonner, LCSW.

1982-1983. PSYCHOLOGIST TRAINEE, Pixley Elementary School, Pixley, California. Managed and facilitated a school counseling program, provided assessment, individual and family counseling, parent education, and teacher consultation. Supervised by Barry Sommer, M.A., Educational Psychologist, and Ed Dietiker, PhD.

Research;

July, 1994 to Present. RESEARCH CONSULTANT, Odyssey House of Utah, Salt Lake City, Utah. Design, implement, supervise data collection, and conduct data analysis on a series of research projects as identified jointly by the staff of Odyssey House and the consultant. Supervised by John Hardy, PhD.

June, 1991 to Present. INDEPENDENT RESEARCH, Odyssey House of Utah, Salt Lake City, Utah. Compiled data on demographics and clinical profiles of residents to explore typologies, change over time in treatment, and success rates of people in treatment.

Experience (con't)

September, 1986 to June, 1988. RESEARCH ASSISTANT, Utah State University, Logan, Utah. Assisted Dr. Damian McShane as part of an ongoing research project on laterality of brains using CT scans and with research for the Graduate Indian Training Program.

August, 1982 to June, 1983. RESEARCH ASSISTANT, California State College, Bakersfield. Scored test results and entered data for research project on employee qualifications and job satisfaction at China Lake Naval Station in California.

Teaching:

Fall, 1988 -1991; INSTRUCTOR, Utah State University, undergraduate psychology classes for the extension program, classes taught include Introduction to Counseling, Child Abuse and Neglect, Introductory Psychology, and History and Systems of Psychology.

Summer, 1990; INSTRUCTOR, Westminster College, undergraduate class in Thanatology

Spring, 1988; INSTRUCTOR, Utah State University, undergraduate Social Psychology through Com-Net system.

Fall, 1987; Utah State University, worked with professor designing Psychology 121, Human Relations, and developing class materials for use by Graduate Student instructors.

1984-1985; INSTRUCTOR, Lincoln County Community Education and Flathead Valley Community College. Introductory Psychology, Psychology of Women, and Human Potential Seminar.

Presentations

April, 1992. Rocky Mountain Psychological Association, Boise, ID. "Differences in males and females in a long term residential treatment facility."

September, 1994. Millon Clinical Inventories Conference, Minneapolis, MN. "Assessment of drug addicts at three intervals of treatment time in a Therapeutic Community using the MCMI II."