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Sharon Teresa Jordan

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CORRELATES OF COGNITIVE SKILLS USED BY BOYS AND GIRLS ON SEQUENCING AND CONSTRUCTION TASKS

A Thesis
Presented to the
Faculty of
California State University,
San Bernardino

by
Sharon Teresa Jordan
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ABSTRACT

In general, females perform better on tasks requiring verbal skills, while males perform better on tasks requiring nonverbal spatial skills. There are some spatial tasks, however, on which females outperform males. Perhaps females excel on some spatial tasks because they can be solved through verbal problem-solving strategies. In the present study, the scores of eight girls (ranging in age from 7.8 to 11.2 years) and eleven boys (ranging in age from 7.1 to 11 years) on three tests requiring varying levels of spatial-sequencing skills were analyzed. The tests analyzed were the Halstead-Reitan Trail Making Tests (Trails A and Trails B) and the Beery-Buktenica Developmental Test of Visual Motor Integration (VMI). The problem-solving strategies used by the boys and girls to complete these tests were determined indirectly through correlational analyses. The boys' and girls' test scores were compared to their test scores on verbal and nonverbal spatial portions of the Wechsler Intelligence Scale for Children-Revised (WISC-R) and the Luria-Nebraska Neuropsychological Battery-Children's Revision (LNNB-CR). As predicted, the girls' scores on both Trails A and Trails B covaried significantly with verbal skills measured by the
WISC-R and the LNNB-CR (p < .05). Also as predicted, the boys' scores on Trails A and Trails B correlated significantly with nonverbal spatial skills measured by the WISC-R and the LNNB-CR (p < .05). However, contrary to predictions, the boys' scores on Trails A and Trails B also correlated significantly with verbal skills measured by the WISC-R and the LNNB-CR (p < .05). Both the boys' and the girls' VMI scores were significantly related to verbal and nonverbal skills measured by the WISC-R and the LNNB-CR (p < .05). The results suggest that girls use verbal strategies to complete Trails A and Trails B, while the boys use both verbal and nonverbal spatial skills to complete the same tasks. Both boys and girls appear to employ verbal and nonverbal spatial strategies to complete the VMI.
ACKNOWLEDGEMENTS

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INTRODUCTION

A substantial body of literature indicates that females generally score higher on tests of verbal ability, while males score higher on tests measuring spatial and mathematical skills (e.g., Seward & Seward, 1980). There are several theories that propose to account for these differences, including neurological, hormonal, and cultural theories. Advocates of neurological theories claim that these differences are innate, resulting from sex differences in the organization of the brain. Some advocates of hormonal theories argue that different levels of sex hormones influence cognitive abilities. Finally, some advocates of cultural theories state that sex differences in cognitive functioning result from the methods that are used to socialize children.

The purpose of the current study is to determine if different cognitive strategies are employed by males compared to females on spatial-sequencing tasks. Toward this end, the introduction is organized in the following manner. First the literature on sex-related cognitive differences is reviewed. Then the literature on possible causal factors is reviewed.
Sex Differences

General Intellectual Functioning

Most standardized intelligence tests have been constructed to minimize sex bias (Maccoby & Jacklin, 1974), and this standardization appears to have been successful at eliminating bias on the overall Full Scale Intelligence Quotients (FSIQ) on the Wechsler Intelligence Scale for Children (WISC), the Wechsler Intelligence Scale for Adults (WAIS), and the Stanford-Binet Intelligence Test (Burstein, Bank, & Jarvik, 1980). However, Burstein et al. report that sex differences still exist on the subscales that comprise these intelligence tests. Specifically, females tend to score higher on the scales that measure verbal abilities, such as the Vocabulary and Similarities subtests, while males score higher on the scales that measure spatial abilities, such as the Picture Completion and Block Design subtests (Royer, 1978).

Verbal Abilities

Female superiority on verbal tasks has been substantiated by several literature reviews (Broverman, Klaiber, Kobayashi, & Vogel, 1968; Buffery & Gray, 1972; Burnstein, et al., 1980; Maccoby & Jacklin, 1974). The verbal abilities discussed in these reviews included reading, vocabulary, spelling, grammar, articulation, word fluency, verbal analogies, listening, and age of first speech.
Sex differences in verbal abilities may begin very early in life, with the child's first utterances and babbling (McCarthy, 1954). In a review of vocalization rates of young infants, Maccoby and Jacklin (1974) found that while most studies did not report significant sex differences; the few that did favored females. For example, in 1969, Lewis tested how infants responded to four different pictures of a male's face containing irregular (scrambled) facial features and regular (normal) facial features. The infants were between 3 months and 13 months of age. Lewis discovered that across all age levels, the girls vocalized more than the boys did. In a later study on the vocalization rate of infants, Lewis and Freedle (1972) found that girls vocalized more often than boys when interacting with their mothers. It should be noted, however, that girls tend to mature faster than boys, and that this earlier maturation may account for some of the verbal superiority reported among girls (Segalowitz, 1983). Early maturation of verbal skills among girls might also lead them to establish verbal communication as their preferred mode of interacting with the environment (Sherman, 1978).

Girls have been reported to acquire language skills earlier than boys and to display increased fluency in their early language skills (Hirst, 1982). In addition, their speech is more comprehensible when compared to the speech
of boys. For example, McCarthy (1930) recorded the comprehensible verbal responses of children who were 18 months and 24 months old. He found that at 18 months, 14 percent of boys' verbal responses were comprehensible, compared with 38 percent of girls' speech. At 24 months, the rate of comprehensible speech was 49 percent for the boys and 78 percent for the girls. Furthermore, girls begin to formulate sentences earlier than boys, and they create longer sentences (Anastasi & Foley, 1953). The language skills of girls under the age of three have been found to be better predictors of later language abilities than are the language skills of young boys (Moore, 1967), suggesting that females' language skills remain more consistent than do males'.

Throughout the preschool period, girls continue to show a slight verbal advantage over boys (McGuinness & Pribram, 1979). They have a larger vocabulary than boys (Anastasi & Foley, 1953), and they reportedly talk to other children more frequently than do boys (Smith & Connolly, 1972). However, a recent study conducted by Stoner and Spence (1983) indicated that preschool-aged girls were not more verbally expressive than were preschool-aged boys. The discrepant results might be due to methodological differences. For example, Stoner and Spence determined the degree of expressive speech by the children's scores on The Expressive One-Word Picture Vocabulary Test, while Smith
and Connolly based their interpretations on the frequency of the children's speech during free play.

During grade school, females' advantage on verbal tasks is not consistent. Females continue to excel on some verbal tasks, while males perform equally well on others (Maccoby & Jacklin, 1974). Reading is one of the verbal tasks on which grade-school-aged females generally excel (Weintraub, 1966). Females learn to read earlier than males and seem to maintain this advantage throughout the grade school years. For example, in 1951 Konski studied the reading readiness of children when they entered the first grade, and then retested the children when they completed the school year. She discovered that there were no significant sex differences at the beginning of the year, but that the girls performed significantly better than the boys on reading achievement tests at the end of the year. Anderson, Hughes, and Dixon (1956) also studied the reading skills of young children; however, the children that they studied were in an unstructured classroom, which enabled the children to determine the pace at which they learned to read. The researchers observed that in the unstructured environment the girls generally learned to read six months earlier than the boys. They also observed that over half of the girls learned to read at the same age as children in a traditional first-grade class, while only one-third of the boys had mastered reading skills by this
age. Other research indicates that there are more boys than girls that exhibit reading disabilities during grade school, yet even among children with normal reading abilities, girls generally outperform boys in reading achievement (Gullahorn, 1979).

In addition to reading, girls in grade school excel over boys in grammar, spelling, and some word fluency tasks (Maccoby, 1966). Girls' articulation skills also mature earlier than boys' (Anastasi & Foley, 1953). In fact, the articulation abilities of girls in the first grade are equivalent to those of boys in the second grade (Anastasi & Foley, 1953). Anastasi and Foley suggest that the earlier maturity in articulation seen among females gives them an advantage over males in verbal skills which leads females to superior verbal abilities throughout the life span.

Even though girls excel on numerous verbal tasks during grade school, boys perform equally well as girls on other verbal tasks, including some tasks of verbal fluency and tasks of verbal understanding (Maccoby & Jacklin, 1974). For example, Kagan, Rosman, Day, Phillips, and Phillips (1964) examined the performances of seven- and eight-year-old children on a battery of psychological tests which included 2 measures of verbal fluency, and found that the boys had higher fluency scores than the girls. In a different study, Corah (1965) administered the Full-Range Vocabulary test to children between the ages of 8 and 11,
and found that the boys tended to obtain higher Vocabulary IQ scores. However, Corah also stated that the children’s fathers had higher Vocabulary IQ’s than their mothers and so the results might be due to characteristics of the subject sample. Although boys may perform equally well on some verbal tasks during grade school, girls’ superior performance compared to boys on most verbal tasks becomes solidified and consistent around the age of 10 or 11 (Maccoby & Jacklin, 1974).

Similar trends have been found in studies of sex differences in verbal skills among adults. Between the ages of 16 and 64 years, women have been reported to obtain higher mean scores than men on verbal portions of the WAIS (Matarazzo, 1972), the Scholastic Aptitude Test (SAT), and the Graduate Record Exam (GRE) (Hoyenga & Hoyenga, 1979). Among elderly adults (60 to 90 years of age), women outperform males on both the Vocabulary subtest of the Stanford-Binet and the Similarites subtest of the Wechsler-Bellevue (Blum, Fosshage, & Jarvik, 1972). Thus, females seem to maintain a fairly consistent verbal advantage over males throughout the life span.

**Spatial Abilities**

Spatial aptitude can be divided into two categories: "spatial orientation" (e.g., perception of the position and configuration of objects in space with the observer as reference point) and "spatial visualization"
(e.g., manipulation of parts of a stimulus while maintaining a mental image of the relationships among the parts) (Burnstein et al., 1980). Tasks that are thought to measure various dimensions of spatial ability include mazes, form boards, block counting from the Differential Aptitude Test and the Primary Mental Abilities (PMA), and the Block Design and Picture Assembly subtests from the Wechsler Scales (Denno, 1982).

There is some controversy as to when sex differences in spatial performance first appear. Some researchers report that males show a spatial advantage over females during infancy (Khan & Cataio, 1984), while others report that it begins around ages 6 to 8 (Harris, 1978; McGuinness & Pribram, 1979). Still others report that sex differences on spatial tasks are not apparent until early adolescence (Maccoby & Jacklin, 1974). Most researchers agree that sex differences on spatial tasks become reliable around the time of puberty (see McGee, 1979 for a review), yet there are a few researchers who claim that sex differences in spatial skills do not exist (Caplan, MacPherson, & Tobin, 1985).

During the latter part of childhood, boys have been reported to be superior when compared with girls on numerous spatial tasks. For example, boys are superior to girls on directional tasks. They are superior on naming the direction that an arrow is pointed, on indicating the
direction of a particular city, and on remembering
directions while riding in a car (Lord, 1941). Then, at
ages 9 to 10, boys excel on spatial serial-learning tests
(Orsini, Chiacchio, & Grossi, 1982), and at ages 10 to
11.5, boys outperform girls on spatial judgment tests, such
as the Moray House Space Test, which measures spatial
judgment of 2- and 3-dimensional figures (Emmett, 1949).
Eighth- and ninth-grade male students have also been
reported to obtain higher spatial scores than females on
Thurstone's Primary Mental Abilities Test (Hobson, 1947).

Among adults aged 60 and younger, males generally
outperform females on perceptual maze tasks (Davies, 1965)
and on tasks involving cubes, cards, spatial orientation,
and spatial visualization (Very, 1967). Sex differences
reported among elderly adults also generally favor males.
For example, Cohen, Shaie, and Gribbin (1977) administered
a test battery to elderly adults (who were 69 and 70 years
old) which contained 6 measures of spatial abilities.
Males performed better than females on five of the spatial
subtests.

Even though males appear to outperform females on most
spatial tasks, there are some spatial tasks on which
females excel over males, including the Street Gestalt Test
(Bogen, DeZure, Tenhouten, & Marsh, 1972) and some spatial
dot localization tasks (Kimura, 1969). Estes (1974) also
reported that females excel on the Digit Symbol subtest of
the Wechsler scales. Furthermore, elderly females have been found to outperform males on the WAIS Block Design subtest (Blum, Fossage, and Jarvik, 1972).

An explanation for the contradictory reports on sex differences in spatial skills is that some spatial tasks might be solved through either spatial or verbal strategies, and that males and females may tend to employ different strategies in trying to solve these tasks (Burstein, Bank, & Jarvik, 1980; Estes, 1974). Specifically, females may tend to employ verbal problem-solving strategies to complete nonverbal spatial tasks, while males tend to employ nonverbal strategies. Estes offered this hypothesis to account for female superiority on the Digit Symbol subtest of the Wechsler scales. He stated that performance on this subtest might involve verbal encoding, a skill on which females are thought to have an advantage over males. In 1978, Royer tested Estes' hypothesis by varying the amount of figural and spatial orientation information provided in the Digit Symbol subtest, and his results supported Estes' hypothesis. He found that women performed better on the symbol set that had all the symbols figurally different, which presumably meant that these figures were easily encoded verbally. The males performed better on the form set that had the greatest amount of spatial orientation information. Hence, some spatial tasks might be solved
through verbal methods, and females might outperform males on these types of spatial tasks. If this is true, then not all "spatial" tasks can be considered as measurements of spatial abilities.

Mathematical Abilities

In addition to some spatial skills, males have been reported to be superior to females on some mathematical tasks (McGee, 1979). Males and females apparently attain and master mathematical skills in a similar fashion, although girls generally learn to count earlier than boys (Maccoby & Jacklin, 1974). Performance differences usually begin to emerge between the fourth and seventh grades. After the seventh grade, girls are often reported as excelling on tests of mathematical computation (e.g., addition and subtraction problems), while boys excel on tests of mathematical reasoning, problem solving, and problems involving visual-spatial ability (Khan & Cataio, 1984). Apparently, once these performance differences emerge, boys’ mathematical skills increase more rapidly than girls’, which gives males a mathematical advantage throughout the rest of the life span (Fox, Tobin, Brody, 1979; Maccoby & Jacklin, 1974; McGuinness & Pribram, 1979). Male superiority on mathematical tasks is evident even when the previous mathematical training of males and females has been matched (Benbow & Stanley, 1980).

It has been postulated that mathematical skills are
related to spatial abilities (McGee, 1979; Petersen & Wittig, 1979), and that the relationship between mathematical ability and spatial ability gives boys an advantage over girls on most mathematical problems.

If some spatial problems can be solved verbally, then perhaps some mathematical problems can also be solved through verbal strategies, and females may tend to employ different strategies than males do when solving the same mathematical problems. Fennema (1974) has reported that there are not significant sex differences on mathematical problems that can be solved either verbally or spatially (such as with algebra problems), but that there are sex differences on mathematical problems which are solved primarily through spatial reasoning (such as with geometry). Males often solve geometric problems better than females. Thus, once again, females might tend to solve mathematical problems through verbal strategies. If this is true, then before mathematical problems are considered as spatial tasks, the type of mathematical problem must first be assessed.

Determinants of Sex Differences

Neurological Factors

According to McGee (1979), past research on hemispheric specialization indicates 1) that the left cerebral hemisphere is specialized for language functions, while the right hemisphere is specialized for spatial
processing, and 2) that males have greater hemispheric specialization than females. Much of the evidence for this phenomenon comes from research on split-brain patients (Sperry, 1964) and from research on patients with unilateral brain damage (McGlone, 1977). Unilateral left hemispheric brain damage results in aphasia three times more often in males than in females, and unilateral right hemispheric damage results in more severe visual-spatial losses in males (McGlone, 1977).

Females may process spatial information bilaterally, while males primarily rely on their right hemisphere to process spatial information. There is anatomical evidence that suggests that female fetuses are predisposed to bilateral representation of spatial processing. Lacoste-Utamsing and Woodward (1984) found that the caudal portion of the corpus callosum differed in length depending on if the fetus was male or female. Apparently between the twenty-sixth and forty-first weeks of gestation, female fetuses have larger and wider caudal portions of the corpus callosum than do male fetuses. These differences have also been reported among adults (Lacoste-Utamsing & Holloway, 1982). These research findings are relevant since the caudal portion of the corpus callosum is thought to be involved in the transference of visual, and perhaps spatial, information between the hemispheres (Durden-Smith & deSimone, 1984). Witelson (1984) states that this
research indicates that there is greater interhemispheric communication in females than in males, and that this communication might aid verbal abilities while hindering spatial abilities. Anatomical research, however, should be interpreted with caution since structural differences do not necessarily account for functional differences.

Anatomical differences have also been observed in young infants. Female infants show greater asymmetries in the frontal area (Wada, Clark, & Hamm, 1975) and in the temporal planum than do male infants (Witelson & Pallie, 1973). The latter finding is relevant since the temporal speech cortex is involved in higher analyses of speech sounds (Harris, 1975).

In addition to the anatomical differences found in males and females, the cerebral hemispheres of boys and girls might also mature at different rates (Levy & Reid, 1976; Waber, 1976). The left hemisphere of females appears to mature earlier than that of males, which might predispose females to excel verbally (Waber, 1976). The right hemisphere of males, however, appears to mature at an earlier age than females and this might lead them to excel spatially (Levy & Reid, 1976; Waber, 1984). In fact, the right hemisphere of males might be specialized for spatial processing as early as age 5 (Levy & Reid, 1976) or age 6 (Witelson, 1976), while females appear to process spatial information bilaterally as late as age 13 (Witelson, 1976).
The hypothesis that spatial functions are lateralized differently in males and females is supported by research on nonverbal dichotic listening tasks (Knox & Kimura, 1970) and on nonverbal tactile recognition tests (Witelson, 1976).

**Genetic, Chromosomal, and Hormonal Factors**

Spatial abilities might be heritable (McGee, 1979; Vandenberg, 1971) and appear to be less affected by environmental factors than are verbal abilities (McGee, 1979). Verbal abilities, however, have not been linked to genetic determinants (Maccoby & Jacklin, 1974). Much of the evidence for heritability of spatial skills comes from research on twins (Vandenberg, 1971), although some researchers claim there is evidence that spatial abilities might be enhanced by an X-linked, recessive gene (Bock & Kolakowski, 1973; Goodenough, Gandini, Olkin, Pizzamigilio, Thayer, & Witkin, 1977; Guttman, 1974; Hartlage, 1970; Stafford, 1961).

If high spatial ability is an X-linked recessive trait, then it would follow that more males than females would be affected (McGee, 1979). According to O’Connor’s (1943) hypothesis, the expected proportion of people showing high abilities should be similar to people with other recessive traits, such as night blindness. He determined that the expected proportion of females manifesting high spatial abilities is determined by
squaring the observed proportion of males who show this trait, and he reported that the proportion of males showing high spatial abilities was .50. Thus, the expected proportion of females would be .25. Several researchers have reported results that are fairly consistent with O'Connor's expectations (e.g., Bock & Kolakowski, 1978; Loehlin, Sharan, & Jaccoby, 1978). However, some research does not support the X-linked hypothesis (DeFries, 1976) and other research based on evidence from patients with Turner's Syndrome casts doubt on the validity of this hypothesis (Garron, 1970). Females with Turner's Syndrome have only one X chromosome (instead of the normal XX pair). Thus, it would be expected that they should express spatial abilities similar to normal males since males also have only one X chromosome (Garron, 1970). However, females with Turner's Syndrome have lower spatial abilities than normal women, even though their verbal abilities are within the normal range.

Research conducted on people who have other kinds of chromosomal abnormalities show that males who have an extra X chromosome (Klinefelter's Syndrome—XXY chromosomal pattern) and who have normal intellectual abilities (approximately fifty percent are retarded) are reported as also having normal spatial abilities (Durden-Smith & deSimone, 1984). Perhaps spatial ability in females depends on a certain amount of ovarian testosterone, and
this level is lacking in females with Turner's Syndrome because they are missing the second X chromosome that provides this level (Harris, 1978). Males with Klinefelter's Syndrome that have normal spatial skills might have normal skills because their one Y chromosome provides the required level of testosterone for development of this skill.

The effects of female sex hormones on intellectual functioning have been studied in genotypically male patients who have the androgen insensitivity syndrome (Masica, Money, Ehrhard, & Lewis, 1969). Males with this syndrome are insensitive to the male sex hormone androgen but remain sensitive to female sex hormones. Thus, they appear to be females, but their chromosomal and gonadal make-up is male. These children are raised as females, but they do not develop secondary sex characteristics at puberty. When tested on the Wechsler Intelligence Tests (the patients ranged in age from 5.5 to 27.75 years), they performed significantly better on the verbal subtests than on the performance subtests. This pattern of performance is similar to that of normal females, and the researchers concluded that this pattern was partly due to the subject's insensitivity to male sex hormones (Masica et al., 1969).

Overall, the literature suggests that a certain level of testosterone is necessary for the development of normal spatial abilities in both males and females. It also
appears that female sex hormones play a part in the development of normal language skills. Perhaps spatial and verbal skills are not enhanced by a particular level of these hormones, but rather by an optimal estrogen-androgen balance (McGee, 1979).

Environmental Factors

Some theorists claim that males' and females' verbal and spatial skills would be the same if their upbringing and education were more similar (Parsons, 1980). Boys and girls are typically treated differently from birth, perhaps because of cultural norms and expectations or even because of the physical characteristics of infants at birth. Male neonates are generally larger and have stronger neck muscles when compared to female neonates. Parents might respond to these physical differences by treating girls as more fragile than boys and relating to them verbally rather than physically (Parsons, 1980). Mothers have been observed to handle their infant sons more often than their daughters, and to talk to their daughters more often than their sons; and as their infants mature, parents tend to encourage their sons to explore the environment, while encouraging their daughters to be sociable. Parsons suggests that the tendency for boys to explore the environment might predispose them to excel in spatial abilities, while the social interactions of girls might lead them to excel verbally.
It has also been suggested that during the school years girls might not perform as well as they potentially could in academic endeavors because they fear that boys will show disapproval if they outperform the boys (Coleman, 1961). Parents might also encourage males to take classes that require mathematical and spatial skills more often than they encourage females to take such classes (Parson, 1980), and spatial skills might be enhanced through the exercises required by these classes (Berry, 1966). In addition, many parents expect males to perform better than females in mathematical courses (Poffenberger & Norton, 1963). Thus, in addition to the spatial advantage that males have on most spatial tasks, they may excel on these types of tasks due to their greater experience, societal expectations, and parental support.

**Summary and Implications**

The evidence for sex differences on verbal and spatial tasks is not consistent, although it does suggest that females score higher on many verbal tasks, while males score higher on many spatial tasks. There are several possible explanations for the inconsistencies in the literature. For example, the variations in research findings may be due to methodological differences or differences among the populations that were sampled. For example, some studies on cognitive-related sex differences are conducted on college students. However, college
students must have certain levels of verbal and spatial abilities to succeed in (or even be admitted to) college. Thus, it is questionable if these results can be generalized to the entire population.

Another reason that sex differences might not consistently appear is that studies are often conducted on different age groups, and sex differences might not reliably appear during some age periods. For example, according to Maccoby and Jacklin (1974), sex differences on spatial tasks do not reliably appear until after puberty, even though other researchers have reported sex differences during this period (e.g., Emmett, 1949). Thus, possible developmental changes should also be considered when researchers evaluate sex differences.

It has also been proposed that some spatial tasks can be solved by either verbal or nonverbal spatial strategies, and that males and females might use different problem-solving strategies to accomplish these tasks. Specifically, females might use verbal strategies, while males use nonverbal spatial strategies (Burstein et al., 1980). If this is true, then although a test is primarily spatial in nature, it still might not measure the similar skills in females compared to males since the two groups might employ different strategies to solve the same task. It is also possible that males and females employ different cognitive strategies on other types of tests, such as tasks
involving sequencing skills. Once again, boys might employ spatial strategies while girls employ verbal strategies.

If there actually are sex differences in cognitive skills, they will influence both psychological and neuropsychological testing since boys and girls might not use the same cognitive skills on the same test. For example, if a spatial test can be solved by either verbal or spatial strategies, and if girls and boys rely primarily on different strategies, then this test would not be measuring the same problem-solving skills in the two groups. Scores on this test would not universally reflect boys' and girls' spatial ability. This possibility should be a primary concern to neuropsychologists since they are often called on to determine the intellectual level and cognitive skills of children. Unfortunately, as Parsons and Pritchino (1978) have noted, gender is not frequently taken into account in neuropsychological research. However, since McGlone (1977) has indicated that there might be possible interactions between gender, lateralization of brain deficits, and performance on neuropsychological tests, more research in this field is definitely warranted.

In the present study, the performance scores of boys and girls on two spatial-sequencing tests will be compared to determine if the boys' and girls' scores covary differently with verbal and nonverbal spatial measures.
One of the tests is the Halstead-Reitan Trail Making Test (TMT), which consists of two parts, Trails A and Trails B. Trails A measures simple sequencing skills, while Trails B measures more complex sequencing skills (Lezak, 1983). Since Trails A and Trails B measure different levels of sequencing skills, they will be analyzed separately. The other test that will be analyzed is the Beery-Buktenica Developmental Test of Visual-Motor Integration (VMI), which is thought to measure construction-motor skills in a visual-spatial drawing task (Beery, 1967). These tests were chosen because they force hypothesis testing since it is possible that they can be solved through either verbal or nonverbal spatial strategies.

There are three separate hypotheses. The first hypothesis is that the boys and girls will use different strategies to solve the sequencing required to complete Trails A. Specifically, boys are expected to employ nonverbal spatial techniques, while girls are expected to employ verbal strategies. The second hypothesis is that boys are expected to employ primarily nonverbal spatial strategies to complete Trails B, while girls are expected to use primarily verbal strategies. The third hypothesis is that girls might use either verbal or nonverbal strategies to solve the VMI, while boys are expected to employ primarily nonverbal spatial strategies. This hypothesis is nondirectional regarding the expected
correlates of the girls' scores on the VMI since performance on the VMI requires the replication of geometric designs and it might not be possible to rely primarily on verbal problem-solving strategies to complete this task. Hence, it is possible that both boys and girls will employ nonverbal spatial strategies to complete the VMI.

The strategies employed by the boys and girls on Trails A, Trails B, and the VMI will be determined indirectly through a correlational analysis and a multiple regression analysis. The boys' and girls' scores on Trails A, Trails B, and the VMI will be compared to their scores on two well-established measures of psychological and neuropsychological skills to determine the skills that correlate with the boys' and girls' performances on three selected tests. First, the boys' and girls' scores on the selected tests will be compared to their scores on the Wechsler Intelligence Scale for Children-Revised (WISC-R) to determine how their scores correlate with verbal and performance skills. Next, the boys' and girls' scores on the three selected tests will be compared to their scores on a neuropsychological test, the Luria-Nebraska Neuropsychological Battery-Children's Revision (LNNB-CR), which consists of 11 subtests that measure a variety of behavioral and cognitive skills. This comparison will allow a more detailed analysis of the skills that correlate
with the boys' and girls' scores on Trails A, Trails B, and the VMI.

Through the correlational analysis, the skills that correlate with the boys' and girls' performance scores on Trails A, Trails B, and the VMI can be determined. The boys' and girls' correlations can then be compared to determine if their scores on the three tests correlate differently with verbal and nonverbal spatial measures. Through the multiple regression analysis, prediction equations can be created to determine the variables that best predict the boys' and girls' performances on Trails A, Trails B, and the VMI. These variables can be compared to determine whether or not they are similar for the two groups.

In summary, it is hypothesized that the boys and girls will employ different problem-solving strategies to complete Trails A and Trails B. The different strategies used on the tests will be measured indirectly through correlational procedures. The girls' performance scores on both Trails A and Trails B are expected to covary with verbal skills, while the boys' scores on these two tests are expected to covary primarily with nonverbal spatial skills. The girls' scores on the VMI might covary with either verbal or nonverbal spatial skills, while the boys' scores on the VMI are expected to covary with nonverbal spatial skills.
METHOD

Subjects

The subjects were chosen from an outpatient children's clinic where they had been referred for various behavioral and academic problems (primarily low grades). There were eight females and eleven males. The overall age range was from 7.1 to 11.2 years of age. The girls ranged in age from 7.8 to 11.2 years (mean age = 9.5 years) and boys ranged in age from 7.1 to 11 years (mean age = 9.6 years).

The children's problems were not of apparent organic origin. Their WISC-R Full Scale IQs were within the normal range (80 - 130), they were all right-handed, and their reading, spelling, and arithmetic skills as determined by the Wide Range Achievement Test (WRAT) were within one standard deviation (±) of their FSIQ. In addition, the children had normal or corrected-to-normal visual abilities.

Measures

The Halstead-Reitan Trail Making Test

The Trail Making Test (TMT) is a paper and pencil test which consists of two parts, Trails A and Trails B. Trails A consists of 15 circles scattered around on a piece of
paper, and inside the circles are the numbers 1 to 15. The object is to connect the numbers in their appropriate numerical sequence as quickly as possible. Trails B also consists of 15 scattered circles which contain the numbers 1 to 8 and the letters A to G. The object is to connect the numbers and letters in alternating sequences (e.g., 1 to A, 2 to B, etc.) (Reitan, 1971). The amount of time needed to correctly complete the sequence is the child's raw score. The children's version of the TMT was used, which is a shortened version of the adult's form (Reitan, 1955).

According to Reitan (1971), performance on the TMT requires visual comprehension and symbolic interpretation of the stimulus material, visual scanning, and the ability to alternate between a numerical series and alphabetical series. More recently, Ehrenstein, Heister, and Cohen (1983) determined that performance on the TMT is largely dependent on the processes involved in visual search of varying targets. Thus, the performance on the TMT depends on spatial visualization. Performance on this test also depends on motor speed and attention (Lezak, 1983). Lezak states that this test, like others involving motor speed and attention, is sensitive to the effects of brain injury since brain damaged children perform more poorly on the TMT than do children without brain damage (Reitan, 1971).
According to Sattler (1982), the information on the reliability and validity of the Halstead-Reitan scales is scarce, however as previously reported, the TMT is highly sensitive to brain damage and discriminates between people with and without brain damage (Reitan, 1958, 1971).

The Beery-Buktenica Developmental Test of Visual-Motor Integration

The Visual-Motor Integration Test (VMI) was designed primarily to measure the degree that visual perception and motor behavior are integrated in young children (Beery, 1967). It can be administered to children between the ages of 2 and 15, although it was primarily designed to be administered to children in preschool and the early primary grades. According to Beery, this test was designed to be used as a tool for educational assessment.

The VMI consists of 24 geometric figures. The first figures are relatively simple and each successive figure becomes more complex. According to Beery (1967), geometric designs were chosen because they, unlike letters, were thought to be familiar to children from various backgrounds. The figures are to be copied onto a piece of paper. The VMI age equivalent score is determined by adding together the correctly replicated drawings until there are three consecutive failures. This raw score is then converted to age equivalent scores through age-appropriate norms (Beery, 1982).
Although Schooler & Anderson (1979) reported that there are no race or sex differences in performance scores on the VMI, other research conflicts with this report. Martin, Sewell, and Manni (1977) reported that there were race differences on the VMI since anglos tended to perform better on the VMI than did minorities. There are also differences in the predictive ability of the VMI for boys and girls (Fuerth and Forsythe, 1980). During the early part of grade school, the VMI scores of females are better predictors of academic achievement than are the VMI scores of males.

According to Sattler (1982), the overall reliability of the VMI is high. The test-retest reliability of the VMI ranges in the low .80s, the internal consistency reliability coefficients range from .70 to the low .90s, and the interrater reliability coefficients range in the .90s. The validity of the VMI has been tested against the following: chronological age (r = .89), mental age (r ranges from .38 to .59), perceptual skills (r = .80), reading achievement (r = .50), and psycholinguistic skills (r ranges from .20 to .81).

The Luria-Nebraska Neuropsychological Battery-Children’s Revision

The Luria-Nebraska Neuropsychological Battery-Children’s Revision (LNNB-CR) is a revision of the adult battery, and is based on the neurological theories of
Luria (Golden, Hammeke, & Purish, 1980). The current form of the children's battery has undergone four major revisions. The children's battery was first introduced for use with children between the ages of 8 and 13 years, however there are currently some norms that extend to children who are seven years old (Plaisted, Gustavson, Wilkening, & Golden, 1983).

The children's battery consists of 149 items which are grouped into the following 11 summary scales: Motor, Rhythm, Tactile, Visual, Receptive Speech, Expressive Language, Writing, Reading, Arithmetic, Memory, and Intellectual Processes. The LNNB-CR does not purport to measure all the neuropsychological skills of children, and the scales do not measure unitary skills. However the items within each summary scale measure, to a certain degree, the neuropsychological skill named by that scale (Plaisted et al, 1983).

Past research indicates that the LNNB-CR differentiates between brain damaged and normal children (Gustavson, Golden, Leark, Wilkening, Hermann, & Plaisted, 1982; Wilkening, Golden, MacInnes, Plaisted, & Hermann, 1981). Wilkening and her co-workers (1981) reported an accuracy rate of 86.2 percent for the LNNB-CR's ability to differentiate between brain damaged children and normal children. Furthermore, Geary, Jennings, and Schultz (1982) reported that the success rate for the LNNB-CR to
differentiate between children with and without learning disabilities was 86.7 percent.

The norms for the LNNB-CR are built on a combination of male and female scores. According to R. A. Leark (personal communication, August 18, 1985), there were no significant sex differences in performance observed among the norm-sample, so separate norms were not deemed necessary.

As stated above, the LNNB-CR reliably discriminates between brain damaged and normal children. The validity of the LNNB-CR has been tested against the Halstead-Reitan Battery (r = .92) (Tramontana, Sherrets, & Wolf; 1983), and the Minnesota Percepto-Diagnostic Test (r ranged from -.10 to .71) (Snow, Hartlage, Hynd, & Grant, 1983).

The Wechsler Intelligence Scale for Children-Revised

Wechsler first introduced his test to the general public in 1939. Since then, Wechsler has developed numerous forms of his first scale, Form 1. Included in these revisions are the Wechsler Intelligence Scale for Children (WISC) and its revision, the Wechsler Intelligence Scale for Children-Revised (WISC-R).

The WISC-R consists of 12 subtests, six subtests measure verbal skills and six subtests measure nonverbal skills. The subtests that comprise the Verbal Scale are: Information, Similarities, Arithmetic, Vocabulary,
Comprehension, and Digit Span. The subtests that make-up the Performance Scale are: Picture Completion, Picture Arrangement, Block Design, Object Assembly, Coding, and Mazes (Cooper, 1982).

Kaufman (1979) proposes that there are actually three WISC-R Scales, instead of just the two Verbal and Performance Scales, that should be considered when interpreting WISC-R. The three Scales are: 1) the Verbal Comprehension Quotient (VQ), which is comprised of the Information, Similarities, Vocabulary, and Comprehension subscales, 2) the Perceptual Organization Quotient (PQ), which consists of the Picture Completion, Picture Arrangement, Block Design, Object Assembly, and the Mazes subscales, and 3) the Freedom from Distractibility Quotient (DQ), which is comprised of the Arithmetic, Digit Span, and Coding subscales (Kaufman, 1975). The three factor loadings have been identified for both males and females (Kaufman, 1979).

Kaufman (1979) states that VQ and PQ are similar enough to the Wechsler Verbal and Performance Scales that the two Wechsler Scales can be interpreted as good estimates of Verbal Comprehension and Perceptual Organization abilities. Furthermore, Kaufman states that VQ and PQ dwell primarily in the cognitive domain, while DQ might be a cognitive or a behavioral measure. There are numerous skills that DQ might measure, including the
child's ability to attend to the task at hand, his or her ability to manipulate numerical symbols, or the child's sequencing ability. In light of these numerous possibilities, Kaufman states that the interpretation of DQ may vary from person to person.

Hale and Potok (1980) report that the WISC-R might be gender biased since the WISC-R regression prediction equations for reading ability differed for females and males. The authors concluded that even though the differences were statistically significant, they might be of little practical importance.

According to Sattler (1982), the WISC-R is a highly reliable test. Each of the IQ Scales have a reliability coefficient of .89 or higher. The average reliability coefficient is .96 for the FSIQ, .94 for the VIQ, and .90 for the PIQ. The reliability coefficients are somewhat lower for the subtests, yet Sattler states that they are adequate. In addition, the validity of the WISC-R has been determined by comparisons with other intelligence tests, school grades, achievement tests, and receptive vocabulary tests. Sattler states that these studies indicate that the WISC-R has satisfactory concurrent validity with the median correlations ranging from .30 to .80.

Procedure

This study was based on archival data collected from
an outpatient children's center. Approximately 200 clinical files were examined and the information from fifty-seven of these files was collected. These files were chosen since the children had taken the tests that were selected to be examined in this study. The files chosen to be used in this study were selected from the fifty-seven files. A file was chosen if the child's WISC-R FSIQ was within the normal range, if his or her problems were not organically based, if he or she was right-handed, and if his or her WRAT scores were within one standard deviation of his or her WISC-R FSIQ. These files represent the 19 children mentioned in the subjects section.

The children were tested separately by the same male clinical neuropsychologist. They were administered a battery of psychological and neuropsychological examinations which required approximately seven hours to complete. These examinations were administered at two or three separate sessions.

Due to the small sample sizes used in this study, the results are preliminary in nature and the generalizability of the results is also limited. The results are powerful, however, when applied to the groups chosen to be studied since the children were chosen from a large clinic population and represent a homogeneous clinical subset.
RESULTS

Descriptive statistics were utilized to determine the means and standard deviations of the boys' and girls' scores on the various tests. The means and standard deviations were then analyzed through a series of t-tests and F-tests.

The results were then analyzed through a series of correlational procedures. The boys' and girls' correlations between their scores on the three selected tests and their scores on the WISC-R (overall IQ Scales, the subtests, and the Kaufman Scales) were analyzed first. Then the boys' and girls' correlations between their scores on the three selected tests and their Luria-Nebraska scores were analyzed. Additionally, verbal and nonverbal spatial Scales from both the WISC-R and the Luria were partialled out. From the WISC-R Scales, VIQ and PIQ were selected to be partialled out. From the Luria Scales, the Visual Scale and the Receptive Speech Scale were chosen to be partialled out. The Visual Scale was chosen because it measures elements of visual-spatial ability. The Receptive Speech Scale was selected because it measures elements of internal vocalization.

After the correlational analysis, a stepwise multiple
regression analysis was conducted. Separate analyses were run with the WISC-R Scales, WISC-R subtests, Kaufman Scales and Luria-Nebraska Scales. The WISC-R Scales that were used were VIQ and PIQ. The WISC-R subtests that used were the Information, Similarites, Block Design, and Object Assembly subtests. These subtests were chosen because Information and Similarites have the highest loadings on the Verbal Scale, and Block Design and Object Assembly have the highest loadings on the Performance Scale (Kaufman, 1975). The Scales chosen from the Luria for the stepwise multiple regression analysis were the Writing, Reading, Visual, and Math Scales. The Writing and Reading Scales were chosen because they measure verbal construction skills. The Visual Scale was selected because it measures some visual-spatial skills. The Math Scale was chosen because it measures a combination of semantic and symbolic skills.

Furthermore, it should be noted that all raw scores were converted to standard scores so that the data were based on similar interval scales. The WISC-R IQ scores and the Kaufman Indices were Deviation IQ scores (mean = 100, standard deviation = 15). The WISC-R subtest scores were scaled scores. The Luria-Nebraska scores were converted to T-scores. The raw scores on both Trails A and Trails B were converted to z-scores. The VMI raw scores were converted to Deviation Quotients.
Descriptive Statistics

The children's means and standard deviations on the tests selected to be examined in this study are shown in Tables 1 through 5. In Table 1 the means and standard deviations associated with the boys' and girls' scores on Trails A, Trails B, and the VMI are shown. Table 2 shows the means and standard deviations associated with the two groups' scores on the WISC-R Scales (FSIQ, VIQ, and PIQ). In Table 3 the means and standard deviations associated with the Kaufman Scales are shown. Table 4 shows the means and standard deviations associated with the boys' and girls' scores on the subtests of the WISC-R. In Table 5 the means and standard deviations associated with the Luria-Nebraska are shown.

F-tests and t-tests

The boys' and girls' means and standard deviations were compared through a series of t-tests and F-tests. First the basic characteristics (age, grade level, and FSIQ) of the boys and girls were chosen to be within the following ranges: the ages of the children were between 7 and 12 years, their grade levels were between the second and sixth grades, and their WISC-R FSIQ's were within the normal range of 80 and 130. Table 6 shows the results of the t-tests and the F-tests used to compare the boys' and girls' basic characteristics. This table shows
Table 1
Means and Standard Deviations on Selected Tests

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Raw Score</td>
<td>z-score</td>
</tr>
<tr>
<td>Males</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trails A</td>
<td>20.09</td>
<td>.67</td>
</tr>
<tr>
<td>Trails B</td>
<td>53.64</td>
<td>.26</td>
</tr>
<tr>
<td>VMI</td>
<td>13.36</td>
<td>83.09</td>
</tr>
<tr>
<td>Females</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trails A</td>
<td>21.57</td>
<td>.68</td>
</tr>
<tr>
<td>Trails B</td>
<td>65.00</td>
<td>.08</td>
</tr>
<tr>
<td>VMI</td>
<td>12.75</td>
<td>75.38</td>
</tr>
</tbody>
</table>

Note. Raw scores for Trails A and Trails B are the number of seconds needed to complete tasks. Raw scores for the VMI are the number of correct replications until three consecutive failures.
Table 2
Means and Standard Deviations on the WISC-R Scales

<table>
<thead>
<tr>
<th>Variable</th>
<th>Males Mean</th>
<th>Standard Deviation</th>
<th>Females Mean</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>FSIQ</td>
<td>98.45</td>
<td>12.36</td>
<td>97.13</td>
<td>10.20</td>
</tr>
<tr>
<td>VIQ</td>
<td>94.45</td>
<td>16.52</td>
<td>96.88</td>
<td>9.46</td>
</tr>
<tr>
<td>PIQ</td>
<td>103.55</td>
<td>9.56</td>
<td>97.88</td>
<td>12.29</td>
</tr>
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</table>
Table 3
Means and Standard Deviations on the Kaufman Scales

<table>
<thead>
<tr>
<th>Variable</th>
<th>Males Standard</th>
<th>Females Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>Deviation</td>
</tr>
<tr>
<td>VQ</td>
<td>94.00</td>
<td>18.29</td>
</tr>
<tr>
<td>PQ</td>
<td>106.91</td>
<td>9.58</td>
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<tr>
<td>DQ</td>
<td>91.82</td>
<td>12.98</td>
</tr>
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</table>
Table 4
Means and Standard Deviations on the WISC-R Subtests

<table>
<thead>
<tr>
<th>Variable</th>
<th>Males Mean</th>
<th>Standard Deviation</th>
<th>Females Mean</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Information</td>
<td>8.36</td>
<td>3.20</td>
<td>8.13</td>
<td>2.42</td>
</tr>
<tr>
<td>Similarities</td>
<td>9.00</td>
<td>3.92</td>
<td>10.13</td>
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<tr>
<td>Arithmetic</td>
<td>8.82</td>
<td>2.60</td>
<td>9.00</td>
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<tr>
<td>Vocabulary</td>
<td>8.18</td>
<td>4.35</td>
<td>9.25</td>
<td>2.82</td>
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<tr>
<td>Comprehension</td>
<td>10.45</td>
<td>2.34</td>
<td>10.75</td>
<td>3.85</td>
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<tr>
<td>Digit Span</td>
<td>8.91</td>
<td>3.15</td>
<td>7.38</td>
<td>2.50</td>
</tr>
<tr>
<td>Pic. Comp.</td>
<td>11.73</td>
<td>3.10</td>
<td>10.50</td>
<td>2.33</td>
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<tr>
<td>Pic. Arrang.</td>
<td>11.18</td>
<td>2.27</td>
<td>9.88</td>
<td>1.36</td>
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<tr>
<td>Block Design</td>
<td>10.64</td>
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<td>10.25</td>
<td>3.24</td>
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<td>Object Assm.</td>
<td>10.73</td>
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<tr>
<td>Coding</td>
<td>8.64</td>
<td>2.78</td>
<td>9.00</td>
<td>2.67</td>
</tr>
<tr>
<td>Mazes</td>
<td>13.33</td>
<td>5.16</td>
<td>9.00</td>
<td>3.34</td>
</tr>
</tbody>
</table>

Table 5
Means and Standard Deviations on Luria-Nebraska Standardized Scales

<table>
<thead>
<tr>
<th>Variable</th>
<th>Males</th>
<th>Females</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Standard</td>
<td>Standard</td>
</tr>
<tr>
<td></td>
<td>Mean</td>
<td>Deviation</td>
</tr>
<tr>
<td>Motor</td>
<td>55.91</td>
<td>8.03</td>
</tr>
<tr>
<td>Rhythm</td>
<td>54.55</td>
<td>11.35</td>
</tr>
<tr>
<td>Tactile</td>
<td>69.27</td>
<td>14.37</td>
</tr>
<tr>
<td>Visual</td>
<td>52.09</td>
<td>6.52</td>
</tr>
<tr>
<td>Rec.Speech</td>
<td>64.82</td>
<td>11.70</td>
</tr>
<tr>
<td>Exp.Speech</td>
<td>58.45</td>
<td>8.65</td>
</tr>
<tr>
<td>Writing</td>
<td>71.00</td>
<td>17.89</td>
</tr>
<tr>
<td>Reading</td>
<td>54.73</td>
<td>16.82</td>
</tr>
<tr>
<td>Math</td>
<td>59.55</td>
<td>11.69</td>
</tr>
<tr>
<td>Memory</td>
<td>55.82</td>
<td>8.76</td>
</tr>
<tr>
<td>Intell.Pro.</td>
<td>58.09</td>
<td>11.26</td>
</tr>
</tbody>
</table>

Note. The individual Luria-Nebraska scores were converted to standard scores for this analysis.

Rec.Speech = Receptive Speech Scale;
Exp.Speech = Expressive Language Scale;
Table 6

Analysis of Boys' and Girls' Basic Characteristics

<table>
<thead>
<tr>
<th>Variable</th>
<th>t-tests</th>
<th></th>
<th>F-tests</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Boys</td>
<td>Girls</td>
<td>S.D.</td>
<td>S.D.</td>
</tr>
<tr>
<td>Age</td>
<td>9.64</td>
<td>9.50</td>
<td>1.35</td>
<td>1.15</td>
</tr>
<tr>
<td>Grade</td>
<td>3.45</td>
<td>3.63</td>
<td>.66</td>
<td>.99</td>
</tr>
<tr>
<td>FSIQ</td>
<td>98.45</td>
<td>97.13</td>
<td>12.36</td>
<td>10.20</td>
</tr>
</tbody>
</table>

Note. S.D. = Standard Deviation. The probability of each t-score and F-value is greater than .05.
that there are not significant differences between the means of the boys' and girls' ages, grade levels and Full Scale Intelligence Quotients (the probability of each t-score is greater than .50). Table 6 also shows that the variability associated with the boys' and girls' ages, grade levels, and Full Scale Intelligence Quotients is not significantly different (the probability of each F-value is greater than .20).

A series of t-tests and F-tests was also conducted on the boys' and girls' scores on Trails A, Trails B, and the VMI. The boys' and girls' scores were compared to determine if their performance scores on the selected tests are significantly different. The means and standard deviations of the children's actual test performances were previously shown in Table 1. The results of the t-tests and F-tests are presented in Table 7. This t-score column shows that the differences between the boys' and girls' means on the selected tests are not significantly different (the probability of each t-score is greater than .20). The F-value column in Table 7 also shows that the variability associated with the boys' and girls' scores on the VMI was not significantly different (p > .10); the variability associated with their scores on Trails B tended toward significance (p = .06); and the variability associated with the boys' and girls' scores on Trails A was significantly different (p < .05). Thus, Table 7 shows that the girls'...
Table 7

Summary of t-tests and F-tests Between Boys' and Girls' Scores

<table>
<thead>
<tr>
<th>Variable</th>
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<th>F value</th>
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<td>Grade</td>
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<td>2.29</td>
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<td>1.52</td>
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<td>VIQ</td>
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<td>1.65</td>
</tr>
<tr>
<td>VQ</td>
<td>-.45</td>
<td>2.41</td>
</tr>
<tr>
<td>PQ</td>
<td>1.35</td>
<td>1.82</td>
</tr>
<tr>
<td>DQ</td>
<td>.37</td>
<td>1.11</td>
</tr>
<tr>
<td>Trails A</td>
<td>-.03</td>
<td>3.31*</td>
</tr>
<tr>
<td>Trails B</td>
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<td>3.04</td>
</tr>
<tr>
<td>VMI</td>
<td>1.32</td>
<td>1.32</td>
</tr>
</tbody>
</table>

Note. t-test degrees of freedom = 18.
F-test degrees of freedom = 7, 10.
*p < .05.
Trails A scores vary more than the boys' Trails A scores, and that the girls' scores on Trails B tend toward varying more than the boys' scores on Trails B.

Overall Pearson Correlation Coefficients

The overall Pearson Product-Moment correlation coefficients are shown in Tables 8 through 11. Scattergrams indicated that all the zero-order correlations appear to be based on linear relationships. The correlations in each matrix are divided into three values: 1) a value for the total group, 2) a value for the boys' correlations, and 3) a value for the girls' correlations. Table 8 shows the correlation matrix between the three selected tests and the WISC-R Scales (FSIQ, VIQ, and PIQ). Table 9 shows the correlation matrix for the relationships between the selected tests and the Kaufman Scales. Table 10 shows the correlation matrix between the selected tests and the WISC-R subtests. Table 11 shows the matrix between the selected tests and the Luria-Nebraska Scales. Most of the correlations are nonsignificant. The significant correlations will be discussed in greater detail. First the significant correlations between the selected tests and the WISC-R Scales will be discussed. Then the correlations between the selected tests and the Luria Scales will be discussed.
Table 8
Correlation Matrix Between Selected Tests and WISC-R Scales

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<th>Trails B</th>
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<td>VIQ</td>
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<td>Boys</td>
<td>.47</td>
<td>Boys -.33</td>
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<td></td>
<td>Girls</td>
<td>.46</td>
<td>Girls .66</td>
</tr>
<tr>
<td>PIQ</td>
<td>Both</td>
<td>.46</td>
<td>Both .20</td>
</tr>
<tr>
<td></td>
<td>Boys</td>
<td>.31</td>
<td>Boys -.15</td>
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<td></td>
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<td>Girls .48</td>
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<tr>
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<td>Both</td>
<td>.51*</td>
<td>Both .12</td>
</tr>
<tr>
<td></td>
<td>Boys</td>
<td>.48</td>
<td>Boys -.33</td>
</tr>
<tr>
<td></td>
<td>Girls</td>
<td>.61</td>
<td>Girls .66</td>
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</tbody>
</table>

* p < .05.
Table 9

Correlation Matrix Between Selected Tests and the Kaufman Scales

<table>
<thead>
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<th>Trails B</th>
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</thead>
<tbody>
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<td><strong>VQ</strong></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Both</td>
<td>.36</td>
<td>Both .07</td>
<td>Both .38</td>
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<tr>
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<td>.47</td>
<td>Boys -.31</td>
<td>Boys .24</td>
</tr>
<tr>
<td>Girls</td>
<td>.24</td>
<td>Girls .64</td>
<td>Girls .80*</td>
</tr>
<tr>
<td><strong>PQ</strong></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Both</td>
<td>.48</td>
<td>Both .23</td>
<td>Both .36</td>
</tr>
<tr>
<td>Boys</td>
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<td>Girls</td>
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<tr>
<td><strong>DQ</strong></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Both</td>
<td>.48*</td>
<td>Both -.11</td>
<td>Both .12</td>
</tr>
<tr>
<td>Boys</td>
<td>.42</td>
<td>Boys -.46</td>
<td>Boys .33</td>
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<tr>
<td>Girls</td>
<td>.57</td>
<td>Girls .21</td>
<td>Girls -.08</td>
</tr>
</tbody>
</table>

**Note.** The correlation between the girls' Trails A scores and their VQ scores is significant \( r = .72, p < .05 \) when the VQ equation is based on the Information, Vocabulary, and Similarities WISC-R subtests.

\* \( p < .05 \).
Table 10
Correlation Matrix Between Selected Tests and WISC-R

<table>
<thead>
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<th>Subtests</th>
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<th>Trails B</th>
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<td>Boys</td>
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<td>Boys -.09</td>
<td>Boys .31</td>
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<td>Both -.42</td>
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<tr>
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<td>Boys -.04</td>
<td>Boys .23</td>
</tr>
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<tr>
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<td>Both -.25</td>
<td>Both .47</td>
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<tr>
<td>Boys</td>
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<td>Boys -.10</td>
<td>Boys .03</td>
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<tr>
<td>Girls</td>
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<td>Girls .02</td>
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<td>Both .55*</td>
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<td>Boys .38</td>
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<td>Boys .09</td>
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<td>Girls .09</td>
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<td>Both .47</td>
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<td>Boys .06</td>
<td>Boys .47*</td>
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<td>Girls</td>
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<td>Girls .84**</td>
<td>Girls .62</td>
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<td>Boys .13</td>
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</tbody>
</table>

*p < .05.  **p < .01.  ***p < .001.
Table 11
Correlation Matrix Between Selected Tests and Luria Scales

<table>
<thead>
<tr>
<th></th>
<th>VMI</th>
<th>Trails A</th>
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<td>Girls -.80*</td>
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<td>Boys .06</td>
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<td>Girls .76*</td>
<td>Girls .81*</td>
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<tr>
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<tr>
<td>Girls</td>
<td>-.68</td>
<td>Girls -.36</td>
<td>Girls -.32</td>
</tr>
</tbody>
</table>

Note.  Rec.Speech = Receptive Speech;  
Exp.Lang. = Expressive Language;  
*p < .05.  **p < .01.  ***p < .001.
Correlations Between the Selected Tests and the WISC-R Scales

Trails A

When the boys' and girls' Trails A scores were analyzed as one group, their scores did not correlate significantly with VIQ, PIQ, or the Kaufman Scales (p > .10). Their scores did correlate significantly with the Similarities subtest (r = -.52, p < .05). The significant correlations associated with Trails A are shown in Table 12.

When the scores for each gender were analyzed separately, the girls' Trails A scores, as hypothesized, correlated significantly with verbal skills measured by the WISC-R (see Table 12). Their Trails A scores were significantly related to the verbal components measured by VQ when the more culturally loaded Comprehension subtest was removed from the VQ equation (r = .72, p < .05). The girls' Trails A scores were also related to the skills measured by the Picture Arrangement subtest of the WISC-R (r = .84, p < .05). However, the correlation between the girls' Trails A scores and their Picture Arrangement scores became nonsignificant when the verbal components measured by VQ were partialled out (r = .72, p < .05). Hence, there appears to be a verbal component accounting partially for the relationship between the girls' scores on Trails A and their scores on the Picture Arrangement subtest.

The first hypothesis also predicted that the boys' Trails A scores would covary primarily with nonverbal
Table 12

Significant Correlations Associated With Trails A

<table>
<thead>
<tr>
<th>WISC-R Scales</th>
<th>Both</th>
<th>Boys</th>
<th>Girls</th>
</tr>
</thead>
<tbody>
<tr>
<td>VQ</td>
<td>-.02</td>
<td>-.38</td>
<td>.72*</td>
</tr>
<tr>
<td>Pic. Ar.</td>
<td>-.44</td>
<td>.06</td>
<td>.84*</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Luria Scales</th>
<th>Both</th>
<th>Boys</th>
<th>Girls</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rhythm</td>
<td>-.52*</td>
<td>-.07</td>
<td>-.96***</td>
</tr>
<tr>
<td>Reading</td>
<td>.35</td>
<td>.58*</td>
<td>.12</td>
</tr>
<tr>
<td>Math</td>
<td>-.44*</td>
<td>.04</td>
<td>-.84*</td>
</tr>
<tr>
<td>Memory</td>
<td>.01</td>
<td>-.46*</td>
<td>.76*</td>
</tr>
</tbody>
</table>

Note. VQ is based on WISC-R Information, Vocabulary, and Similarities subtests. Pic. Ar. = the WISC-R Picture Arrangement subtest.

*p < .05. ***p < .001.
spatial factors. However, in contrast to the girls' Trails A scores, the boys' scores were not significantly related to any WISC-R Scales, WISC-R subtests, or Kaufman Scales ($p > .05$) (see Tables 8 - 10). Therefore, from these results alone, it is not possible to determine the skills that covary with the boys' Trails A scores.

A stepwise multiple regression analysis (Tables 13 through 16) showed that most of the variables added to the regression equations did not add significant predictive ability to the prediction equations. Furthermore, the $F$-values corresponding with the predictive weights of the overall equation were seldom significant. Therefore, since the first variable selected for the regression equation adds the most predictive ability and is the most accurate predictor variable from the multiple regression variables, it was chosen to be analyzed in this study. Table 13 shows the multiple regression equations for the boys' and girls' performances on the selected tests when the analysis is based upon VIQ and PIQ. Table 14 shows the multiple regression equations for the boys' and girls' scores on the three selected tests when the regression analysis is based on the Kaufman Scales. Table 15 shows the regression equations when the analysis is based on preselected WISC-R subtests, including the Information, Vocabulary, Block Design, and Object Assembly subtests. Table 16 is a summary table which lists the best predictor variables for
Table 13
Multiple Regression Equations Based on VIQ and PIQ

I Predicting Trails A Performance

<table>
<thead>
<tr>
<th>Predictor Variable</th>
<th>Stepwise F</th>
<th>Overall F</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) Both Groups</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PIQ</td>
<td>.68</td>
<td>.68</td>
</tr>
<tr>
<td>2) Males Only</td>
<td></td>
<td></td>
</tr>
<tr>
<td>VIQ</td>
<td>1.10</td>
<td>.50</td>
</tr>
<tr>
<td>PIQ</td>
<td>.01</td>
<td></td>
</tr>
<tr>
<td>3) Females Only</td>
<td></td>
<td></td>
</tr>
<tr>
<td>VIQ</td>
<td>3.78</td>
<td>1.68</td>
</tr>
<tr>
<td>PIQ</td>
<td>.20</td>
<td></td>
</tr>
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</table>

II Predicting Trails B Performance

<table>
<thead>
<tr>
<th>Predictor Variable</th>
<th>Stepwise F</th>
<th>Overall F</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) Both Groups</td>
<td></td>
<td></td>
</tr>
<tr>
<td>VIQ</td>
<td>2.26</td>
<td>1.50</td>
</tr>
<tr>
<td>PIQ</td>
<td>.36</td>
<td></td>
</tr>
<tr>
<td>2) Males Only</td>
<td></td>
<td></td>
</tr>
<tr>
<td>VIQ</td>
<td>1.11</td>
<td>.53</td>
</tr>
<tr>
<td>PIQ</td>
<td>.07</td>
<td></td>
</tr>
<tr>
<td>3) Females Only</td>
<td></td>
<td></td>
</tr>
<tr>
<td>VIQ</td>
<td>4.33</td>
<td>.09</td>
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<td>.03</td>
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</table>

III Predicting VMI Performance

<table>
<thead>
<tr>
<th>Predictor Variable</th>
<th>Stepwise F</th>
<th>Overall F</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) Both Groups</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PIQ</td>
<td>4.39</td>
<td>3.11</td>
</tr>
<tr>
<td>VIQ</td>
<td>1.65</td>
<td></td>
</tr>
<tr>
<td>2) Males Only</td>
<td></td>
<td></td>
</tr>
<tr>
<td>VIQ</td>
<td>2.60</td>
<td>1.34</td>
</tr>
<tr>
<td>PIQ</td>
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<td></td>
</tr>
<tr>
<td>3) Females Only</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PIQ</td>
<td>2.80</td>
<td>1.27</td>
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</table>

Note. The probability of all the predictor variables is greater than .05.
Table 14

Multiple Regression Equations Based on the Kaufman Scales

I Predicting Trails A Performance

<table>
<thead>
<tr>
<th>Predictor Variable</th>
<th>Stepwise F</th>
<th>Overall F</th>
</tr>
</thead>
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<td>1) Both Groups</td>
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</tr>
<tr>
<td>PQ</td>
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<td>DQ</td>
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</tr>
<tr>
<td>VQ</td>
<td>.06</td>
<td></td>
</tr>
<tr>
<td>2) Males Only</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DQ</td>
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<td>.96</td>
</tr>
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<td>PQ</td>
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</tr>
<tr>
<td>VQ</td>
<td>.14</td>
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</tr>
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<td></td>
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<tr>
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II Predicting Trails B Performance

<table>
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<th>Overall F</th>
</tr>
</thead>
<tbody>
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</tr>
<tr>
<td>VQ</td>
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<td>1.46</td>
</tr>
<tr>
<td>PQ</td>
<td>1.23</td>
<td></td>
</tr>
<tr>
<td>DQ</td>
<td>.47</td>
<td></td>
</tr>
<tr>
<td>2) Males Only</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PQ</td>
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<td>.42</td>
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<tr>
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<td>.16</td>
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</tr>
<tr>
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</tr>
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</tr>
<tr>
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</tr>
<tr>
<td>DQ</td>
<td>.22</td>
<td></td>
</tr>
<tr>
<td>PQ</td>
<td>.23</td>
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III Predicting VMI Performance

<table>
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<th>Overall F</th>
</tr>
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</tr>
<tr>
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</tr>
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</tr>
<tr>
<td>VQ</td>
<td>.52</td>
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</tr>
<tr>
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</tr>
<tr>
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</tr>
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<td>PQ</td>
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</tr>
<tr>
<td>DQ</td>
<td>.13</td>
<td></td>
</tr>
<tr>
<td>3) Females Only</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DQ</td>
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<td>.72</td>
</tr>
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<td>.55</td>
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</tr>
<tr>
<td>VQ</td>
<td>.05</td>
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</tr>
</tbody>
</table>

*p < .05.
### Table 15

**Multiple Regression Equations Based on WISC-R Subtests**

#### I Predicting Trails A Performance

<table>
<thead>
<tr>
<th>Predictor Variable</th>
<th>Stepwise F</th>
<th>Overall F</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) Both Groups</td>
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<td></td>
</tr>
<tr>
<td>Blk.Ds.</td>
<td>1.32</td>
<td>.63</td>
</tr>
<tr>
<td>Info.</td>
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</tr>
<tr>
<td>Ob.As.</td>
<td>.47</td>
<td></td>
</tr>
<tr>
<td>Sim.</td>
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</tr>
<tr>
<td>2) Males Only</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Info.</td>
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<td>.49</td>
</tr>
<tr>
<td>Blk.Ds.</td>
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<td></td>
</tr>
<tr>
<td>Ob.As.</td>
<td>.59</td>
<td></td>
</tr>
<tr>
<td>Sim.</td>
<td>.12</td>
<td></td>
</tr>
<tr>
<td>3) Females Only</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sim.</td>
<td>1.38</td>
<td>.65</td>
</tr>
<tr>
<td>Info.</td>
<td>.15</td>
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</tr>
</tbody>
</table>

#### II Predicting Trails B Performance

<table>
<thead>
<tr>
<th>Predictor Variable</th>
<th>Stepwise F</th>
<th>Overall F</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) Both Groups</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Info.</td>
<td>1.21</td>
<td>.46</td>
</tr>
<tr>
<td>Blk.Ds.</td>
<td>.31</td>
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</tr>
<tr>
<td>Ob.As.</td>
<td>.07</td>
<td></td>
</tr>
<tr>
<td>2) Males Only</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Blk.Ds.</td>
<td>.55</td>
<td>.12</td>
</tr>
<tr>
<td>Ob.As.</td>
<td>.05</td>
<td></td>
</tr>
<tr>
<td>Sim.</td>
<td>.03</td>
<td></td>
</tr>
<tr>
<td>3) Females Only</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Info.</td>
<td>3.85</td>
<td>2.46</td>
</tr>
<tr>
<td>Blk.Ds.</td>
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<td></td>
</tr>
<tr>
<td>Ob.As.</td>
<td>1.71</td>
<td></td>
</tr>
<tr>
<td>Sim.</td>
<td>.49</td>
<td></td>
</tr>
</tbody>
</table>

#### III Predicting VMI Performance

<table>
<thead>
<tr>
<th>Predictor Variable</th>
<th>Stepwise F</th>
<th>Overall F</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) Both Groups</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ob.As.</td>
<td>3.01</td>
<td>.95</td>
</tr>
<tr>
<td>Blk.Ds.</td>
<td>1.20</td>
<td></td>
</tr>
<tr>
<td>Info.</td>
<td>.28</td>
<td></td>
</tr>
<tr>
<td>Sim.</td>
<td>.02</td>
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</tr>
<tr>
<td>2) Males Only</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ob.As.</td>
<td>1.99</td>
<td>1.22</td>
</tr>
<tr>
<td>Sim.</td>
<td>.63</td>
<td></td>
</tr>
<tr>
<td>3) Females Only</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Blk.Ds.</td>
<td>7.51*</td>
<td>7.33</td>
</tr>
<tr>
<td>Info.</td>
<td>7.31</td>
<td></td>
</tr>
<tr>
<td>Ob.As.</td>
<td>2.65</td>
<td></td>
</tr>
<tr>
<td>Sim.</td>
<td>.33</td>
<td></td>
</tr>
</tbody>
</table>

Note. Blk.Ds. = Block Design; Info. = Information; Ob.As. = Object Assembly; Sim. = Similarities.
Table 16

Best Predictors Based on the Multiple Regression Equations

<table>
<thead>
<tr>
<th>Trails A</th>
<th>Trails B</th>
<th>VMI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boys</td>
<td>Girls</td>
<td>Boys</td>
</tr>
<tr>
<td>VIQ</td>
<td>VIQ</td>
<td>VIQ</td>
</tr>
<tr>
<td>DQ</td>
<td>VQ</td>
<td>PQ</td>
</tr>
<tr>
<td>Reading</td>
<td>Math</td>
<td>Writing</td>
</tr>
</tbody>
</table>

Note. The variables listed in the first three lines are from the WISC-R. The variables listed in the fourth line are from the Luria-Nebraska. Info. = Information, Sim. = Similarities; Blk.Ds. = Block Design; Ob.As. = Object Assembly.
the boys' and girls' performance scores on the three selected tests from the various Tables listed above.

As predicted by the first hypothesis, the multiple regression analysis revealed that the best WISC-R predictors for the girls' performance on Trails A are verbal scales (see Table 16). VIQ was the best predictor variable when VIQ and PIQ were used to predict the girls' Trails A performance (see Table 13). VQ was the best predictor variable when the Kaufman factor analytic variables (VQ, PQ, and DQ) were used to predict the girls' performance on Trails A (see Table 14). The Similarities subtest was the best predictor variable for the girls' Trails A performance when the WISC-R subtests used to predict the girls' performance were the Information, Similarities, Block Design, and Object Assembly subtests (see Table 15). Hence, not only did the girls' Trails A scores correlate with verbal skills measured by the WISC-R, they were also predicted the most accurately by verbal WISC-R variables.

The best predictors for the boys' performance on Trails A also included verbal variables, which was not predicted by the first hypothesis (see Table 16). VIQ was the best predictor variable for the boys' Trails A performance when the predictor variables were VIQ and PIQ (see Table 13). DQ was the best predictor variable from the Kaufman factor analytic indices. DQ measures a variety
of skills, including, possibly, both verbal and nonverbal skills (see Table 14). The WISC-R Information subtest was the best predictor variable for the boys' Trails A performance when the predictor variables were based on the Information, Similarities, Block Design, and Object Assembly subtests (see Table 15). With the possible exception of DQ, the best predictor variables for the boys' Trails A scores are measurements of verbal skills. Although the boys' Trails A scores did not correlate significantly with the WISC-R Scales, WISC-R subtests, or Kaufman factor analytic indices, the multiple regression analysis indicates that the boys' Trails A performance is best predicted by the skills measured by VIQ, DQ, and the Information subtest.

**Trails B**

When the boys' and girls' Trails B scores were analyzed as one group, their scores did not correlate significantly with VIQ, PIQ, or the Kaufman Scales (p > .05). Their Trails B scores did, however, correlate significantly with the Digit Span subtest of the WISC-R (r = .55, p < .05). The significant correlations associated with Trails B are shown in Table 17.

As predicted by the second hypothesis, the girls' scores on Trails B correlated significantly with verbal skills measured by the WISC-R (see Table 17). Their Trails B scores correlated significantly with the verbal skills
Table 17

Significant Correlations Associated With Trails B

<table>
<thead>
<tr>
<th></th>
<th>Both</th>
<th>Boys</th>
<th>Girls</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>WISC-R Scales</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>VIQ</td>
<td>.38</td>
<td>.33</td>
<td>.68*</td>
</tr>
<tr>
<td>VQ</td>
<td>.38</td>
<td>.24</td>
<td>.80*</td>
</tr>
<tr>
<td>Dig. Sp.</td>
<td>.55*</td>
<td>.38</td>
<td>.21</td>
</tr>
<tr>
<td>Pic. Ar.</td>
<td>.47</td>
<td>.47*</td>
<td>.62</td>
</tr>
<tr>
<td><strong>Luria Scales</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rhythm</td>
<td>-.42</td>
<td>-.10</td>
<td>-.80*</td>
</tr>
<tr>
<td>Memory</td>
<td>.24</td>
<td>.06</td>
<td>.81*</td>
</tr>
</tbody>
</table>

Note. Dig. Sp. = the WISC-R Digit Span subtest; Pic. Ar. = the WISC-R Picture Arrangement subtest.

*p < .05.
measured by both VIQ (r = .68, p < .05) and VQ (r = .80, p < .05).

In contrast to the girls', the boys' Trails B scores did not significantly correlate with VIQ or VQ (p > .10) (see Table 17). Their Trails B scores correlated significantly with only one WISC-R test, the Picture Arrangement subtest (r = .47, p < .05). Hence the boys' Trails B scores are related to the skills which are also measured by the Picture Arrangement subtest.

As predicted by the second hypothesis, the girls' Trails B scores were best predicted by the verbal variables included in the multiple regression equations (see Table 16). The girls' Trails B scores were best predicted by VIQ when the predictor variables consisted of VIQ and PIQ (see Table 13). Their Trails B scores were best predicted by VQ when the Kaufman factor analytic indices were used to predict the girls' Trails B performance (see Table 14). The Information subtest was the best predictor variable when the Information, Similarities, Block Design, and Object Assembly subtests were used to predict the girls' Trails B performance (see Table 15). Once again, as with Trails A, the girls' Trails B scores correlated significantly with verbal skills measured by the WISC-R and were predicted the most accurately by verbal WISC-R variables.

The boys' Trails B scores were best predicted by both
verbal and nonverbal variables included in the multiple regression equations (see Table 16). Their Trails B scores were best predicted by VIQ when VIQ and PIQ were used to predict the boys' Trails B scores (see Table 13). Their Trails B scores were best predicted by PQ when the Kaufman factor analytic indices were used to predict the boys' Trails B performance (see Table 14). The Block Design subtest was the best predictor variable when the multiple regression equation was based on the Information, Similarities, Block Design, and Object Assembly subtests (see Table 15). Overall, the boys' Trails B scores correlated with the skills measured by the Picture Arrangement subtest and their Trails B scores were predicted the most accurately by both verbal and nonverbal WISC-R variables.

The VMI

When the boys' and girls' VMI scores were analyzed as one group, their scores correlated with the verbal skills measured by VIQ ($r = .42, p < .05$) and the WISC-R Comprehension subtest ($r = .57, p < .05$). Their VMI scores also correlated significantly with the skills measured by PIQ ($r = .46, p < .05$), PQ ($r = .48, p < .05$), DQ ($r = .48, p < .05$), and the Object Assembly subtest ($r = .58, p < .05$). The significant correlations associated with the VMI are shown in Table 18.

The third hypothesis was nondirectional regarding the
Table 18

Significant Correlations Associated With the VMI

<table>
<thead>
<tr>
<th>WISC-R Scales</th>
<th>Both</th>
<th>Boys</th>
<th>Girls</th>
</tr>
</thead>
<tbody>
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<td>.46</td>
</tr>
<tr>
<td>PIQ</td>
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<td>.31</td>
<td>.60</td>
</tr>
<tr>
<td>FSIQ</td>
<td>.51*</td>
<td>.48</td>
<td>.61</td>
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<tr>
<td>PQ</td>
<td>.48*</td>
<td>.39</td>
<td>.51</td>
</tr>
<tr>
<td>DQ</td>
<td>.48*</td>
<td>.42</td>
<td>.57</td>
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<tr>
<td>Info.</td>
<td>.49</td>
<td>.44*</td>
<td>.37</td>
</tr>
<tr>
<td>Arith.</td>
<td>.47</td>
<td>.58**</td>
<td>.87**</td>
</tr>
<tr>
<td>Comp.</td>
<td>.57*</td>
<td>.18</td>
<td>-.17</td>
</tr>
<tr>
<td>Blk. Ds.</td>
<td>.26</td>
<td>.46*</td>
<td>.77*</td>
</tr>
<tr>
<td>Ob. As.</td>
<td>.58*</td>
<td>.46*</td>
<td>.08</td>
</tr>
<tr>
<td>Luria Scales</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rec. Sp.</td>
<td>-.67***</td>
<td>-.74**</td>
<td>-.69*</td>
</tr>
<tr>
<td>Memory</td>
<td>-.45*</td>
<td>-.53*</td>
<td>-.61</td>
</tr>
<tr>
<td>Int. Pro.</td>
<td>-.61*</td>
<td>-.66*</td>
<td>-.68*</td>
</tr>
</tbody>
</table>

Note. Info. = the WISC-R Information subtest; Arith. = the WISC-R Arithmetic subtest; Comp. = the WISC-R Comprehension subtest; Blk. Ds. = the WISC-R Block Design subtest; Ob. As. = the WISC-R Object Assembly subtest; Rec. Sp. = Luria Receptive Speech Scale; Int. Pro. = Luria Intellectual Processes Scale. *p < .05. **p < .01. ***p < .001.
expected correlates of the girls' VMI scores. Interestingly, their VMI scores did not correlate significantly with the verbal skills measured by VIQ or VQ (p > .05) (see Table 18), but their VMI scores did correlate significantly with the WISC-R Block Design subtest (r = .77, p < .05) and the WISC-R Arithmetic subtest (r = .87, p < .05). When the verbal skills measured by VQ were partialled out, the correlation between the VMI and the Block Design subtest became nonsignificant (r = .77, p > .05), however since the value of the partial correlation is the same as the value of the zero-order correlation, the nonsignificance of this partial correlation appears to be due to a decrease in the degrees of freedom that are associated with the partial correlation. The correlation between the VMI and the Arithmetic subtest remained significant when VQ was partialled out (r = .88, p < .05). Hence, the correlation between the girls' VMI scores and their Arithmetic scores are not based on the skills also measured by VQ. Thus, the girls' VMI scores appear to be related to skills measured by the Block Design and Arithmetic subtests.

As predicted by the third hypothesis, the boys' scores on the VMI correlated significantly with nonverbal spatial factors (Table 18). The boys' VMI scores were significantly related to the WISC-R Block Design subtest.
(r = .46, p < .05) and the WISC-R Object Assembly subtest (r = .46, p < .05). The Block Design subtest might not be a pure measure of nonverbal spatial abilities since the relationship between the boys' Block Design scores and VMI scores became nonsignificant when VQ was partialled out (r = .09, p > .50). The correlation between the boys' Object Assembly scores and their VMI scores, however, does not appear to depend upon verbal factors since it remained significant when VQ was partialled out (r = .55, p < .05). Furthermore, the boys VMI scores were correlated with the Information subtest of the WISC-R (r = .44, p < .05). Hence, as predicted by the third hypothesis, the boys' VMI scores correlated significantly with nonverbal spatial factors. However, unpredicted by the third hypothesis, the boys' VMI scores also correlated with verbal skills measured by the Information subtest.

According to the multiple regression analysis, the best predictor variables for the girls' VMI performance were primarily nonverbal (see Table 16). The girls' VMI scores were best predicted by PIQ when VIQ and PIQ were used to predict their VMI performance (see Table 13). Their scores were predicted the best by DQ when the Kaufman factor analytic indices comprised the multiple regression equation (see Table 14). DQ might measure both verbal and nonverbal skills. The girls' VMI performance was best predicted by the Object Assembly subtest when the
regression equation was based on the Information, Similarities, Block Design, and Object Assembly subtests (see Table 15). Overall, the girls' VMI scores correlated with primarily nonverbal WISC-R scales and were best predicted by nonverbal spatial WISC-R variables.

The multiple regression analysis also indicated that the boys' VMI performance scores were best predicted by a combination of verbal and spatial variables (see Table 16). Their VMI scores were best predicted by VIQ when VIQ and PIQ were used to predict the boys' VMI performance (see Table 13). VQ was the best predictor variable when the Kaufman factor analytic indices were used to predict the boys' VMI performance scores (see Table 14). The Object Assembly subtest was the best predictor variable for the boys' VMI performance scores when the Information, Similarities, Block Design, and Object Assembly WISC-R subtests were used to predict the boys' VMI performance scores (see Table 15). Hence, similar to Trails A and Trails B, the boys' VMI scores correlated significantly with nonverbal and WISC-R verbal variables and their VMI scores were also predicted most accurately by both verbal and nonverbal WISC-R variables.
Correlations Between the Selected Tests
and the Luria-Nebraska Scales

Trails A

The significant correlations between Trails A and the Luria-Nebraska scales are shown in Table 12. The boys' and girls' Trails A scores, when analyzed as one group, correlated significantly with the Luria Rhythm Scale ($r = -.52, p < .05$) and the Luria Math Scale ($r = -.44, p < .05$).

According to the first hypothesis, the girls' Trails A scores were expected to correlate primarily with the Verbal Scales of the Luria-Nebraska. The girls' Trails A scores, however, did not correlate significantly with any of the Luria-Nebraska Verbal Scales ($p > .05$) (see Table 11). The girls' Trails A scores were related to the Luria Memory Scale ($r = .81, p < .05$), the Luria Rhythm Scale ($r = -.80, p < .05$), and the Luria Math Scale ($r = .84, p < .05$) (see Table 12). Partialing out the Receptive Speech Scale made the correlation between Trails A and the Luria Math Scale become nonsignificant ($r = -.70, p > .05$), which indicates that this correlation depends partially upon the verbal skills also measured by the Luria Receptive Speech Scale.

According to the first hypothesis, the boys' Trails A scores were expected to correlate primarily with nonverbal spatial scales of the Luria-Nebraska. Their Trails A scores did not correlate with any spatial scales of the Luria-Nebraska ($p > .05$), but their Trails A scores did

66
correlate significantly with the skills measured by the Luria Reading Scale \( (r = .58, p < .05) \) (see Table 12). The boys' Trails A scores also correlated significantly with the Luria Memory Scale \( (r = -.46, p < .05) \). The correlation between Trails A and the Luria Reading Scale remained significant when the skills measured by the Luria Visual Scale were partialled out \( (r = .66, p < .05) \), but the correlation between Trails A and the Luria Memory Scale became nonsignificant when the Luria Visual Scale was partialled out \( (r = -.46, p > .05) \). However, once again, the zero-order correlation between Trails A and the Luria Memory Scale and the partial correlation involving these scales have the same value, so the nonsignificance of the partial correlation appear to be due to a loss in degrees of freedom. Overall, the boys' Trails A scores are significantly related to the skills measured by the Luria Memory Scale and, unpredicted by the first hypothesis, the boys' Trails A scores also correlated significantly with verbal skills measured by the Luria Reading Scale.

Table 19 shows the regression analysis based upon the Luria-Nebraska Scales. The best predictor variable for the girls' Trails A performance was the Luria Math Scale when the predictor variables consisted of the Reading, Writing, Math, and Visual Scales of the Luria-Nebraska (see Table 19). Hence, the girls' Trails A scores correlated significantly with the skills measured by the Luria Memory.
Table 19
Multiple Regression Equations Based on Luria Scales

I Predicting Trails A Performance

<table>
<thead>
<tr>
<th>Predictor Variable</th>
<th>Stepwise F</th>
<th>Overall F</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) Both Groups</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Math</td>
<td>3.58</td>
<td>.08</td>
</tr>
<tr>
<td>Reading</td>
<td>6.90*</td>
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<tr>
<td>Visual</td>
<td>.31</td>
<td></td>
</tr>
<tr>
<td>Writing</td>
<td>.07</td>
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</tr>
<tr>
<td>2) Males Only</td>
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<td></td>
</tr>
<tr>
<td>Reading</td>
<td>4.64</td>
<td>1.47</td>
</tr>
<tr>
<td>Visual</td>
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</tr>
<tr>
<td>Writing</td>
<td>.53</td>
<td></td>
</tr>
<tr>
<td>Math</td>
<td>.19</td>
<td></td>
</tr>
<tr>
<td>3) Females Only</td>
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<td></td>
</tr>
<tr>
<td>Math</td>
<td>9.64*</td>
<td>1.09</td>
</tr>
<tr>
<td>Visual</td>
<td>.44</td>
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<td>Writing</td>
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</tr>
<tr>
<td>Reading</td>
<td>.05</td>
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II Predicting Trails B Performance

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<th>Predictor Variable</th>
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<th>Overall F</th>
</tr>
</thead>
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<td>1) Both Groups</td>
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<td></td>
</tr>
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<td>Math</td>
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<td>.63</td>
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<tr>
<td>Reading</td>
<td>.82</td>
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</tr>
<tr>
<td>Visual</td>
<td>.06</td>
<td></td>
</tr>
<tr>
<td>2) Males Only</td>
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<td></td>
</tr>
<tr>
<td>Writing</td>
<td>.87</td>
<td>.28</td>
</tr>
<tr>
<td>Math</td>
<td>.16</td>
<td></td>
</tr>
<tr>
<td>Reading</td>
<td>.01</td>
<td></td>
</tr>
<tr>
<td>3) Females Only</td>
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<td></td>
</tr>
<tr>
<td>Math</td>
<td>2.44</td>
<td>2.06</td>
</tr>
<tr>
<td>Writing</td>
<td>2.06</td>
<td></td>
</tr>
<tr>
<td>Visual</td>
<td>1.53</td>
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<tr>
<td>Reading</td>
<td>.11</td>
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</tr>
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</table>

III Predicting VMI Performance

<table>
<thead>
<tr>
<th>Predictor Variable</th>
<th>Stepwise F</th>
<th>Overall F</th>
</tr>
</thead>
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<td>1) Both Groups</td>
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<td>Math</td>
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<tr>
<td>Reading</td>
<td>.32</td>
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<tr>
<td>Visual</td>
<td>.11</td>
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</tr>
<tr>
<td>Writing</td>
<td>.03</td>
<td></td>
</tr>
<tr>
<td>2) Males Only</td>
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<td>Writing</td>
<td>1.33</td>
<td>.68</td>
</tr>
<tr>
<td>Math</td>
<td>.15</td>
<td></td>
</tr>
<tr>
<td>3) Females Only</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Math</td>
<td>1.43</td>
<td>.25</td>
</tr>
<tr>
<td>Reading</td>
<td>.83</td>
<td></td>
</tr>
<tr>
<td>Writing</td>
<td>.25</td>
<td></td>
</tr>
</tbody>
</table>

* p < .05.
and the Luria Math Scales and their Trails A scores are best predicted by the Luria Math Scale. Thus, the girls' Trails A scores correlated indirectly with verbal skills measured by the Luria since the relationship between their Trail A scores and their Math scores was based partially on verbal skills assumed to be measured by the Luria Receptive Speech Scale.

The best predictor variable for the boys' Trails A performance was the Luria Reading Scale when the predictor variables consisted of the Reading, Writing, Math, and Visual Scales of the Luria-Nebraska (see Table 19). Thus overall, the boys' Trails A scores correlated directly with verbal skills measured by the Luria and indirectly with nonverbal visual-spatial skills measured by the Luria. Furthermore the boys' Trails A scores were the most accurately predicted by the Luria Reading Scale.

**Trails B**

The significant correlations associated with Trails B and the Luria Scales are shown in Table 17. When analyzed together, the girls' and boys' scores correlated significantly with the Luria Rhythm Scale ($r = -0.52$, $p < .05$) and the Luria Math Scale ($r = -0.44$, $p < .05$).

When analyzed separately, the girls' Trails B scores did not significantly correlate with the Verbal Scales of the Luria ($p > .05$) (see Table 11). However, their Trails B scores are related to the Luria Memory Scale ($r = 0.81$, $p < .05$).
p < .05) and the Luria Rhythm Scale (r = -.80, p < .05). The correlation between Trails B and the Luria Memory Scale remained significant when the Receptive Speech Scale was partialled out (r = .93, p < .01). The correlation between Trails B and the Luria Rhythm Scale also remained significant when the Luria Receptive Speech Scale was partialled out (r = -.81, p < .05). Hence these correlations are not partially based on the skills also measured by the Receptive Speech Scale.

When the boys' Trails B scores were analyzed, their Trails B scores did not significantly correlate with any of the Luria-Nebraska Scales (p > .05) (see Table 11).

The best predictor variable for the girls' Trails B scores was the Math Scale when the regression equation was based on the Reading, Writing, Math, and Visual Scales of the Luria-Nebraska (see Table 19). Hence, the girls' Trails B scores correlated significantly with the skills measured by the Memory and Rhythm Scales and their Trails B scores were the most accurately predicted by the Luria Math Scale.

The best predictor variable for the boys' Trails B scores was the Luria Writing Scale when the regression equation was based on the Luria Reading, Writing, Math and Visual Scales (see Table 19). The boys' scores did not significantly correlate with any of the Luria Scales, but the multiple regression analysis indicates that their
Trails B scores are best predicted by the Luria Writing Scale when the predictor variables are those listed above.

The VMI

The significant correlations associated with the VMI and the Luria-Nebraska are shown in Table 18. When treated as one group, the boys' and girls' VMI scores correlated significantly with the skills measured by the Luria Receptive Speech Scale ($r = -.67$, $p < .05$) and the Luria Intellectual Processes Scale ($r = -.61$, $p < .05$).

When analyzed separately, the girls' VMI scores were significantly related to the skills measured by the Receptive Speech Scale ($r = -.69$, $p < .05$) and the Luria Intellectual Processes Scale ($r = -.68$, $p < .05$) (see Table 18). The correlation between the girls' VMI scores and their Intellectual Processes scores became nonsignificant when the Receptive Speech Scale ($r = -.33$, $p > .05$) was partialled out. This partial correlation indicates that the relationship between the girls' VMI scores and their Luria Intellectual Processes scores is partially based on factors also measured by the Receptive Speech Scale. Thus, the girls' VMI scores are both directly and indirectly related to verbal skills measured by the Luria-Nebraska.

Similarly, the boys' VMI scores correlated significantly with the Luria Receptive Speech Scale ($r = -.74$, $p < .01$) (see Table 18). Their VMI scores were also significantly correlated with the Luria Memory Scale.
(r = -.53, p < .05) and the Luria Intellectual Processes Scale (r = -.66, p < .05). The correlation between the boys' VMI scores and their Luria Memory scores became nonsignificant when either the Luria Visual Scale or the Luria Receptive Speech Scale was partialled out (p > .05). The correlation between the VMI and the Luria Intellectual Processes Scale remained significant when the Luria Visual Scale was partialled out (r = -.67, p < .05) but became nonsignificant when the Receptive Speech Scale was partialled out (r = -.41, p > .10). Thus the boys' VMI scores are indirectly and directly correlated with both verbal and nonverbal skills measured by the Luria-Nebraska.

The best predictor variable of the girls' VMI scores was the Luria Math Scale when the regression equation was based on the Luria Reading, Writing, Math, and Visual Scales (see Table 19). Hence their scores were predicted the most accurately by the Luria Math Scale. Furthermore, the girls' VMI scores correlated significantly with verbal skills measured by the Receptive Speech Scale. Their VMI scores also correlated significantly with the skills measured by the Intellectual Processes Scale.

The best predictor variable for the boys' VMI scores was the Luria Writing Scale when the regression equation was based on the Luria Reading, Writing, Math, and Visual Scales (see Table 19). Hence the boys' VMI scores correlated directly and indirectly with nonverbal and
verbal skills measured by the Luria-Nebraska, and their VMI scores were the most accurately predicted by the Luria Writing Scale.

**Cross-Product Partial Correlations**

First the partial correlations between the three selected tests (Trails A, Trails B, and the VMI) and the WISC-R scales while partialling out Luria Scales will be discussed. Then the partial correlations between the selected tests and the Luria Scales while partialling out WISC-R scales will be discussed.

**Partialling Out Luria-Nebraska Scales**

As previously reported, the girls' Trails A scores correlated directly and indirectly with verbal skills measured by the WISC-R. Their Trails A scores correlated significantly with the skills measured by VQ when the more culturally loaded Comprehension subtest was removed from the VQ equation. The partial correlation analysis indicates that the correlation between Trails A and VQ is based on skills measured by the Luria Receptive Speech Scale. These results support the first hypothesis since the girls' Trails A scores correlated with verbal skills measured by both the WISC-R and the Luria-Nebraska. The significant zero-order correlations associated with Trails A while partialling out Luria Scales are shown in Table 20.
Table 20
Correlations Between Trails A and the WISC-R Scales While Partialling Out Luria Scales

<table>
<thead>
<tr>
<th>Correlations with the Girls' Trails A Scores</th>
<th>Correlations with the Boys' Trails A Scores</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trails A and VQ w/o Rspeech</td>
<td>r = .65</td>
</tr>
<tr>
<td>Trails A and Pic.Ar. w/o Rspeech</td>
<td>r = .83*</td>
</tr>
<tr>
<td>Trails A and Pic.Ar. w/o Visual</td>
<td>r = .85*</td>
</tr>
<tr>
<td>Trails A and DQ w/o Visual</td>
<td>r = -.56*</td>
</tr>
<tr>
<td>Trails A and Dig.Sp. w/o Rspeech</td>
<td>r = -.62*</td>
</tr>
</tbody>
</table>

Note. w/o = without. Rspeech = the Luria Receptive Speech Scale; Visual = the Luria Visual Scale; Pic.Ar. = the WISC-R Picture Arrangement subtest; Dig.Sp. = the WISC-R Digit Span subtest.
The girls' Trails A scores were also significantly related to their WISC-R Picture Arrangement subtest scores. This correlation remained significant when either the Receptive Speech Scale or the Luria Visual Scale was partialled out (see Table 20). Hence, the correlation between Trails A scores and the Picture Arrangement scores is not based on the skills measured by the Receptive Speech Scale or the Visual Scale of the Luria-Nebraska. Even though the correlation between Trails A and the Picture Arrangement subtest remained significant when the Receptive Speech Scale was partialled out, it was reported earlier that this correlation became nonsignificant when VQ was partialled out. Hence the correlation between the girls' Trails A scores and their Picture Arrangement scores depends partially on the verbal skills measured by VQ but does not depend upon the verbal skills measured by the Luria Receptive Speech Scale.

The boys' Trails A scores were not significantly correlated with any of the WISC-R Scales or WISC-R subtests yet there is a significant relationship between the boys' Trails A scores and DQ when the skills measured by the Luria Visual Scale are partialled out (see Table 20). There is also a significant relationship between the boys' Trails A scores and their Digit Span subtest scores when the skills measured by the Luria Receptive Speech Scale are partialled out (see Table 20).
The significant zero-order correlations associated with Trails B while partialling out Luria Scales are shown in Table 21. The girls' Trails B scores were significantly correlated with the verbal skills measured by VIQ and VQ. These correlations are not based upon the skills measured by the Luria Visual Scale (see Table 21). The relationship between Trails B and VIQ became nonsignificant when the Luria Receptive Speech Scale was partialled out, however the relationship between Trails B and VQ remained a high number and was almost significant (p = .07) when the Receptive Speech Scale was partialled out (see Table 21). Thus the correlations involving VIQ and VQ respond differently when the Luria Receptive Speech Scale is partialled out. However the skills measured by the Receptive Speech Scale do partially account for the relationship between the girls' Trails B scores and their VIQ scores which supports the second hypothesis.

The boys' Trails B scores correlated significantly with only one WISC-R test, the Picture Arrangement subtest. This correlation became nonsignificant when either the Luria Visual Scale or the Luria Receptive Speech Scale was partialled out (see Table 21). Hence, the correlation between the boys' Trails B scores and their Picture Arrangement scores depends partially upon the skills measured by both the Luria Visual Scale and the Luria Receptive Speech Scale. These results support the second
Table 21
Correlations Between Trails B and the WISC-R Scales While Partialling Out Luria Scales

<table>
<thead>
<tr>
<th>Correlations with the Girls’ Trails B Scores</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trails B and VIQ w/o Visual</td>
</tr>
<tr>
<td>Trails B and VIQ w/o Rspeech</td>
</tr>
<tr>
<td>Trails B and VQ w/o Visual</td>
</tr>
<tr>
<td>Trails B and VQ w/o Rspeech</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Correlations with the Boys’ Trails B Scores</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trails B and Pic.Ar. w/o Visual</td>
</tr>
<tr>
<td>Trails B and Pic.Ar. w/o Rspeech</td>
</tr>
</tbody>
</table>

Note. w/o = without; Rspeech = the Luria Receptive Speech Scale; Visual = the Luria Visual Scale; Pic.Ar. = the WISC-R Picture Arrangement subtest.

$**p < .01.$
hypothesis since the boys' Trails B scores indirectly correlated with nonverbal skills measured by the Luria. The boys' Trails B scores were also, however, indirectly related to verbal skills measured by the Luria-Nebraska which was not predicted by the second hypothesis.

The third hypothesis regarding the expected correlates of the girls' VMI scores was nondirectional and the WISC-R zero-order correlations indicated that the girls' VMI scores were primarily related to nonverbal skills measured by the WISC-R. The significant zero-order correlations associated with the VMI while partialling out Luria Scales are shown in Table 22. The partial correlations involving the Luria Scales indicate that the WISC-R zero-order correlations are also based on the verbal skills measured by the Luria Receptive Speech Scale and are not based upon the skills measured by the Luria Visual Scale (see Table 22). Thus, the girls' VMI scores are correlated directly and indirectly with both nonverbal and verbal skills measured by the WISC-R and the Luria.

The third hypothesis predicted that the boys' VMI scores would correlate primarily with nonverbal spatial skills measured by the WISC-R and Luria. The zero-order correlations involving the WISC-R scales partially supported this hypothesis since the boys' scores correlated significantly with the WISC-R Block Design subtest. The boys' VMI scores also correlated significantly with verbal
Table 22
Correlations Between the VMI and the WISC-R Scales While Partialling Out Luria Scales

<table>
<thead>
<tr>
<th></th>
<th>Girls' VMI Scores</th>
<th></th>
<th>Boys' VMI Scores</th>
<th></th>
</tr>
</thead>
<tbody>
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<td>VMI and Blk.Des. w/o Visual</td>
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<td></td>
<td>VMI and Blk.Des. w/o Visual</td>
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<tr>
<td>VMI and Blk.Des. w/o Rspeech</td>
<td>r = .52</td>
<td></td>
<td>VMI and Blk.Des. w/o Rspeech</td>
<td>r = .59*</td>
</tr>
<tr>
<td>VMI and Arith. w/o Visual</td>
<td>r = .94**</td>
<td></td>
<td>VMI and Arith. w/o Rspeech</td>
<td>r = .73</td>
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<tr>
<td>VMI and Arith. w/o Rspeech</td>
<td>r = .73</td>
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<td></td>
<td></td>
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<tr>
<td>VMI and Ob.As. w/o Visual</td>
<td>r = .59*</td>
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<td></td>
</tr>
<tr>
<td>VMI and Ob.As. w/o Rspeech</td>
<td>r = .53</td>
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<td></td>
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</tr>
<tr>
<td>VMI and Info. w/o Visual</td>
<td>r = .49</td>
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<td></td>
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</tr>
<tr>
<td>VMI and Info. w/o Rspeech</td>
<td>r = .53</td>
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<td></td>
<td></td>
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</tbody>
</table>

Note. w/o = without; Blk.Des. = the WISC-R Block Design subtest; Rspeech = the Luria Receptive Speech Scale; Arith. = the WISC-R Arithmetic subtest; Visual = the Luria Visual Scale; Info. = the WISC-R Information subtest. *p < .05. **p < .01.
skills measured by the WISC-R Information subtest, and this relationship was not predicted by the third hypothesis. Similar results were obtained when the Luria Visual Scale and the Luria Receptive Speech Scale were separately partialled out from the WISC-R zero-order correlations which indicates that the boys' VMI scores are correlated with both verbal and nonverbal skills measured by the WISC-R and the Luria-Nebraska (see Table 22).  

Partialling Out WISC-R Scales

The significant zero-order correlations associated with Trails A while partialling out WISC-R Scales are shown in Table 23. As previously reported, the girls' Trails A scores were significantly correlated with the Luria Rhythm Scale and the Luria Math Scale. The correlation between Trails A and the Luria Rhythm Scale remained significant when either PIQ or VIQ were partialled out (see Table 23). The correlation between Trails A and the Luria Math Scale remained significant when PIQ was partialled out but did not remain significant when VIQ was partialled out (see Table 23). Hence the correlation between the girls' Trails A scores and their Luria Math scores depends partially on the skills measured by VIQ which supports the first hypothesis.

The boys' Trails A scores correlated with the Luria Reading Scale and the Luria Memory Scale. The correlation between the boys' Trails A scores and their Luria
Table 23
Correlations Between Trails A and the Luria Scales While Partialling Out WISC-R Scales

<table>
<thead>
<tr>
<th>Correlations with the Girls' Trails A Scores</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Trails A and Rhythm w/o VIQ</td>
<td>$r = -0.98^{**}$</td>
</tr>
<tr>
<td>Trails A and Rhythm w/o PIQ</td>
<td>$r = -0.95^{**}$</td>
</tr>
<tr>
<td>Trails A and Math w/o VIQ</td>
<td>$r = -0.70$</td>
</tr>
<tr>
<td>Trails A and Math w/o PIQ</td>
<td>$r = -0.85^{*}$</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Correlations with the Boys' Trails A Scores</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Trails A and Reading w/o VIQ</td>
<td>$r = 0.66^{*}$</td>
</tr>
<tr>
<td>Trails A and Reading w/o PIQ</td>
<td>$r = 0.58^{*}$</td>
</tr>
<tr>
<td>Trails A and Memory w/o VIQ</td>
<td>$r = -0.58^{*}$</td>
</tr>
<tr>
<td>Trails A and Memory w/o PIQ</td>
<td>$r = -0.50$</td>
</tr>
</tbody>
</table>

Note. w/o = without.

*p < .05. **p < .01.
Reading scores remained significant when either VIQ or PIQ was partialled out (see Table 23). The correlation between the boys' Trails A scores and their Luria Memory scores also does not depend on the skills measured by VIQ but it does depend partially on the skills measured by PIQ which partially supports the first hypothesis (see Table 23). However, the correlation between the boys' Trails A scores and their Luria Reading scores indicates that the boys' Trails B scores also correlate significantly with verbal skills measured by the Luria. Thus, the boys' Trails A scores correlate directly and indirectly with both verbal and nonverbal skills measured by the WISC-R and the Luria.

The significant zero-order correlations associated with Trails B while partialling out WISC-R Scales are shown in Table 24. The girls' Trails B scores correlated significantly with the Luria Rhythm Scale. This correlation remained significant when PIQ was partialled out but became nonsignificant when VIQ was partialled out (see Table 24). Hence the correlation between the girls' Trails B scores and their Luria Rhythm scores depends partially on the skills measured by VIQ. Thus, the second hypothesis is supported since the girls' Trails B scores are both directly and indirectly related to verbal skills measured by the WISC-R and the Luria.

The boys' Trails B scores did not correlate significantly with the any of the Luria-Nebraska Scales.
Table 24
Correlations Between Trails B and the Luria Scales While Partialling Out WISC-R Scales

<table>
<thead>
<tr>
<th>Correlations with the Girls' Trails B Scores</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Trails B and Rhythm w/o VIQ</td>
<td>$r = -.75$</td>
</tr>
<tr>
<td>Trails B and Rhythm w/o PIQ</td>
<td>$r = -.80^*$</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Correlations with the Boys' Trails B Scores</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Trails B and Motor w/o VIQ</td>
<td>$r = .57^*$</td>
</tr>
</tbody>
</table>

Note. w/o = without.

*p < .05.
and none of the zero-order correlations became significant when VIQ was partialled out. However, when PIQ was partialled out, the previously nonsignificant correlation between the boys' Trails B scores and their Luria Motor scores became significant (see Table 24). Hence there is a significant relationship between the boys' Trails B scores and their Luria Motor scores when PIQ is partialled out. Although these results do not provide much information, results reported earlier indicate that the boys' Trails B scores correlate significantly with both verbal and nonverbal skills measured by the WISC-R and the Luria-Nebraska.

The significant zero-order correlations associated with the VMI while partialling out WISC-R Scales are shown in Table 25. The girls' VMI scores correlated significantly with the Luria Receptive Speech Scale and the Luria Intellectual Processes Scale. These correlations became nonsignificant when either VIQ or PIQ was partialled out (see Table 25). Hence the correlation between the girls' VMI scores and their Receptive Speech scores and the correlation between the girls' VMI scores and their Intellectual Processes scores are based partially on the skills measured by both VIQ and PIQ which are considered to be measurements of a general ability "G" factor. These results indicate that the girls' VMI scores are correlated significantly with both verbal and nonverbal skills.
Table 25

Correlations Between the VMI and WISC-R Scales While Partialling Out WISC-R Scales

<table>
<thead>
<tr>
<th></th>
<th>Girls' VMI Scores</th>
<th></th>
<th></th>
<th>Boys' VMI Scores</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>VMI and Rspeech w/o VIQ</td>
<td>r = -0.63</td>
<td>VMI and Rspeech w/o VIQ</td>
<td>r = -0.73**</td>
<td></td>
</tr>
<tr>
<td></td>
<td>VMI and Rspeech w/o PIQ</td>
<td>r = -0.42</td>
<td>VMI and Rspeech w/o PIQ</td>
<td>r = -0.81**</td>
<td></td>
</tr>
<tr>
<td></td>
<td>VMI and Int.Pro. w/o VIQ</td>
<td>r = -0.58</td>
<td>VMI and Int.Pro. w/o VIQ</td>
<td>r = -0.55*</td>
<td></td>
</tr>
<tr>
<td></td>
<td>VMI and Int.Pro. w/o PIQ</td>
<td>r = -0.42</td>
<td>VMI and Int.Pro. w/o PIQ</td>
<td>r = -0.66*</td>
<td></td>
</tr>
</tbody>
</table>

Note. w/o = without; Rspeech = the Luria Receptive Speech Scale; Int.Pro. = the Luria Intellectual Processes Scale.
* p < .05. ** p < .01.
measured by the WISC-R and the Luria.

The boys' VMI scores correlated with the Luria Receptive Speech Scale, the Luria Memory Scale, and the Luria Intellectual Processes Scale. Only the correlation between the boys' VMI scores and their Memory scores became nonsignificant when either VIQ and PIQ were partialled out (see Table 25). Once again the boys' VMI scores correlate significantly with both nonverbal and verbal skills measured by the WISC-R and the Luria.

Final Conclusions

As hypothesized, the girls' scores on Trails A and Trails B covary significantly (p < .05) with verbal factors measured by the WISC-R and the Luria-Nebraska. Their scores on Trails A covaried significantly (p < .05) with the verbal skills measured by VQ when the culturally loaded Comprehension subtest was removed from the VQ equation. The girls' Trails B scores covaried significantly (p < .05) with the verbal skills measured by both the Verbal IQ Scale and the Verbal Comprehension Quotient of the WISC-R. Even when the girls' Trail Making scores covaried with scales other than verbal scales, most of the correlations became nonsignificant (p > .05) when the verbal factors measured by either VQ or the Luria Receptive Speech Scale were partialled out.

The girls' VMI scores covaried with both verbal and
nonverbal skills measured by the WISC-R and the Luria (p < .05). Their VMI scores covaried significantly with the verbal skills measured by the Luria Receptive Speech Scale (p < .05). Their VMI scores also correlated with the Intellectual Processes Scale of the Luria (p < .05). Both of these zero-order correlations became nonsignificant (p > .05) when either VIQ or PIQ was partialled out which indicates that they are based partially on the verbal and nonverbal skills measured by VIQ and PIQ which are also known as "G".

The boys' scores on the three selected tests covaried significantly with both nonverbal visual-spatial skills and verbal skills measured by the WISC-R and the Luria-Nebraska (p < .05). The boys' Trails A scores correlated with both the Luria Reading Scale and the Luria Memory Scale (p < .05). The correlation between Trails A and the Luria Memory scale became nonsignificant when the Luria Visual Scale was partialled out (p > .05) which indicates that the correlation is partially based upon visual-spatial factors. The boys' Trails B scores correlated significantly (p < .05) with the Picture Arrangement subtest of the WISC-R and this correlation appears to depend upon both spatial and verbal skills. The boys' VMI scores were correlated significantly (p < .05) with the Luria Receptive Speech Scale, the Luria Memory Scale, and the Luria Intellectual Processes Scale. The correlation between the
boys' VMI scores and their Luria Memory scores became nonsignificant (p > .05) when the Luria Visual Scale was partialled out which indicates that this relationship is based partially on visual-spatial factors. Hence, the boys' scores on Trails A, Trails B, and the VMI are related both directly and indirectly to nonverbal and verbal skills measured by the WISC-R and the Luria-Nebraska.
DISCUSSION

The first hypothesis was partially supported. It stated that the girls' Trails A scores were expected to covary primarily with verbal skills measured by the WISC-R and the Luria-Nebraska, while the boys' Trails A scores were expected to covary primarily with nonverbal spatial skills on these same tests.

The girls' Trails A scores covaried with the verbal factors measured by VQ when the culturally loaded WISC-R Comprehension subtest was removed from the VQ equation. Their Trails A scores were also indirectly related to verbal factors since the correlations between their Trails A scores and their Picture Arrangement scores became nonsignificant when VQ was partialled out. The significant correlation between the girls' Trails A scores and their Luria Math scores also became nonsignificant when VQ was partialled out. Hence, the girls' Trails A scores were both directly and indirectly correlated with verbal skills measured by the WISC-R. In addition, the best predictors for the girls' Trails A scores were primarily verbal predictors which also supports the hypothesis regarding the girls' Trails A scores.

The boys' scores on Trails A did not directly covary
with nonverbal spatial skills, but they did covary indirectly with spatial measures. The significant correlation between their Trails A scores and their Luria Memory scores became nonsignificant when the visual-spatial components measured by the Luria-Nebraska Visual Scale were partialled out. Hence, in an indirect way, the boys' Trails A scores covaried with nonverbal spatial factors.

The boys' Trails A scores, however, also covaried significantly with the Luria Reading Scale. This relationship was not predicted by the first hypothesis and it remained significant even when the Luria Visual Scale was partialled out. The multiple regression analysis also indicated that the best predictor variables for the boys' Trails A scores consisted of both verbal and nonverbal predictor variables. Thus, it appears that the boys' Trails A scores are related, directly and indirectly, to both nonverbal spatial skills and verbal skills measured by the WISC-R and the Luria Nebraska.

The second hypothesis was partially supported. It stated that the girls' scores on Trails B would primarily covary with verbal skills measured by the WISC-R and the Luria-Nebraska, while the boys' Trails B scores would primarily covary with nonverbal spatial skills measured by these tests.

The girls' Trails B scores covaried significantly with verbal skills measured by the WISC-R Verbal IQ Scale and
Kaufman's Verbal Comprehension Quotient. These correlations support the hypothesis that the girls' Trails B scores would covary with verbal measures. In addition, the results from the multiple regression analysis also support the second hypothesis since the best predictors for the girls' Trails B performance were primarily verbal.

In support of the second hypothesis, the boys' Trails B scores were indirectly related to spatial components measured by the WISC-R. Their Trails B scores correlated significantly with their Picture Arrangement scores and this correlation became nonsignificant when the skills measured by the Luria Visual Scale were partialled out. Hence, the correlation between the boys' Trails B scores and their Picture Arrangement scores is partially based on the visual-spatial skills measured by the Luria Visual Scale. However, as with Trails A, the boys' scores on Trails B are also significantly related to verbal skills as indicated by the loss in significance of the correlation between the boys' Trails B scores and their Picture Arrangement scores when VQ was partialled out. Furthermore, the multiple regression analysis revealed that the best predictors for the boys' Trails B performance consist of both nonverbal and verbal predictor variables. Thus, as with Trails A, the boys' performance on Trails B is related to both nonverbal and verbal factors measured by the WISC-R and the Luria-Nebraska.
The third hypothesis was also partially supported. This hypothesis was nondirectional regarding the expected correlates of the girls' VMI scores. Hence, the girls' VMI scores could covary with either verbal or nonverbal spatial factors. The third hypothesis, however, was directional for the boys' VMI performance and it stated that their scores were expected to covary primarily with nonverbal spatial factors measured by the WISC-R and the Luria-Nebraska.

Although the girls' VMI scores did not significantly correlate with verbal skills measured by the WISC-R, they were significantly related to verbal skills measured by the Receptive Speech Scale of the Luria-Nebraska. The girls' VMI scores also correlated significantly with the Intellectual Processes Scale of the Luria. This correlation became nonsignificant when the Luria Receptive Speech Scale was partialled out which indicates that the relationship between the girls' VMI scores and their Intellectual Processes scores is based partially on verbal skills. Furthermore, the girls' VMI scores correlated significantly with their WISC-R Block Design scores which indicates that the girls' VMI scores also covary with the spatial skills measured by the Block Design subtest. Hence, the girls' VMI scores covaried significantly with both verbal and nonverbal spatial skills measured by the WISC-R and the Luria-Nebraska.
In support of the third hypothesis, the boys' VMI scores correlated with spatial factors measured by the WISC-R. Their scores correlated with the Block Design and the Object Assembly subtests. The relationship between the boys' VMI scores and their Object Assembly scores might, however, be partially based upon verbal components since the correlation became nonsignificant when VQ was partialled out. Furthermore, the boys' VMI scores were correlated significantly with verbal skills measured by the Luria Receptive Speech Scale which indicates, as with both Trails A and Trails B, that the boys' VMI scores are related to both verbal and nonverbal spatial skills measured by the WISC-R and the Luria.

Overall, the girls' scores on Trails A and Trails B were significantly related to verbal skills measured by the WISC-R and the Luria-Nebraska. Hence, the hypotheses regarding the girls' performances on Trails A and Trails B are supported. The girls' VMI scores correlated significantly with both verbal and nonverbal spatial skills measured by the WISC-R and the Luria.

The boys' scores on Trails A, Trails B, and the VMI correlated with nonverbal spatial skills measured by the WISC-R and the Luria-Nebraska which supports the hypotheses concerning the boys' performances. However, these results were primarily derived from the partial correlation analysis. The boys' scores on Trails A, Trails B, and the
VMI were also significantly related to verbal skills measured by the WISC-R and the Luria-Nebraska, which was not predicted by the three hypotheses. Hence, the boys' scores on Trails A, Trails B, and the VMI are related to both verbal and nonverbal spatial factors measured by the WISC-R and the Luria.

There are several possible explanations dealing with why the verbal correlates of the girls' scores on Trails A and Trails B were strong and measured through direct correlations while the predicted nonverbal spatial correlates of the boys' scores on Trails A and Trails B were weak and measured primarily through indirect partial correlations. One possible explanation is that the verbal superiority of girls between the ages of seven and eleven is stronger than the nonverbal spatial superiority of boys in this same age group. Perhaps there is a link between the early maturity of females and their verbal superiority in this age group. Waber (1976) has reported that the people, regardless of sex, who mature early tend to excel in verbal skills while those who mature later tend to excel in spatial skills. Since females generally mature faster than males, the verbal superiority often reported for females might be due to their maturation rate. Sherman (1978) has hypothesized that the early verbal advantage experienced by females leads them to prefer verbal approaches to problem solving throughout their lives.
Hence, girls between the ages of seven and eleven might have already established verbal strategies as their major problem-solving technique. These verbal problem-solving techniques might have been employed by the girls in the present study.

A second explanation why the nonverbal spatial correlates of the boys' scores were nonsignificant deals with the age when sex differences in spatial ability become well-established. Perhaps sex differences in spatial skills between the ages of seven and eleven are not very strong or very consistent. Maybe sex differences in spatial visualization ability are related to varying levels of sex hormones. According to Khan and Catio (1984), sex differences in spatial ability usually begin to appear around the age of nine or ten, which correlates with the period when the production of sex hormones is on the increase. As differences in hormonal levels of estrogen and androgen increase, sex differences in spatial visualization also become more apparent, with both reaching a peak around age 18. Hence, if sex differences in spatial ability are related to an increase in the production of sex hormones, they might not be strong enough to detect until after the age of nine or ten. It is also possible that sex differences on some visual-spatial tasks are not strong enough to detect until after puberty (Maccoby & Jacklin, 1974). Perhaps boys between the ages of seven and eleven
do not primarily employ spatial strategies to work through visual-spatial sequencing tasks. They might, instead, employ problem-solving strategies based upon a combination of nonverbal spatial skills and verbal skills to complete Trails A and Trails B.

Another possible reason why the correlations between the boys' scores on the Trail Making Tests and the nonverbal spatial scales were nonsignificant while the correlations between the girls' Trail Making Test scores and the verbal scales were significant deals with the actual scores of the boys and girls used in this study. First, the variability associated with the boys' and girls' Trails A scores was significantly different, while the variability associated with Trails B tended toward significance. Hence, the girls' Trail Making scores were more variable than were the boys' Trail Making scores. The boys' Trail Making scores might have been restricted so that an accurate measurement of the skills that correlate with the boys' scores was not obtained. A larger sample of boys' scores would be required to determine if the scores of the boys were actually restricted in range.

Furthermore, the small samples used in this study reduced the statistical power of the study. If the scores of more boys were used in the study, then a more accurate picture of the skills that significantly correlate with their scores on the three selected tests might have been
obtained. It should be noted, however, that the relationship between the girls' scores on the Trail Making Tests and verbal scales was extremely strong despite the small number of girls' scores. Hence, the relationship between verbal skills and the girls' scores on Trails A and Trails B is very, very strong.

The results regarding the VMI indicate that both the boys' and girls' VMI scores correlate significantly with both verbal and nonverbal spatial skills measured by the WISC-R and the Luria-Nebraska. Since the VMI requires more complex spatial-sequencing problem-solving strategies than either Trails A or Trails B, it may be too complex to be completed solely through reliance on one type of problem-solving skill. Hence, both verbal and nonverbal skills are probably needed to accomplish the spatial-sequencing needed to complete the VMI forms, and since Trails A and Trails B are not as complex as the VMI, girls might be able to complete them through primarily verbal problem-solving skills. Boys in this age group might tend to use a combination of nonverbal and verbal skills to solve spatial-sequencing tasks which would give them an advantage over girls on this type of task.

The implications of this study deal primarily with psychological testing since boys and girls might not be using the same cognitive skills to complete the sequencing on Trails A and Trails B. These tasks appear to be
measuring verbal problem-solving skills among girls and a combination of nonverbal and verbal problem-solving skills among boys. Hence, Trails A and Trails B do not appear to be measuring the same problem-solving skills used by boys and girls. The different problem-solving skills employed by boys and girls on these tasks may represent different information processing strategies used by the two groups on these type of sequencing tasks. Thus, the examiner that administers these tests might want to consider the gender of the test-taker before interpreting the results. A girl's low scores on the TMT might indicate that she has some verbal processing difficulties, while a boy's low scores might indicate he has more nonverbal spatial difficulties. Further research in this area is definitely warranted.

A similar study on the test scores of adults might provide more insight into sex differences on Trails A, Trails B, and the VMI. Sex differences in verbal and nonverbal proclivity might be better established among adults making the resulting correlations stronger and easier to interpret. In addition, the samples should be larger in order to increase the statistical power of the study and to increase the generalizability of the results. The performances of clinical and nonclinical groups on the selected tests could also be compared to determine if the two groups employ similar problem-solving strategies on
these tests. If the two groups employ similar strategies, the tests could then be administered to nonclinical populations to study their cognitive skills.
REFERENCES


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