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ABSTRACT

There is a growing awareness among researchers that the magnitude of cognitive sex differences is affected by a number of subject variables. To examine spatial and verbal cognitive sex differences as a function of personal and family handedness, the 478 offspring who participated in the Minnesota family study and 454 offspring who participated in the Texas family study were tested. Results from these studies are contrasted with those presented by Hyde (1981) in her reanalysis of studies reviewed by Maccoby and Jacklin (1974). In aggregate, the results from the studies reviewed, which range in number of subjects studied from 44 to 45,222, show that the approximate magnitude of sex difference in spatial abilities is a .50 standard deviation (SD); the approximate magnitude of sex difference in verbal abilities is .25 SD. Cognitive sex differences explain only a small proportion of the total variation among individuals; however, small mean sex differences are shown to generate large differences in the proportion of males to females at the tails of the distributions for spatial and verbal cognitive abilities. These results have practical implications for career counseling and the study of developmental reading disabilities. (Author/JAC)

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Cognitive Sex Differences and Their Practical Implications[1]

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Running Head: Cognitive Sex Differences

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Abstract

The magnitude of spatial and verbal cognitive sex differences is examined for 478 offspring who participated in the Minnesota family study and 454 offspring who participated in the Texas family study. Results from these studies are constrasted with those presented by Hyde (1981) in her reanalysis of studies reviewed by Maccoby and Jacklin (1974). In aggregate, the results from the studies reviewed which range in number of subjects studied from 44 to 45,222, show that the approximate magnitude of sex difference in spatial abilities is .50 SD; the approximate magnitude of sex difference in verbal abilities is .25 SD. Cognitive sex differences explain only a small proportion of the total variation among individuals; however, small mean sex differences are shown to generate large differences in the proportion of males to females at the tails of the distributions for spatial and verbal cognitive abilities. Practical implications of cognitive sex differences are discussed.

Cognitive Sex Differences and Their Practical Implications

Several investigators have recently shown that sex accounts for only a small proportion of the total variance in spatial and verbal test scores (e.g., Hyde, 1981; Plomin & Foch, 1981). There is growing awareness among investigators working in this area, however, that the magnitude of cognitive sex difference is affected by a number of subject variables, including age, handedness, familial handedness, and task-related variables, such as two-dimensional versus three-dimensional spatial tests. The purpose of this paper is to: (i) examine the magnitude of spatial and verbal cognitive sex differences as a function of personal and family handedness, and (ii) to outline practical implications of between-sex and within-sex differences in spatial and verbal test performance.

Methods

The Data

The data presented in this paper were obtained in two family studies involving nearly 1800 parents and offspring in over 450 families. Results from these studies will be contrasted with those from studies reviewed by Maccoby and Jacklin (1974) and reanalyzed by Hyde (1981).

Tests Administered in our Previous Family Studies

We have administered a variety of spatial and verbal tests to the members of participating families in two previous family studies. This paper focuses on the results obtained for the Mental Rotations Test and the Extended Range Vocabulary Test.

Spatial Abilities. The Mental Rotations Test consists of 20 items based on a set of drawings showing combinations of 10 blocks in various orientations used initially by Shepard and his associates at Stanford (e.g., Shepard & Metzler, 1971). These items have been adapted by Vandenberg for paper-and-pencil use (Vandenberg & Kuse, 1978). A practice item from this test is shown in Figure 1. The subject is required to determine which two of four alternatives show the

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Figure 1 about here

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same set of blocks as the stimulus item after the stimulus has been rotated in three-dimensional space. Correlations of the Mental Rotations Test with other cognitive measures have indicated strong association with tests of spatial abilities and virtually no association with tests of verbal ability.

Verbal Abilities. The Extended Range Vocabulary Test consists of 48 vocabulary items designed to measure verbal comprehension. This test is one of 72 cognitive tests available in the Educational Testing Service's Kit of Factor-Referenced Cognitive Tests (Ekstrom, French, & Harman, 1976). A practice item from this test is shown in Figure 2. The subject is required to determine

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Figure 2 about here

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which of five alternative words has the same meaning as the stimulus word. For parents and offspring (N = 1015) who participated in the Texas family study, the correlation between scores on the Mental Rotations and Extended Range Vocabulary Tests was r = .06.

Age Effects. Marked age effects on the Mental Rotations and Extended Range Vocabulary Tests were found in our previous studies. For example, among the 1015 participants in the Texas family study the correlation between age and scores on the Mental Rotations Test was $r = -.29$; the correlation between age and scores on the Extended Range Vocabulary Test was $r = .33$. For all analyses presented in this paper, test scores were age-adjusted. A z-score banding technique was used in which test scores were standardized within age groups, thereby eliminating both linear and non-linear differences among the groups. This banding technique has been shown to be comparable to using polynomial regression to regress out the effects of age (DeFries et al., 1979).

Hand Preference

In addition to measuring spatial and verbal abilities, we have measured hand preference in our previous studies using an adapted version of the Edinburgh Inventory (Oldfield, 1971) (see Figure 3). The inventory consists of 10 questions

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Figure 3 about here

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about which hand is habitually used in various activities (writing a letter, throwing a ball, holding a match, cutting with scissors, hammering a nail, brushing teeth, dealing cards, drawing pictures, holding a knife while slicing, and holding a fork while eating). In an unpublished study of 335 introductory psychology students at Texas A&M University we found the test-retest reliability of this inventory to be 0.92 after an interval of 3 weeks. A full discussion of retest reliabilities for the Edinburgh Inventory has been provided elsewhere (McMeekan & Lishman, 1975).

Family Demographics

Among the family demographics data obtained in our previous family studies are data which provide a measure of the family's socioeconomic status based upon the father's occupation and education. These variables are necessary in order to determine a family's social position using the two-factor Index of Social Position (ISP) scale developed by Hollingshead (1957). In the Minnesota family study, student volunteers in the age range from 17- to 21-years were found to be from families distributed rather uniformly across social class as measured by this scale. Among 269 student participants, 12% were from Social Class I (ISP scores ranging from 11-17), 22% were from Social Class II (ISP scores ranging from 18-27), 36% were from Social Class III (ISP scores ranging from 28-43), 24% were from Social Class IV (ISP scores ranging from 44-60), and 5% were from Social Class V (ISP scores ranging from 61-77). Lower ISP scores represent "higher" levels of attainment in both education and occupation. A similar distribution of ISP scores was found in the Texas family study.

Procedure

In each of our previous family studies, the same general methodological procedure was used for the purpose of obtaining family data. The experimenter met with small groups of student volunteers consisting of about 10 students each. The number of students per session was limited to permit questions about the study. Typically, volunteers were students enrolled in the introductory psychology course. Only students who had families living in the metropolitan vicinity where the study was conducted were recruited for participation.

During each testing session, the experimenter provided a brief description of the purpose of the study. Tests of specific cognitive abilities and hand preference were administered. Each student was then trained to administer the tests and a personal and family demographics questionnaire, given a set of written instructions, and asked to administer the questionnaire, the hand preference inventory, and the cognitive tests to all members of his or her family who were between 11 and 69 years of age. In addition to the tests and questionnaires, the booklet that students took home to administer to their family members included detailed typewritten instructions and an informed consent form that was signed by each participant in the project including the parents and siblings of the student volunteers. This procedure for involving introductory psychology students as "experimenters" has enabled us to obtain family data that are otherwise difficult to obtain.

Routine Reliability Checks on the Data Obtained

Critics of our method for obtaining family data may say that it is cheap and easy. We prefer to describe the method as inexpensive and unique. Training introductory psychology students to administer tests and questionnaries to their family members is an inexpensive way of collecting valuable family data. We have offered no monetary remuneration for participation. Also, this method provides a unique (or easy, if you prefer) way of collecting family data. A training session with the students is required. The purpose of this session is to test and train the student volunteers. The goals of training are to describe, discuss, and explain, in as much detail as necessary, the testing procedures to be used by the student experimenter when at home testing his or her family members. The students view themselves as experimenters and their family members as subjects. They derive intrinsic pleasure from playing the active experimenter role that is expected of them.

Our confidence in the family data that students return to us has increased in proportion to the number of reliability checks performed on the data obtained.

We have performed a variety of routine general as well as statistical reliability checks on the data returned to us by each participating student volunteer.

General Reliability Checks. Students are interviewed at the time family data are returned. This allows the experimenter to gain an impression of the student's involvement, commitment, and excitement in the project. Many students, when offered the opportunity, describe in detail the problems they encountered while testing in their homes, the fact that one or another family member was unable or unwilling to participate, and express sincere interest in finding out more about the study.

Students are asked during the interview about information concerning the data (e.g., missing data) that might affect the results. Typically, in consultation with the student, we conduct a visual inspection of the data for each family member. Attrition due to the return of incomplete family data and failure to return data has ranged between 7-15 percent in our previous family studies.

Statistical Reliability Checks. Several statistical reliability checks are routinely performed on the family data obtained. For the cognitive tests, age-standardized scores for student volunteers are compared with those obtained from family members. Since the tests were administered to the student volunteers under standardized time limits by the principal investigator, we expect the means within sexes and variances across sexes to be equal in the comparisons made. Also, the means and variances for the cognitive tests administered have been compared with published norms. In addition to these group comparisons, split-half reliability estimates have been obtained. Table 1

Table 1 about here

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provides descriptive statistics and reliabilities for the cognitive tests administered in the Texas family study. The Mental Rotations Test, on which the total possible score is 40 (there being two correct alternatives for each of 20 items), was administered in two parts, five minutes each. In over 1000 individuals in 250 families, the reliability estimate obtained from split-half administrations of this test was 0.83 (the same as that reported by Vandenberg & Kuse, 1978 in their normative sample). A sex difference favoring males on the Mental Rotations Test was highly significant ($P < 0.0001$). The Extended Range Vocabulary Test, on which the total possible score is 48, was also administered in two parts. Consistent with published recommended time limits, six minutes were allowed for each part (Ekstrom et al., 1976). The reliability estimate obtained from split-half administrations of this test to all participants in the Texas family study was .86. A sex difference favoring females was highly significant ($P < 0.005$).

In addition to reliability checks performed on the cognitive tests, we have made several statistical comparisons with hand preference data. Using the same measure of hand preference in two family studies has allowed us to compare incidence estimates of left hand preference obtained in each study. Also, we have compared our combined results with those from previous population studies, altogether encompassing 38,505 subjects in 8572 families (McGee & Cozad, 1980). Figure 4 shows a compilation of incidence figures of left hand preference

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Figure 4 about here

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among 20,231 offspring, by sex, from four mating types. Considering the means of combined offspring figures across studies for each mating type, a marked trend is seen. The incidence of left hand preference among offspring is lowest from families in which both parents are right handed (8.84%), intermediate from families in which mating for handedness is discordant, and highest (46.37%) from families in which both parents are left handed. This trend was found in each of five previous published population studies of human hand preference, and it was found in our studies in which family hand preference data were collected by student volunteers. Moreover, our results have been replicated recently with data collected in the Hawaii Family Study of Cognition (Ashton, 1982).

In addition to the general and statistical reliability checks described above, other statistical comparisons between our data and those reported for the same cognitive tests and hand preference inventory have been offered elsewhere (e.g., Bouchard & McGee, 1977; McGee, 1979a,1979b; McGee, 1982; McGee & Cozad, 1980).

Analyses

In order to facilitate comparisons of results from our studies with those presented by Hyde (1981), we have chosen to use the d statistic as an index of effect size. The d statistic provides a means for expressing the magnitude of differences between two groups in units of variability (Cohen, 1977). d is defined as the ratio of the difference between group means to the standard deviation of either group (since they are assumed equal). Thus:

$$d = \frac{M_1 - M_2}{SD}$$

In the present analyses, as in Hyde's review, the standard deviation was defined as the average of the standard deviations of the two groups compared, males and females.

When $d = 0$, there is 100% overlap in the distributions for the two groups studied; there is no difference between group means. When $d = .50$, there is 33%

nonoverlap in the distributions for the two groups studied. Effect sizes for mean differences between groups expressed by d can be converted to a point-biserial correlation following procedures recommended by Cohen (1977). The squared correlation, expressed as r^2, provides an estimate of the proportion of the total variance in the combined populations accounted for by population membership (e.g., male or female). In the results that follow, we illustrate the use of the d and r^2 statistics for examining the magnitude of sex differences for tests of two- and three-dimensional spatial abilities and for tests of verbal ability. We then outline practical implications of between-sex and within-sex differences in spatial and verbal cognitive test performance.

Results

Sex, Handedness, and Spatial and Verbal Cognitive Abilities

Here we shall examine the magnitude of spatial and verbal cognitive sex differences in the adolescents who participated in the Minnesota and Texas family studies and contrast our findings with those presented by Hyde (1981) in her reanalysis of studies reviewed by Maccoby and Jacklin (1974).

Magnitude of Sex Difference for Tests of Spatial Abilities. Table 2 shows the magnitude of sex difference for tests of two- and three-dimensional spatial

Table 2 about here

abilities. The magnitude of sex difference on the Mental Rotations Test between male and female offspring (N=478) who participated in the Minnesota family study was $d = .82$.

In the Texas family study, hand preference data collected from both parents and offspring allowed us to classify subjects into four handedness groups.

Right handed individuals without a family history of left handedness (RH-) and left handed individuals with a family history of left handedness (LH+) presumably represent the extremes of a continuum of handedness (Hardyck & Petrinovich, 1977; Hardyck, 1977). Intermediate between these two groups are right handers with a family history of left handedness (RH+) and left handers without a family history of left handedness (LH-). Family history of left handedness was operationally defined as having either one or two left handed parents, as determined by their scores on the Edinburgh Inventory. Further details concerning scoring procedures using this inventory are provided elsewhere (McGee & Cozad, 1980). The magnitude of difference on the Mental Rotations Test between male and female offspring (N=454) who participated in the Texas family study ranged from d = .50 to d = 1.13 among the four handedness groups studied. The magnitude of difference between males and females was larger for left handers than for right handers, and largest for left handers with a family history of left handedness (LH-). The observed sex difference in the LH+ group, which is over 1 SD in size, reflects upon the males in this group, who scored higher on the Mental Rotations Test than any of the other subgroups studied.

The d values obtained for the Mental Rotations Test in the Minnesota and Texas family studies are noticeably higher than those reported by Hyde (1981) in her reanalysis of 10 studies of visual-spatial ability from Maccoby and Jacklin's (1974) Table 3.7 and 20 studies of visual-analytic spatial ability from Maccoby and Jacklin's (1974) Table 3.8. There is an approximate .25 SD discrepancy between the median d values reported in previous studies and those found in our studies. One explanation for this discrepancy may be that the magnitude of sex difference is larger for three- than for two- dimensional tests of spatial abilities. In the Minnesota and Texas family studies, we used the Mental

Rotations Test, which requires three-dimensional spatial visualization and mental rotation. In the studies reanalyzed by Hyde (1981), d is the median value for a variety of both two- and three-dimensional tests of spatial abilities.

Magnitude of Sex Difference for Tests of Two-Dimensional Spatial Abilities. Are sex differences larger for three- than for two-dimensional tests of spatial abilities? In order to address this question, we examined the magnitude of sex difference for tests of two-dimensional spatial abilities administered in the Minnesota and Texas family studies. The results are shown in Table 3. For the Hidden Patterns Test, the magnitude of sex

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Table 3 about here

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difference found in the Minnesota sample (N=478) was d = .05. For the Minnesota Paper Form Board Test, the approximate magnitude of sex difference for four handedness groups examined in the Texas family study (N=454) was d = .00. Consistent with observations reported by other investigators (e.g., McGuinness, 1981), we found no evidence for sex differences on tests of two-dimensional spatial abilities.

Magnitude of Sex Difference for Tests of Verbal Abilities. The results for studies of verbal abilities are shown in Table 4. A difference favoring females

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Table 4 about here

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on the Extended Range Vocabulary Test administered in the Texas family study ranged from d = .06 for the LH+ group to d = .41 for the RH- group. Among the four handedness groups studied, the magnitude of difference between males and females was larger for right handers than for left handers, and largest for right handers without a family history of left handedness. The unweighted mean d value on the Extended Range Vocabulary Test for the four handedness groups studied in the Texas sample was d = .24, the same as the median d value for a variety of verbal tests administered in 27 studies reviewed by Maccoby and Jacklin (1974) and reanalyzed by Hyde (1981).

Discussion

Results from 32 studies, including the present family studies, showed that the approximate magnitude of sex difference in spatial abilities is .50 SD. Results from 28 studies, including the Texas family study, showed that the approximate magnitude of sex difference in verbal abilities is .25 SD. How shall we interpret these findings? There are at least two possible approaches to the interpretation of mean sex differences.

As mentioned previously, effect sizes for mean differences between groups expressed by d can be converted to a point-biserial correlation (Cohen, 1977). The squared correlation, expressed as r^2, provides an estimate of the proportion of the total variance in the combined populations accounted for by population membership (male or female). Table 5 shows the proportion of the total

Table 5 about here

variance in spatial and verbal test scores accounted for by sex differences. For spatial abilities, a sex difference of one-half of a standard deviation indicates that sex accounts for 5.9% of the total variance of spatial abilities. For verbal abilities, a sex difference of one-fourth of a standard deviation indicates that sex accounts for 1.5% of the total variance of verbal abilities. To echo the conclusions reached independently by Hyde (1981) and by Plomin and Foch (1981), mean sex differences in spatial and verbal abilities are small; they do not explain much variation among individuals.

Small mean sex differences, however, can generate large differences in the proportion of males to females at the tails of the distributions for spatial and verbal congitive abilities. As noted by Plomin and Foch (1981, p. 385): "... sex differences with substantial overlap between the sexes may be important at the extremes of the distribution." When viewed in this way, we believe that available knowledge concerning cognitive sex differences can become a tool for explaining unequal sex ratios in certain occupations and in certain populations that manifest atypical development of spatial or verbal skills.

Sex Differences in Spatial Abilities: Practical Implications

To illustrate the point that small mean differences generate large differences at the tails of distributions, Table 6 presents hypothetical male and

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Table 6 about here

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female score distributions for spatial test performance with means .50 SD apart. Also shown are proportions of males and females +2 SD above the combined population mean for varying values of d, with corresponding male : female ratios. Note that when d = 0, the proportion of males to females is equal and the male : female ratio is 1:1. When d = .50, as for spatial abilities measured by a variety of two- and three-dimensional spatial tests, the proportion of males +2 SD above the mean is 4.01%, whereas the proportion of females +2 SD above the mean is only 1.22%.

What are the practical implications of these findings? Can small mean sex differences in spatial abilities account for differences in male and female representation in certain occupations? The 3.29:1 ratio of males to females +2 SD above the mean implied by $\underline{d}$ = .50 cannot by itself account for the relative absence of women in certain job categories -- such as engineer, scientist, draftsman, designer -- that tend to require top level spatial abilities. If mean sex differences vary for different types of spatial abilities required in these job categories, as they appear to do in the case of two- versus three-dimensional spatial tasks, then the male : female ratio can become quite large. For $\underline{d}$ = 1.00, for example, the proportions of males and females +2 SD above the population mean are 6.68% and .62%, respectively. The resulting ratio of males to females is 10.77:1.

These results have practical implications for counselors. For instance, a female who wishes to enter a field requiring high-level spatial skills would need to obtain a very high score in relation to other females to be competitive with males her age. A female might need to score in the eightieth percentile, for example, in order to equal the seventieth percentile of males (McGee, 1979b).

Sex Differences in Verbal Abilities: Practical Implications

Of course, for verbal abilities the situation is reversed. Table 7 presents

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Table 7 about here

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hypothetical male and female score distributions for verbal test performance with means .25 SD apart. Also shown are proportions of males and females -2 SD below the combined population mean for varying values of $\underline{d}$, with corresponding male : female ratios. When $\underline{d}$ = .25, as for verbal abilities measured by a variety of verbal ability tests, the proportion of males -2 SD below the mean is about 3%, whereas the proportion of females -2 SD below the mean is only about 1.5%.

What are the practical implications of these findings? Can small mean sex differences in verbal abilities account for the unequal sex ratio in certain atypical populations, such as among those individuals with developmental reading disabilities? Incidence estimates for reading disability vary from study to study. Not surprisingly, the ratio of male to female disabled readers also varies across studies, but most investigators agree that the incidence of this disorder is higher among males than females. For example, in the estimates compiled by Finucci and Childs (1981), the male : female ratio ranges from 1.2:1 to 5.9:1. High estimates come exclusively from studies involving selected clinic or special school populations. The 1.81:1 ratio of males to females 2 SD below the mean implied by d = .25 for verbal abilities, however, is actually very close to the sex ratio for developmental reading disabilites observed in unselected school populations (for review, see Finucci & Childs, 1981).

Within-Sex Ability Profiles

One final illustration of how sex differences research might be viewed as a tool rather than as an end in itself is suggested by the comparison of ability profiles within sexes. When we compared spatial minus verbal difference scores for the male and female offspring who participated in the Texas family study, a clear picture emerged. Regardless of personal or family handedness, males, in general, showed higher spatial than verbal test performance. Females, in general, showed higher verbal than spatial test performance. These findings are

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Figure 5 about here

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shown in Figure 5. Note that positive spatial minus verbal (S-V) difference scores indicate higher spatial than verbal test scores, and negative difference scores indicate higher verbal than spatial tests scores.

Within-sex profiles of spatial and verbal abilities observed for normal adolescents are important to recognize in light of the ability profiles observed in persons with manifest deficits in specific areas of cognitive functioning. Consider Turner Syndrome and developmental reading disabilities as examples. Females with Turner Syndrome, which is associated with abnormalities of the sex chromosomes, are of normal intelligence and distributed throughout the intellectual range (Garron, 1977); however, they appear to have a characteristic pattern of abilities. Verbal abilities are normal, whereas spatial abilities are impaired (Alexander, Ehrhardt, & Money, 1966). The characteristic pattern of lower spatial than verbal test performance in females with Turner Syndrome, long regarded as a phenotypic expression of a genotypic anomaly, might more accurately be regarded as an expression, perhaps accentuated, of the sex-specific, verbal > spatial pattern of abilities found among females in general.

Developmental reading disability, on the other hand, is a predominantly male disorder. It is characterized by failure to learn to read despite conventional instruction and opportunity to learn. At least some reading disabled children appear to have normal or above average spatial abilities and impaired verbal abilities (for review, see Ansara, Geschwind, Galaburda, Albert, & Gartrell, 1981). The pattern of lower verbal than spatial test performance in males with reading disabilities might simply be regarded as an expression, perhaps accentuated, of the sex-specific, spatial > verbal pattern of abilities found among males in general.

Conclusions

Eleven conclusions are warranted.

1. Taken individually, each of the studies in the literature reviewed, including the Minnesota and Texas family studies, is subject to various types of criticism, ranging from statistical to methodological. Nonetheless, the results from population studies of cognitive sex differences provide a particularly consistent picture if one considers that the investigators had contrasting biases, used a variety of different types of spatial and verbal tests, and obtained data from samples which were unequal in size, age structure, and socioeconomic status.

2. In aggregate, the results from population studies, varying in number of subjects studied from 44 to 45,222, show that the approximate magnitude of sex difference in spatial abilities is .50 SD; the approximate magnitude of sex difference in verbal abilities is .25 SD.

3. The one-half of a standard deviation difference between males and females in spatial abilities indicates that sex accounts for 5.9% of the total variance of spatial abilities.

4. The one-fourth of a standard deviation difference between males and females in verbal abilities indicates that sex accounts for 1.5% of the total variance of verbal abilities.

5. Small mean sex differences can generate large differences in the proportion of males to females at the tails of the distributions for spatial and verbal cognitive abilities.

6. The proportions of males and females at the tails of the distributions for spatial and verbal abilities vary as a function of d, the magnitude of difference between two groups.

7. For spatial abilities, as d increases, the proportion of males to females +2 SD above the population mean increases, and the proportion of males to females -2 SD below the population mean decreases.

8. For verbal abilities, as d increases, the proportion of males to females +2 SD above the population mean decreases, and the proportion of males to females -2 SD below the population mean increases.

9. The magnitude of cognitive sex difference probably varies for different types of spatial and verbal abilities; for example, it appears to be larger for three-than two-dimensional spatial tests.

10. Regardless of personal or family handedness, males, in general, show higher spatial than verbal test performance. Females, in general, show higher verbal than spatial test performance.

11. Cognitive sex differences explain only a small proportion of the total variation among individuals; however, sex differences in spatial and verbal cognitive abilities have both theoretical and practical implications.

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Table 1

DESCRIPTIVE STATISTICS AND RELIABILITIES FOR COGNITIVE TESTS IN THE Texas FAMILY STUDY

Test	Total Possible	Test Time	N	Mean	SD	Split-half Reliability	Sex Difference P
Mental Rotations Test[a]	40	2 parts/ 5 minutes each part	1015	14.91	9.40	.831	M>F 0.0001
Extended Range Vocabulary Test[b]	48	2 parts/ 6 minutes each part	1015	25.45	8.16	.864	M<F 0.005

a. Vandenberg and Kuse (1978).

b. Ekstrom, French, and Harman (1976).

Table 2

MAGNITUDE OF SEX DIFFERENCES FOR TESTS OF TWO- AND THREE-DIMENSIONAL SPATIAL ABILITIES

Study	Description	Sample	Handedness Type	N	d*	Direction of Effect	Note
Hyde (1981)	Re-analysis of studies of visual-spatial ability from Maccoby & Jacklin's (1974) Table 3.7	Age range across studies: 11-39 N range across studies: 80-6167	-	-	.45	M > F	d is median value for a variety of 2-D and 3-D tests of spatial ability administered in 10 studies
	Re-analysis of studies of visual-analytic spatial ability from Maccoby & Jacklin's (1974) Table 3.8	Age range across studies: 12-80 N range across studies: 26-180	-	-	.51	M > F	d is median value for tests of field articulation (e.g., Rod & Frame Test) administered in 20 studies
McGee (1977)	Minnesota Family Study	Offspring (N=478)	-	-	.82	M > F	d value for 3-D Mental Rotations Test
Present Study	Texas Family Study	Offspring (N=454)	LH+	56	1.13	M > F	d values for 3-D Mental Rotations Test
			LH-	74	.63	M > F	
			RH+	91	.50	M > F	
			RH-	233	.54	M > F	
			Total	454	.70	M > F	d value is unweighted mean for four handedness groups in present study

$*d = \frac{M_1 - M_2}{SD}$ = Magnitude of difference between two groups

Table 3

MAGNITUDE OF SEX DIFFERENCE FOR TESTS OF TWO-DIMENSIONAL SPATIAL ABILITIES

Study	Description	Sample	Handedness Type	N	d	Direction of Effect	Note
McGee (1977)	Minnesota Family Study	Offspring (N=478)	-	-	.05	M > F	d value for 2-D Hidden Patterns Test
Present Study	Texas Family Study	Offspring (N=454)	LH+	56	.29	M > F	d values for 2-D Minnesota Paper Form Board Test
			LH-	74	.24	M < F	
			RH+	91	.03	M > F	
			RH-	233	.08	M < F	
			Total	454	.00	M = F	d value is unweighted mean for four handedness groups in present study

Table 4

MAGNITUDE OF SEX DIFFERENCES FOR TESTS OF VERBAL ABILITIES

Study	Description	Sample	Handedness Type	N	d	Direction of Effect	Note
Hyde (1981)	Re-analysis of studies of verbal abilities from Maccoby & Jacklin's (1974) Tables 3.3 and 3.4	Age range across studies: 11-64 N range across studies: 44-45222	-	-	.24	M < F	d is median value for a variety of verbal tests administered in 27 studies
Present Study	Texas Family Study	Offspring (N=454)	LH+	56	.06	M < F	d values for the Extended Range Vocabulary Test
			LH-	74	.24	M < F	
			RH+	91	.24	M < F	
			RH-	233	.41	M < F	
			Total	454	.24	M < F	d value is unweighted mean for four handedness groups in present study

Table 5

PROPORTION OF TOTAL VARIANCE IN SPATIAL AND VERBAL TEST SCORES ACCOUNTED FOR BY SEX DIFFERENCES

Ability	d Magnitude of Difference	r^2 Proportion of Variance
Spatial	.50 SD[a]	5.9%[c]
Verbal	.25 SD[b]	1.5%[c]

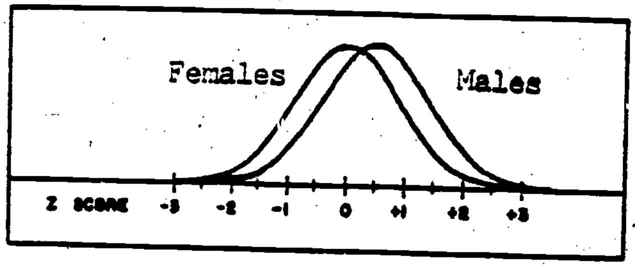
a. The approximate magnitude of the sex difference in spatial abilities is .50 SD.

b. The approximate magnitude of the sex difference in verbal abilities is .25 SD.

c. After Cohen (1977), p. 23, Table 2.2.1).

Table 6

HYPOTHETICAL SCORE DISTRIBUTIONS FOR SPATIAL TEST PERFORMANCE

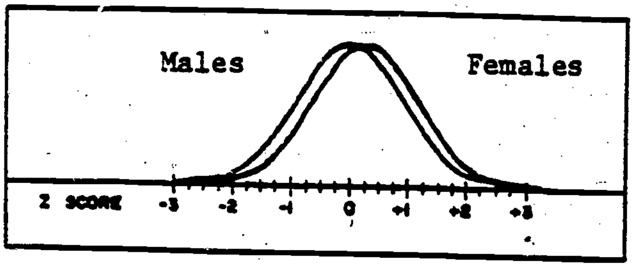


Proportion of males and females +2 SD above mean for varying values of d, with male : female ratios

d	Proportion Males	Proportion Females	Ratio Male : Female
d = .0	.0228	.0228	1:1
d = .1	.0256	.0202	1.27:1
d = .2	.0287	.0179	1.60:1
d = .3	.0322	.0158	2.04:1
d = .4	.0359	.0139	2.58:1
d = .5	.0401	.0122	3.29:1
d = .6	.0446	.0107	4.17:1
d = .7	.0495	.0094	5.27:1
d = .8	.0548	.0082	6.68:1
d = .9	.0606	.0071	8.54:1
d =1.0	.0668	.0062	10.77:1

Table 7

HYPOTHETICAL SCORE DISTRIBUTIONS FOR VERBAL TEST PERFORMANCE



Proportion of males and females -2 SD below mean for varying values of d, with male : female ratios

d	Proportion Males	Proportion Females	Ratio Male : Female
d = .0	.0228	.0228	1:1
d = .1	.0256	.0202	1.27:1
d = .2	.0287	.0179	1.60:1
d = .3	.0322	.0158	2.04:1
d = .4	.0359	.0139	2.58:1
d = .5	.0401	.0122	3.29:1
d = .6	.0446	.0107	4.17:1
d = .7	.0495	.0094	5.27:1
d = .8	.0548	.0082	6.68:1
d = .9	.0606	.0071	8.54:1
d =1.0	.0668	.0062	10.77:1

Figure Captions

Figure 1. Example item from the Mental Rotations Test.

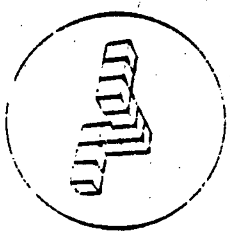
Figure 2. Example item from the Extended Range Vocabulary Test.

Figure 3. Adapted version of Edinburgh Inventory.

Figure 4. Incidence of left hand preference among 20,231 offspring, by sex, from four mating types (adapted from McGee & Cozad, 1980).

Figure 5. Age-standardized spatial minus verbal (S-V) difference scores for offspring (N = 454) who participated in the Texas family study.

P



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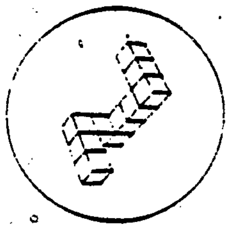

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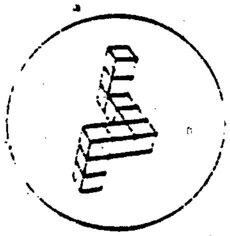

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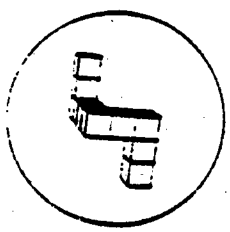

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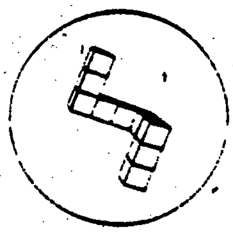


P

jovial

1 refreshing

2 scare

3 thickset

4 wise

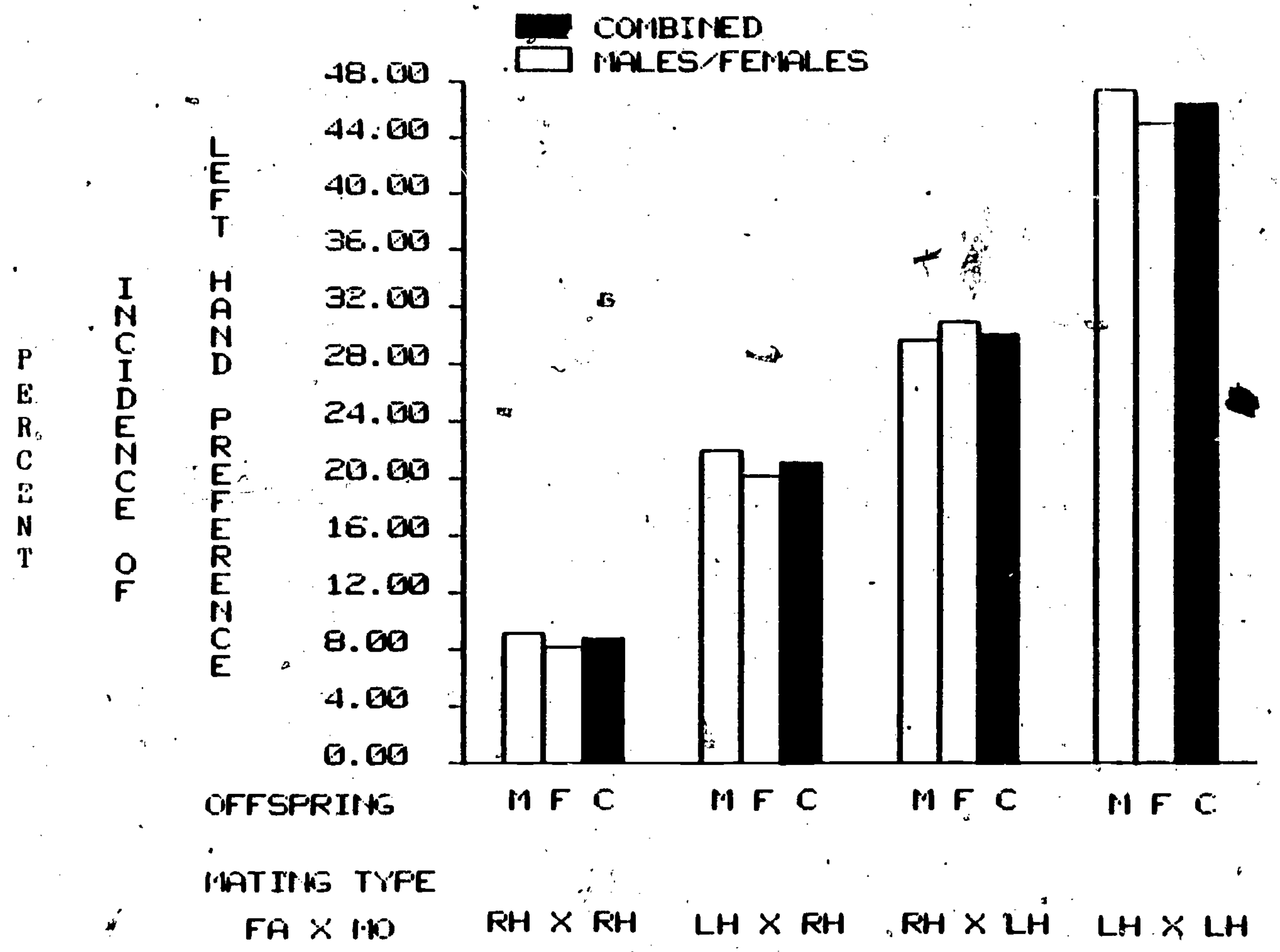
5 jolly

HAND PREFERENCE QUESTIONNAIRE

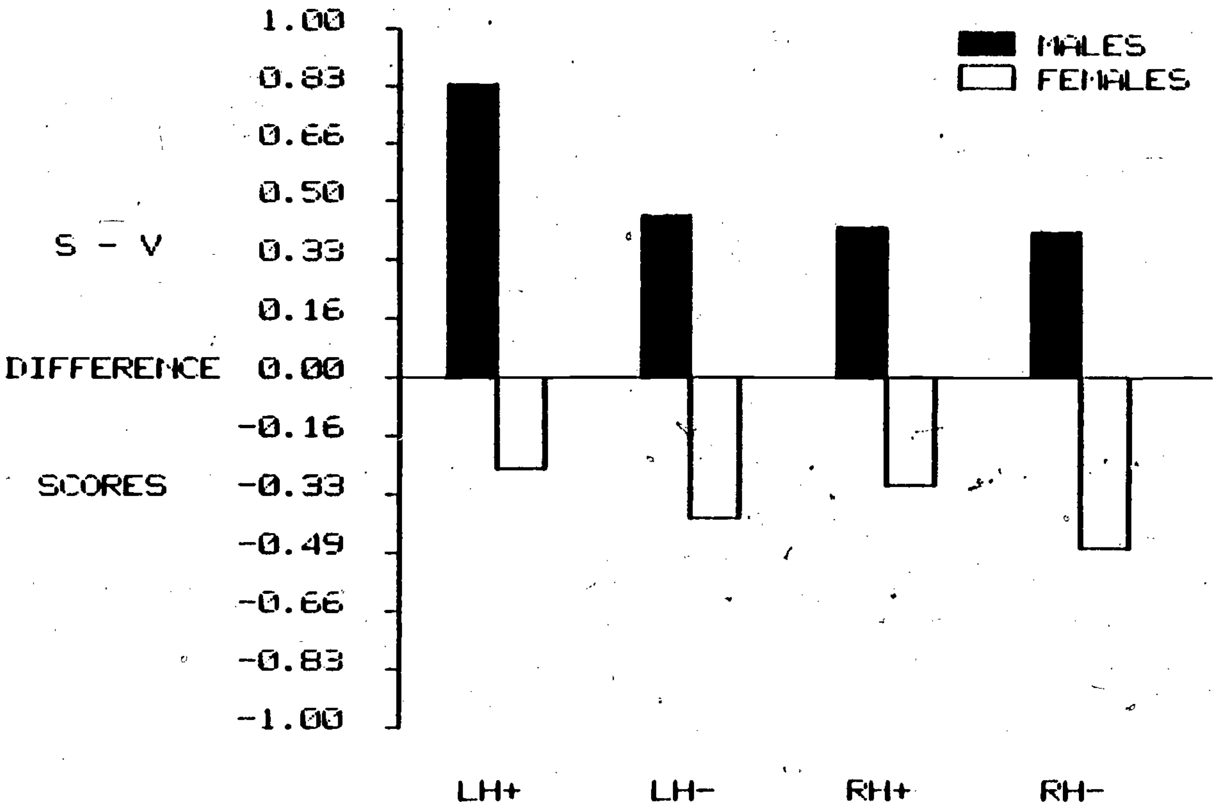
Name ______________________________ ID# ______________________

Please indicate which hand you habitually use for each of the following activities by placing an "X" in the appropriate space provided.

Which hand do you use when:	Right	Left	Either
1. Writing a letter?			
2. Throwing a ball?			
3. Holding a match while striking it?			
4. Cutting with a scissors?			
5. Hammering a nail?			
6. Holding a toothbrush while cleaning your teeth?			
7. Dealing playing cards?			
8. Drawing a picture?			
9. Holding a knife when slicing food?			
10. Holding a fork while eating?			



INCIDENCE OF LEFT HAND PREFERENCE AMONG 20,231 OFFSPRING, BY SEX, FROM FOUR MATING TYPES



NOTE: POSITIVE DIFFERENCE SCORES = SPATIAL > VERBAL.

NEGATIVE DIFFERENCE SCORES = VERBAL > SPATIAL.

OFFSPRING (N=454) WHO PARTICIPATED IN THE TEXAS FAMILY STUDY.