DOCUMENT RESUME

ED 063 545 CG 007 206

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TITLE	Sex Differences in Intellectual Abilities: A Reassessment and A Look At Some New Explanations.
INSTITUTION	Stanford Univ., Calif.
PUB DATE	Apr 72
NOTE	22p.; Paper presented at the American Educational Research Association, Chicago, Illinois, April 3-7, 1972
EDRS PRICE	MF-$0.65 HC-$3.29
DESCRIPTORS	Cognitive Development; Females; Individual Differences; *Intellectual Development; *Intelligence Differences; *Intelligence Factors; Males; *Sex (Characteristics); *Sex Differences; Thought Processes

ABSTRACT

The authors are emmersed in a comprehensive review of the literature on intellectual sex differences. This paper consists of the first progress report and the tentative hypotheses of the work completed so far. Discussion is initially concerned with verbal and spatial abilities. It is concluded that girls learn language earlier, and may continue to have a very small lead over boys. In spatial abilities, it has been found that by the fourth grade, boys begin to excel and that the sex difference increases in high school students. It is noted that there may be an artificial compression of the sex difference in which girls and an exaggeration of the difference where boys excel because of the differential dropout rate. New physiological hypotheses about sex different are also presented. Factors discussed are hormones, prenatal administration of sex hormones, cognitive style related to hormones, and brain lateralization. It is concluded that alternative explanations are different to separate, since the usual picture is that better infant care and less sex-role differentiation occur together. Suggested for further research are areas of self-esteem and sex differences spatial differences and analytical abilities, and differential sex-related reinforcement patterns. (BW)

AERA
April, 1972

Sex Differences in Intellectual Abilities: A Reassessment and a Look at Some New Explanations

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We must start by saying we were overly ambitious for the time we had to prepare this paper (and for the time I have to present it). We are still immersed in a comprehensive review of the literature on intellectual sex differences. You are going to receive the first progress report and the tentative hypotheses of our work so far.

Sex differences in intellectual functioning: a reassessment

Several reviewers have summarized the average differences of boys and girls on a variety of tests of intellectual functioning. (Sherman, 1971; Garai & Scheinfeld, 1968; Broverman, Klaiber, Kobayaski and Vogel, 1968; Maccoby, 1966; Anastasi, 1958; Terman and Tyler, 1954.) All the reviewers divide the test results into some categories of intellectual functioning, but the number and nature of these categories have been diverse. At one end of the spectrum, Broverman sees intellectual differences as falling into two opposite cognitive styles -- automatizers and non-automizers, with girls most often being automatizers. Others have more typically used 6 or 7 categories to fit the test data, with boys and girls excelling in different areas. Maccoby (1966) for example, used general intelligence, verbal ability, number ability, spatial ability, analytic ability, creativity, and achievement.

We disagree with some of the classifications of the data and some of the generalizations from them. We think that sex differences may have been overstated. Because studies showing differences are cited again and again, and studies showing no differences are ignored (and perhaps not published), one can easily get a lopsided view. Much recent work shows small or nonsignificant results in areas once considered clear examples of sex differences. One possible explanation is that sex differences have gotten smaller over the years. We will consider this hypothesis and others after we have looked at specific areas of intellectual abilities. One general problem should be kept in mind. There is still a differential dropout rate in our schools (Fitzsimmons et al., 1969), and this is a cross-cultural phenomenon (Cronbach & Drenth in press). Many more boys drop out of grammar and high schools than girls. And the boys drop out earlier than girls. Test samples then compare a heterogenous sample of girls with an increasingly homogenous and brighter sample of boys. It is a difficult problem to work around. Researchers, even in long term longitudinal studies (Lohnes, 1966) have tended to ignore it. This problem may have the effect of exaggerating some sex differences, particularly those where boys excel, and either minimizing differences in areaswhen girls excel or cancelling out differences in favor of girls that actually exist.

Verbal abilities

McCarthy (1954) and others (e.g., Kagan, 1969) have found that girls talk earlier, utter sentences earlier, and use a greater number of words earlier. Girls say longer sentences and continue to do so. Mead (1953) found these same differences cross-culturally. Girls learn language earlier. But other differences in verbal abilities are not as clear. In 1954 McCarthy summarized 64 experiments on children's language abilities. She stressed that only slight differences existed between the sexes, but did conclude that girls maintain an edge over boys in fluency. Templin (1957) looked at many aspects of children's language from ages three to eight, and concluded that sex differences were very small, but when they did exist they favored girls. More recently in compiling the ITPA norms, McCarthy & Kirk (1963) found very few statistically significant sex differences in a large sample of children from age two to nine years. The differences were so small that the scores of the boys and girls were combined for norming.

One study done in Sweden (Sevensson, 1971) did find consistent sex differences in verbal abilities in favor of girls. 13 year old children were tested in 1961 and 1966 in different types of schools across all socio-economic groups. Neither school, nor SE group accounted for as much variance as did sex. Sweden may not have a differential dropout rate.

Brimer (1969) presents evidence that the method of measuring language ability may be biased in favor of the more fluent girls. Using picture vocabulary tests and pointing responses, he finds sex differences in favor of boys from age 5-8. Sex differences in verbal ability might be better understood by dividing active (productive) language from passive (reactive) language. Girls may excel at production and that difference could cloud equality in other abilities. There is evidence against this hypothesis in the ITPA norms. Using a procedure like Birmer's, McCarthy & Kirk got significant differences in favor of girls. However we do not want to close the door on the active-passive distinction just yet. We would be interested in hearing about any data that might pertain to it.

In summary, girls learn language earlier, but boys do catch up in most verbal tasks. Slight differences, if they are found, do seem to favor girls.

Spatial abilities

There is considerable evidence that the sexes do differ on spatial abilities. Although male superiority is not consistently found (see Sherman, 1971, for a review) and sex differences are not found in young children (Kagan found no differences in 2 and 2 1/2 year olds, 1969) or senior citizens (Schwartz & Karp, 1969) we have yet to find a study in which girls are superior. Differences start to appear in 9 and 10 year olds (Keogh, 1970) and differences get larger in high school age subjects (e.g. Project Talent). The greatest differences may be between 20-30 years of age (Berry, 1966).

Exactly what a spatial task is and what its parameters are is not well defined. The most common tests used to measure spatial ability are the Rod and Frame test (FRT), Embedded figures test (EFT), some variation of a block design test, or match-to-sample drawings.

Boys' superiority in spatial ability may be restricted to visual-spatial ability (Werdelin, 1961; Witkin, et al.,1954). Tests of auditory spatial localization, and haptic pattern tracing do not show sex differences. On the other hand, walking a visual pattern seems to show larger sex differences in 3rd and 4th grades than copying patterns (Keogh, 1970).

There are sex differences in spatial abilities. But the question of exactly what spatial abilities are is not yet answered. The Block design test, EFT, and RFT seem to be measuring partly the same thing, and their scores are correlated. But other test results also correlate with the spatial scores. Sherman argues (1967) that many tests of mathematical and analytic ability involve spatial abilities and are therefore sex biased.

When analytic abilities and spatial abilities are measured independently, sex differences occur primarily in the spatial, not the analytic tasks, That is, as Sherman (1967) demonstrates, spatial tasks that do not include any analytic component show large sex differences (e.g., Flag test), and tests of analytic ability that do not include spatial tasks do not show sex differences. We agree with Sherman's conclusion that sex differences in spatial ability have been overgeneralized to analytic abilities.

Creativity has been measured in very different ways. The particular method of measurement seems to predict the sex differences that are found. If the test of creativity is a test of set breaking it usually involves spatial perception, and the results are consistent with what is known about spatial perception -- boys are better than girls. When the tests involve verbal abilities, as these of divergent thinking-convergent thinking do, girls and women do better (Torrance & Aliotii, 1969). We seem to have no measure of creativity independent of the two known abilities of the two sexes. Thus, little information seems to be related to creativity itself, the variance in score may be accounted for by verbal fluency and/or spatial abilities.

How much of the differences in spatial abilities are learned or trainable is another issue. Similarly it is still an open question as to how much of the speech and reading deficits suffered mainly by boys are retrainable. Girls do respond to training in spatial abilities - perhaps more than boys do, suggesting an earlier lack of training (Kato, 1965; Goldstein and Chance, 1965). Some earlier studies, giving fewer practice trials, did not show this change (Elliott & McMichael, 1963; Wolf, 1965). We do not know of comparable studies showing improvement of boys in verbal abilities, but we would assume that could be done. There is probably a large trainable component, in both verbal and spatial abilities, but it may interact with a large genetic component as well. We'll have something to say about the genetic component later.

Interesting cross-cultural differences have been found using many different kinds of spatial tasks. Berry (1966) found no sex differences in spatial tasks (discrimination tests using closure) in Eskimos. MacArthur (1967) replicated this finding with two other populations of Western Eskimos using the EFT. Berry argues this lack of sex differences in the Eskimo stems from the independence of Eskimo girls and women. Berry has found the usual sex differences in cultures where women are dependent (Temne of Sierra Leone, Scotland). One study done in Kenya (Munroe and Munroe, 1971) found a relationship between performance on a block design copying task and independence. The measure of independence was the distance away from home the subjects were observed during their free time. Subjects observed further from home were significantly better on the block-building task. A cross-sub-cultural study on different types of schools in the United States (Minuchin et al., 1969) may also be studying independence and spatial ability. Measures of picture arrangement increased significantly from more traditional to more contemporary schools in girls, but scores in block design did not change. In contemporary schools where one would expect more emphasis on independence, the girls' scores were higher. It would seem, then, that sex-differences in spatial abilities are at least partly a function of the cultural milieu in which the two sexes are reared.

Summary

Girls learn language earlier, and may continue to have a very small lead over boys. In spatial abilities, by the fourth grade boys begin to excel and the sex difference increases in high school students. As noted earlier, we may have an artifical compression of the sex difference in which girls excel and an exaggeration of the difference where boys excel because of the differential dropout rate.

New physiological hypothesis about sex differences

Hormones

The role of hormones in intellectual functioning is a new area of investigation. More and more is known about hormonal effects on behavior, and just as importantly on behavior affecting hormones. The fact that hormones can be changed by experience (Levine, 1969; Denenberg, 1970, 1969) modifies the "innate" character of the findings we will discuss. Early experience clearly changes adult hormone levels in sub-human animals. If intellectual functions are correlated with hormones, we cannot conclude that sex differences in intellectual functioning are innate. On the other hand, hormonal effects on intellectual function would at least be consistent with the hypothesis that there is a genetic mechanism for individual differences and sex differences in intellectual abilities.

Prenatal administration of sex hormones in humans

A study by Dalton (1968) involved prenatal use of progesterone in treatment of toxemias of pregnancy. It is an experimental study. This is noteworthy since most studies in this area are clinical studies with large sampling problems. Dalton, however, had two control groups. In this study, out of 59 monitored pregnancies where toxemia occurred, 30 mothers were given progesterone, 29 were not; in addition there were 21 normal controls in which no toxemia developed. Progesterone children (both boys and girls) received significantly more "above average" grades than either the normal or toxemic controls (significant differences for all academic subjects and arithmetic). no significant differences in physical education.) Moreover, Dalton was able to divide the progesterone children into high and low dosage groups (mothers who received more or less than 8 grams during pregnancy) and she found a progressive decrease in attainments from "high dosage" to "low [illegible] to controls. Furthermore, children whose mothers received progesterone before the 16th week of pregnancy showed significantly more "above average grades" than children whose mothers received progesterone after the 16th week. Unfortunately the findings were not analyzed by sex of child, so we do not know whether progesterone has more effect on male or female children.

Ehrhardt and Money (1967) report on 10 female subjects whose mothers were given a synthetic hormone, progestin during pregnancy which had an androgenic effect and masculinized these subjects. The girls were tested with standard tests and their average I.Q. score, 125, is said to be significantly different from 100, the mean of the general population. The general population is probably not the appropriate comparison group. The education levels for the parents, reported by the authors, is much higher than would be expected in the general population. In the sample of 9 fathers, 6/9 either completed college or had a post-graduate degree. In the general population, 15% of white males, 25 years and over, have finished four years or more of college. We know that the education of parents is related to I.Q., and 125 would appear to be a reasonable level to expect from an untreated group of children from families with this education level. Perhaps the sampling bias toward better education may be due to the fact that all of these cases come from women whose pregnancies were monitered for miscarriage, probably not a random sample of the population.

We cannot conclude that male or female hormones increase intellectual performance differentially. No study has yet compared the effects of male and female hormones, upon male and female children, in one design. The evidence is that progesterone increased intellectual performance in both boys and girls, and that in a small masculinized sample of girls synthetic progestin may have raised I.Q. Unfortunately we do not have any work on the prenatal effects of androgen on the intellectual abilities of boys. In any case, it would be important to know if specific hormones were related especially closely to spatial or verbal abilities. Overall I.Q. measures are not especially useful.

Hormones and Cognitive Style

Broverman and his colleagues (1964, 1968, 1971) have developed a theory of "automatizing" ability and its relation to sex hormones. Automatizing is the label for a general cognative style which involves excellence in simple, overlearned, perceptual-motor tasks. Non automatizers are said to be able to solve complex learning problems because they can inhibit well learned responses, delay responses, and reverse usual habits. The physiological mechanisms hypothesized to account for these differences are complex and will not be discussed here. In general, both estrogens and androgens are said to increase automatizing abilities. Estrogens are stronger increasers of automatizing abilities than androgens. Therefore the most masculine males will approach the behavior of females.

The psychological evidence for the automatizing cognitive style is based on a battery of tests given to male and female twins (1964) and the factor analysis of these tests. The 1968 paper is the best summary of the psychological evidence for automatizing. The main difficulty is that direct tests of the automatizing ability are not usually given. Rather, inferences are drawn from related tests. Whether these tests are in fact measures of automatizing (or the lack of it) is questionable. For example, language is listed as a simple repetitive task on which girls excel. However the acquisition of language can hardly be considered simple, or repetive when considering the number of novel sentences young children produce. In learning of language girls do excel boys. Boys are said to be able to delay and inhibit behavior, but the tests are not direct tests of delay. Other evidence, not cited by Broverman, indicated either no sex difference (Maccoby, 1966;Kagan et al., 1964) or that boys have more difficulty delaying or inhibiting impulsive behavior. But Broverman asks us to infer from mirror tracing, maze performance and temporal judgment tests that delay and inhibition of behavior is stronger in boys, but of course, mirror tests and mazes have a strong spatial development and recent evidence exists that the females have better time perspectives (Platt et al., 1969).

Broverman gives correlational and experimental evidence that males higher in testoserone are better at simple subtraction problems. And in a well controlled experiment with injections of testosterone or saline solution, males receiving testosterone were better at subtracting numbers than a control. Unfortunately no evidence is given to show that this increase in subtraction was not a general arousal effect and we do not know whether this group would be better or worse at complex problem solving or delay or inhibiting problems. And we do not know as yet if estrogens would have raised their abilities to subtract more <u>or</u> lower their abilities to inhibit more than testosterone.

Much more work needs to be done before conclusions can be drawn as to the nature of the influence of hormones on these abilities, and if these abilities are indeed a cognitive style mutually exclusive of another cognitive style.

<u>Brain lateralization</u>

Knox and Kimura (1970) have reviewed the evidence, and concluded that brain lateralization occurs earliest in girls. This may be either a cause or a result of earlier speech development in girls. There seem to be socio-economic class differences in onset of lateralization, but even in slower onset of lateralization in lower socio-economic classes, girls still lateralize before boys. Speech, language and calculation are clearly connected to the dominant hemisphere. Girls develop this dominance earlier. (Kimura, 1967)

What is not quite as clear are the functions of the non-dominant hemisphere and how the functions of this "minor" hemisphere are affected by early lateralization. Sperry and Levy (1970) argue a case for weaker development of the minor hemisphere in girls, because of the early lateralization. This would account for the superiority of speech and language in girls and the corresponding deficit in spatial abilities. Spatial abilities seem to be controlled by the minor hemisphere. The relevant data are taken from the "split brain preparations" of epileptic patients and by other experimental procedures differentially tapping the two hemispheres (dicotic listening, tasistoscopic presentation to one visual field).

In the split brain subjects, each hemisphere can be taught a problem separately, and although the minor hemisphere is mute, many tasks can be tested exclusively in that hemisphere with pointing responses (Levy-Argesti & Sperry, 1968). The minor hemisphere has been found to be superior in spatial abilities, particularly copying geometric figures, drawing spatial representations, and in the assembling of Kohs blocks in block design tests. Moreover these researchers have found a very different method of problem solving of the same problem in the two hemispheres of the same subject. "The left (dominant) hemisphere tried to solve the problem by means of verbal-symbolic analysis, the right (monor) hemisphere utilized simple visualization. The major hemisphere seemed to be unable to break away from the verbal-analytic mode. We were therefore led to the idea that a hemisphere which is capable of expressing itself in language does not merely have the capability of symbolic-analytic reasoning, but is, in fact, constrained to use such reasoning. Such a hemisphere thinks in terms of symbolic and not visual relationships... there are two modes of information processing, each specific to a given hemisphere...these modes are mutually antagonistic." (Sperry and Levy, 1970).

There are two problems to consider here: (1) does the earlier development of lateralization preclude (or at least hamper) the development of spatial abilities and (2) are those two abilities mutually antagonistic?

We don't believe the abilities are antagonistic. Both verbal and spatial abilities increase throughout at least our early lifetime. In boys of high school age changes in verbal abilities are about as great as they are in girls, while during that same period larger gains in spatial abilities are made by boys than girls. The two modes do not seem antagonistic, changes in one area do not preclude changes in the other. Beyond these overall developmental trends, we simply do not have evidence on the developmental shutoff of one hemisphere by the development of the other.

The brain lateralization information is a new area of investigation. Unfortunately many studies do not use both sexes and much work needs to be done. Nonetheless it is a very provocative area.

Thus, when it comes to a search for biological factors that may be associated with the intellectual characteristics of the two sexes, we find ourselves coming out by that same door wherin we went. We do not find the data sufficient to substantiate the effects of either of the two main presumed causative agents: sex hormones or brain lateralization. We do believe that physiological factors of this kind <u>may</u> turn out to be involved, but perhaps not in a way that directly links intellectual performance to the mean difference between the sexes. For example, we have already noted that either sex may perform better under elevated levels of either male or female hormones -- a fact which would do more to explain <u>within</u> sex differences than <u>between</u> sex differences.

Why are we all so interested in physiological factors? Presumably, because such factors may help to determine the response of a child to educational experiences. There is always the possibility that different kinds of educational practices will succeed better with particular kinds of children, although it is our understanding that the efforts to design curricula specifically for children with particular patterns of abilities have proved disappointing. Still, the problem continues to be important.

Cultural hypotheses about intellectual sex differences.

We have examined intellectual sex differences and we have found that girls learn language earlier and may maintain a slight edge in verbal abilities. Boys start to excel in spatial abilities as early as the 3rd grade, and the difference between the sexes continues to widen through high school. Mathematical abilities are at least in part related to spatial abilities and sex differences in mathematical abilities start at about the 5th grade and widen through junior and senior high school.

We have examined the physiological explanations given for these differences. At this time they can neither be fully supported or refuted. We cannot yet identify physiological factors that might make a difference in the abilities of boys and girls to develop certain intellectual skills.

What about evidence for differential shaping by socialization agents? There is some evidence that female teachers may encourage boys more than girls, usually in the process of trying to "feminize" them -- e.g., trying to make them more tractable and well behaved and interested in such "female" things as art and music (Fagot and Patterson, 1969; Sears and Feldman, 1966). Also there is some evidence that the two sexes may respond to different kinds of reinforcement (Bergan et al., 1971). However there is no evidence whatever that teachers reinforce boys for spatial (or mathematical) performance and girls for verbal performance. And we have no evidence of differential shaping for particular abilities by the parents.

If the differences are to be traced to social influences, the influences probably are not of this direct "shaping" sort. We have reviewed some cross-cultural evidence that there are aspects of the treatment of the two sexes that may be related to differential intellectual abilities, but again we doubt that these are direct shaping.

We are looking for evidence as to whether the amount of sex-role differentiation (within or between cultures, or changes over time) is related to the degree of intellectual sex differences. As to changes in sex role differentiation over time, we are attempting to determine whether the sexes have been growing more alike in intellectual abilities over the past 30 years (in the U.S.). If differences are getting smaller in this country (and if differences are generally greater in underdeveloped countries than in advanced ones) the reasons may be that (1) sex differences in intellectual abilities are a function of the degree of sex-typing (and sex-role differentation) imposed on children, or (2) sex differences are a function of the quality of prenatal and infant care. Male fetuses are more susceptible to miscarriages and birth defects. Better care prenatally and at birth would mean that on the average the boys would be less handicapped in early development and eventual attainment.

These alternative explanations are difficult to separate, since the usual picture is that better infant care and less sex-role differentiation occur together. However in the instances where boys normally excel girls (spatial factors and possibly math) if sex differences diminish at times and places where sex role differentiation is also diminshing, we probably have good evidence for social shaping. Sweden may be an example. It is a country with low infant mortality and high emphasis on equality between the sexes. Mathematical ability in Sweden (Svensson, 1971) does not show the clear sex differences it does in U.S. samples (Hilton & Berglund, 1971). We have insufficient evidence here and would like to be guided to more!

We are still placing our bets that there are intervening processes (other than direct reinforcement of specific abilities, and other than whatever biological factors may exist) which influence the amount of sex difference one finds in a cultural group. We've considered self esteem as that intervening variable.

The sex differences in self esteem are mixed. Boys are more satisfied with themselves as early as age 8 and 9 (Minuchin, et al., 1969) and there continues to be a sex difference in self esteem in elementary school (Sears, 1964), high school and college (Horner, 1972). But in primary school age children both sexes are still committed to the virtues of their own sex. Boys list strength, competence and having more interesting things to play with as advantages of being a boy, while girls say that girls are nicer, better behaved and get to wear pretty clothes. (Minuchin et al., 1969). There is strong reason to believe that a child's self-esteem matters in his school performance -- that it may indeed be the primary element in his motivation to work and try to achieve -- there is no reason why the self-esteem patterns that have been identified so far in either of the sexes at primary-school age should interfere with the school performance of either boys or girls. The situation may be somewhat different after adolescence, when the "fear of success" that Matina Horner has so well identified begins to emerge in girls. But even given differences in self-esteem, it is not clear why spatial and mathematical, but not verbal abilities are affected. The intervening process we are after to explain intellectual sex differences is probably not simply self-esteem.

Independence training is our best candidate so far for as a process mediating sex differences in spatial abilities. As we noted earlier there are cross-cultural indications that independence is related to higher performance on space tasks, both between cultures and within a culture. The Eskimos studied by Berry (on a wide variety of spatial tasks) and MacArthur had no sex differences in spatial abilities. These researchers believed the Eskimo women to be independent. Within a culture (Kenya) the Munroes found that children who are the most independent are best on spatial tasks. Particularly important in this study was the objective measure of independence. Obviously we need more evidence of the performance of men and women (and boys and girls) growing up in widely disparate degrees of sex role differentation.

We wish we could end with a list of do's and don't's for educational practices. But as you have seen, the state of the art will not allow it. All we can do is summarize some do's and don't for educational research. Don't forget to control for differential dropout rates by boys and girls. This factor may be biasing most of the research. Do's for educational research are the many areas that need more work: self-esteem and its within-sex effects on abilities and achievement; spatial abilities and their differences and similarities to mathematical and analytic abilities; differential reinforcement patterns and the within-sex effects of different kinds of reinforcement.

Finally, please send us any information on sex differences, negative or positive, you find in your work. Then the next time we review intellectual sex differences, we may be a little closer to the truth.

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