HUMAN INTELLIGENCE: SEX DIFFERENCES

LISSY F. JARVIK*

Psychogenetics Unit, Veterans Administration Hospital, Brentwood/Los Angeles; and University of California, Los Angeles, California, USA

An extensive review of the literature on sex differences in human intelligence leads to the conclusion that there is strong evidence for sex differences in processing both verbal and spatial information. The few genetic studies that there are all point toward a sex-linked mode of inheritance of certain spatial abilities.

The title " Human Intelligence: Sex Differences " is deceptively simple. After all, which one of us does not have knowledge in this area? But then, Bertrand Russell (1927) warned us half a century ago that:

> What passes for knowledge in ordinary life suffers from three defects: it is cocksure, vague and self-contradictory. The first step towards philosophy consists in becoming aware of these defects, not in order to rest content with a lazy scepticism, but in order to substitute an amended kind of knowledge which shall be tentative, precise, and self-consistent. (pp. 1-2).

But details are not the concern of philosophy; to gather facts is rather, " the business of science. " (Ibid.)

In preparing this report I have tried to adhere to Bertrand Russell's charge and to gather facts from the literature, specifically those facts which bear on sex differences in intellectual functioning.

My own interest in this topic goes back to the 1940s. As part of a long-term study of aging — initiated by the late Franz Kallmann at the New York State Psychiatric Institute, Columbia University — I became involved in the longitudinal assessment of intellectual functioning in twins (Kallmann and Sander 1949, Jarvik et al. 1957 and 1971, Jarvik 1963, Jarvik and Falek 1963, Blum et al. 1970 and 1973, Blum and Jarvik 1974).

SEX AND INTELLECTUAL FUNCTIONING IN THE ELDERLY

At the time of first testing, the twins ranged in age from 60 to over 90 years and all lived in the community rather than in an institution. In this group the mean scores of women exceeded those of men on nearly all subtests administered: Vocabulary List I of the 1916 Stanford-

* The generous assistance of Sheila Chadwick and Lew Bank in preparation of the manuscript is hereby gratefully acknowledged.

Acta Genet. Med. Gemellol. (1975), 24: 189-211

https://doi.org/10.1017/S1120962300790263 Published online by Cambridge University Press

Binet (Terman 1916), three of the five subtests of the Wechsler-Bellevue (Similarities, Digit Symbol Substitution, Block Design — Wechsler 1944), Directions (Price 1933*a*, 1933*b*), Reproduction of Designs (Cornell and Coxe 1934), and a simple paper-and-pencil Tapping Test (Feingold 1950). It was only on Digits Forward and Digits Backward (which together constitute Wechsler's Digit Span Test) that men scored higher than women, and the differences between the sexes were not statistically significant. By contrast, women obtained significantly higher scores than men on tests measuring immediate recall of unfamiliar verbal and visual material (Directions and Reproduction of Designs tests), visual-motor coordination (Tapping Test) and on two performance tests correlating highly with general intelligence (Digit Symbol Substitution and Block Designs tests).

Since women have a longer lifespan than men, it seemed natural to ascribe their higher test scores to differential rates of aging. Subsequently, the first intelligence test with norms for the age group above 60 appeared, the Wechsler Adult Intelligence Scale, or WAIS, and it did *not* show statistically significant sex differences in IQs for persons more than 60 years old (Wechsler 1958). Indeed, the small differences that there were, were generally *in favor of men* rather than women.

To clarify this problem, we reexamined the role of sex differences in our data, including the results of a 20-year follow-up for those aging twins in our study who were tested both in 1947 and 1967 (Blum 1969, Blum et al. 1972 and 1973). There were 73 such persons; however, they included 19 intact twin pairs. To avoid any statistical bias due to twinning, the 19 cotwins were excluded, leaving 54 subjects for a comparative analysis. At the time of the initial testing, these 54 subjects ranged in age from 60 to 73 years (mean ages: 65.38 for the 20 males, and 64.46 for the 34 females). At the time of the retest, the mean ages for males and females were 84.67 and 84.06, respectively. Deviations from an exact 20-year mean increase in age due to the protracted first test round (3 years) and a much shorter retest round (1 year).

For this select group — all of them were still alive 20 years later — the *initial* mean scores of females were also higher than those of males on all tests except Digits Forward and Digits Backward (exactly as had been the case for the total group), but the differences were statistically significant for the smaller group only on two of the tests (Tapping and Digit Symbol Substitution). After the lapse of 20 years, *females again scored higher* on all tests, this time excepting only Digits Backward. Moreover, on the 1967 retest round, differences between males and females on Vocabulary and Similarities reached statistical significance as did those on Tapping and Digit Symbol Substitution.

Computed annual rates of decline over the 20-year period were consistent with our hypothesis of a more rapid decline in males than in females, except for Tapping and Digit Symbol Substitution (Blum et al. 1972). During the second decade of follow-up, when most of the declines occurred, males declined more rapidly than females on all tests other than Digits Backward (Blum et al. 1970).

It is of interest that the superiority maintained in our twin study by males, when compared to females, on the test of immediate recall (Digits Backward) is in accord with observations on male centenarians who were superior on this task to female centenarians (Beard 1968).

https://doi.org/10.1017/S1120962300790263 Published online by Cambridge University Press

SEX AND INTELLECTUAL FUNCTIONING IN ADULTS

The question remains whether the sex differences in performance noted in our subjects pertain only to the older age groups, or whether they are found earlier in adulthood as well. Data from the Berkeley Growth Study (Eichhorn 1973) seem to suggest a more general trend. In that sample, tested at the ages of 10½ and 47 years, consistent female superiority was exhibited on Digit Symbol Substitution and on Vocabulary. Others have corroborated this trend for middle-aged and older samples on Digit Symbol Substitution but not on Vocabulary (Normann 1953, Doppelt and Wallace 1955).

As early as 1934, Kirihara (according to Jones 1959) reported that Japanese men were consistently better than Japanese women, over an age range extending from 20 to 70 years, in solving maze tests and form and figure search tests. In the classical cross-sectional studies, covering most of the age span, men were notably superior in spatial and arithmetical ability, while women tended to excel on tasks with high verbal loading such as analogies, disarranged sentences and vocabulary (Jones and Conrad 1933).

Reporting on the Berkeley Growth Study sample, Bayley (1970) noted an increase in Wechsler-Bellevue Scale scores through age 26, followed by a levelling off of (WAIS) full scale scores through age 36 for both sexes. However, Bayley also reported an increase in the Verbal IQs for males between the ages of 26 and 36 years, and a decrement in the Performance scores of females over the same age interval; Verbal IQs for females remained unchanged.

Still another longitudinal study, the Guidance Study (Honzik and McFarlane 1973), showed a full scale IQ increment (3.8 points) between the ages of 18 and 40 years across both sexes. A comparison by sex found small differences within the average, superior, and very superior groups; however, within the bright-normal group (IQ range of 110-119) males averaged a 2.0 point gain whereas the females' average increase was 6.5 points.

SEX AND INTELLECTUAL FUNCTIONING IN CHILDHOOD

When we look at the adult age ranges, however, we have passed all of the critical periods of development. What is the situation among school-age children or even pre-schoolers? There is a voluminous literature and it has not been possible to cover all of it. Much of the literature consists of statements of opinion and interpretations reminiscent of the misuses of statistics pointed out by Ludwig and Collette (1971) in citing the conclusion that delivery at home, with the aid of midwives, reduces infant mortality because countries with lower infant death rates than the United States have a higher proportion of births taking place at home and make a greater use of midwives; or, the recommendation to shun hospitalization because the risk of dying from an illness when hospitalized is far greater than the risk of dying from an illness when at home. While none of us would fail to recognize the absurdity of such statements, equally absurd conclusions often go unnoticed when presented in the guise of experimental results. " Transposed to numbers, the most unreliable and invalid information, collected in the most unsystematic manner, can be thoroughly impressive " (Ibid., p. 495).

Cognitive Abilities. Avoiding, then, the myriad of unsupported conclusions, what kinds of data are there? In answering that question our starting point was Roberta Oetzel's classified summary of research in sex differences which appeared in The Development of Sex Differences (Maccoby 1966). If we look first at cognitive abilities that have a high verbal loading, we

https://doi.org/10.1017/S1120962300790263 Published online by Cambridge University Press

find that for nearly every one of the categories, starting with the age of first speech and going through spelling, to reading and general verbal skills, there are considerably more studies where girls did better than boys (Fig. 1).

The age range covered extends from one month to adulthood. There was not a single

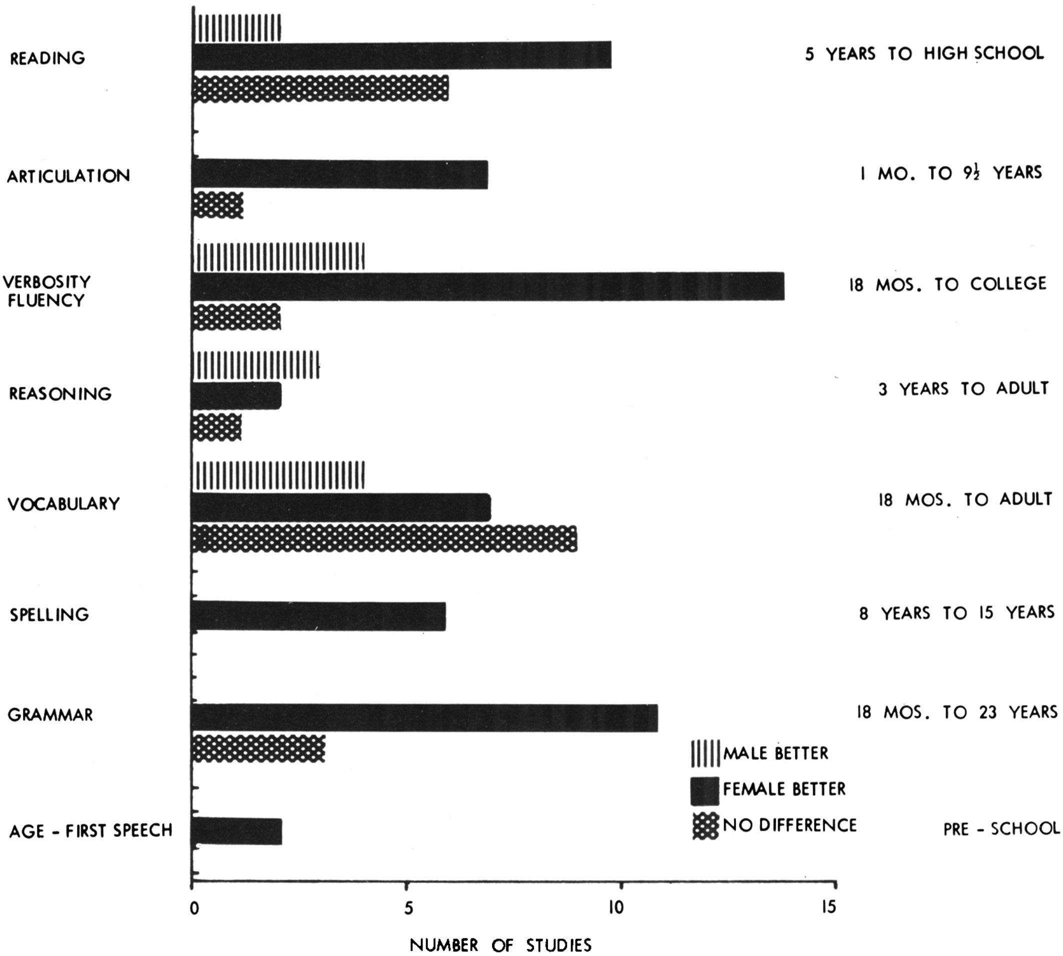

Fig. 1. Sex differences on verbal tests. [*Adapted from Oetzel 1966*].

study in which boys either started speaking earlier, or articulated earlier, or did better on grammar or spelling. In only a single category, " Reasoning, " did more studies find males to score significantly higher than females. Even here, the statement was made that females were better at learning concepts and at problem solving, while males were better at problems in analogies and absurdities. It may not come as a surprise to anyone that on tests of verbal fluency, or verbosity, 14 out of 20 studies found girls to do better than boys.

One of the few studies that found boys higher than girls in verbal ability, was done by

https://doi.org/10.1017/S1120962300790263 Published online by Cambridge University Press

Anastasi and D'Angelo in 1952. Their population was an inner-city group of children. More recently, Alexander et al. (1968) tested inner-city black children prior to their entry into Head Start programs and again thereafter. They found boys markedly superior to girls in language usage — and, after the Head Start program was completed by these children, both sexes showed improvement, but the relative difference between them remained unchanged. Impoverished milieu, especially so for the females whose activities tend to be more restricted than those of the males in these subcultures, has been suggested as a possible explanation for this reversal of the usual trend toward female superiority in verbal abilities and skills. However, this reversal was not confirmed in recent studies (Shipman 1971, and Stanford Research Institute 1972, as cited in Maccoby and Jacklin 1974) where disadvantaged girls were found to be ahead of boys on language measures.

In other cognitive functions there is a repeatedly demonstated superiority of males on tests of *spatial ability* (Fig. 2). Not a single one of 18 studies found girls to be better than boys on these tests, although 6 of them failed to find a statistically significant sex difference. In the remaining 12, boys clearly excelled girls. Boys were generally also superior in *mathematical reasoning*; only 1 out of 21 studies found girls to be better. In computation, there appeared to be no significant difference between the sexes, yet the 3 studies reporting ability to count all found girls to be better. This observation is in line with results on many clerical aptitude tests, where girls tend to score higher than boys. In breaking set and restructuring, however, again there is a difference in favor of boys who scored better than girls in 4 out 6 studies; in the remaining 2 no statistically significant differences between the sexes were found, and in none of them were girls better than boys. Nonetheless, Maccoby and Jacklin (1974, p. 105) conclude from their exhaustive review that the " results on set-breaking, or restructuring, are equivocal. "

IQ and Its Components. In contrast to the sex differences on verbal, spatial, and other cognitive tasks (Figs. 1 and 2), there appears to be remarkable equality with regard to *total IQ*. Of 17 studies, covering an age range from one month to adulthood, 3 studies reported boys better than girls, 3 studies reported girls better than boys, and 11 failed to detect a statistically significant difference between the sexes. For these particular samples, test constructors seem to have succeeded in designing IQ tests apparently free of sexual bias. In general, however, as will be discussed later, such lack of bias cannot be demonstrated.

In *perceptual speed*, the difference seems to favor girls; 8 out of 10 studies find such a difference; none find a difference in favor of boys and 2 fail to detect a statistically significant sex difference. In addition, females were reported to be somewhat superior to males in performance on tasks of perceptual speed; Maccoby and Jacklin (1974, pp. 38-40) note that it is *finger* dexterity at which girls tend to be better; the sexes do not differ on manual dexterity.

Even though we have assigned category names in an attempt to sort out the multitudinous results, the tests within each category are by no means homogeneous. Thus, a category of manual skills, which was eliminated from this particular chart, consisted of tests of balance, throwing, and assembly, in which boys excelled, and dressing skills, at which girls did better. What is needed is a comprehensive survey of the results of homogeneous tests, such as Primary Mental Abilities (Thurstone 1957), to discover whether or not any consistent trend is detectable.

Furthermore, the wide age range covered in these studies presents a particular problem since there may be a change in the organization of intelligence with increasing age. Nearly

https://doi.org/10.1017/S1120962300790263 Published online by Cambridge University Press

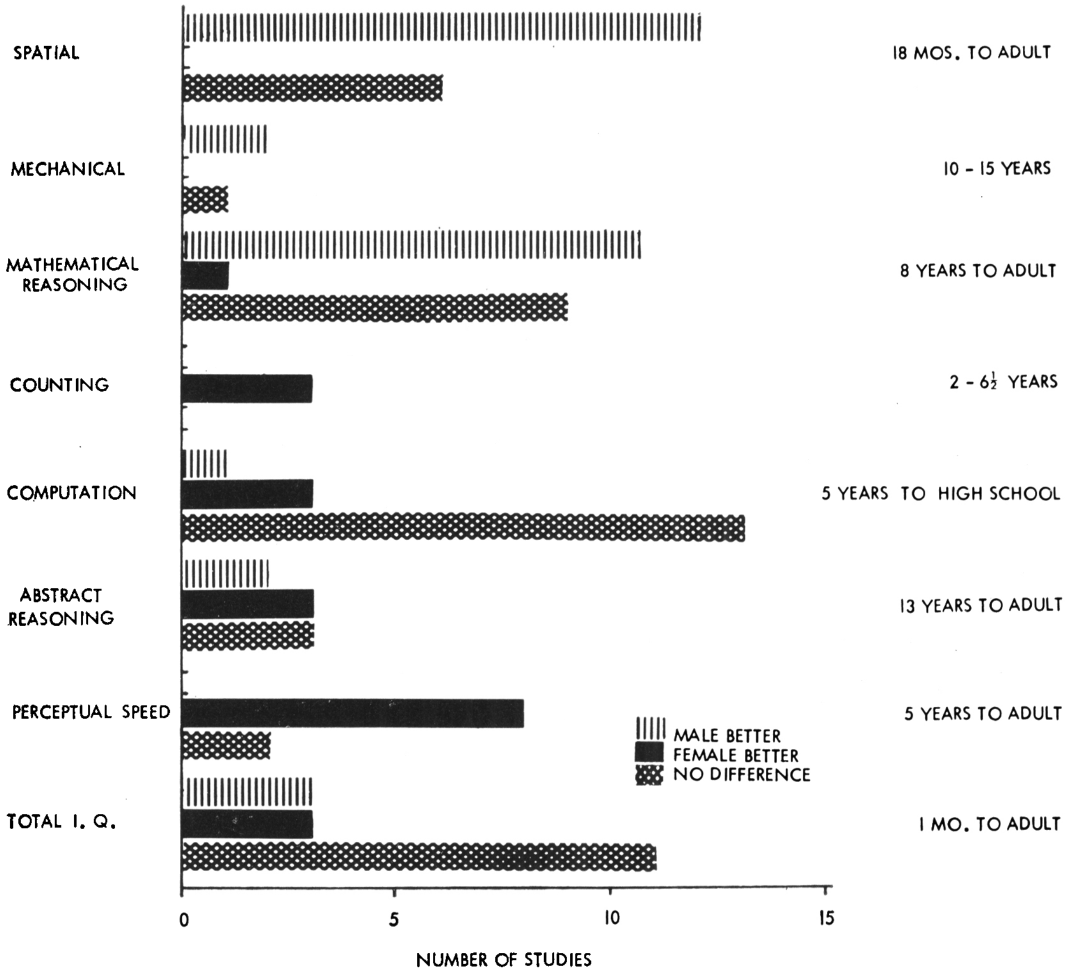

Fig. 2. Sex differences on other nonverbal cognitive tests. [*Adapted from Oetzel 1966*].

everyone who has investigated this problem has found decreasing correlations between tests with increasing age. The studies are well summarized in Anastasi's book (1967) on individual differences, and some additional corroborative evidence appears in Bayley's (1970) chapter on intelligence tests.

Henry Garrett (1946) of Columbia University proposed the differentiation hypothesis that with " increasing age there appears to be a gradual break-down of an amorphous general ability into a group of fairly distinct aptitudes. It seems highly probable that maturation has much to do with this differentiating process, but increasing experience and diverging interests must also contribute heavily. " (Cited in Anastasi 1967, p. 80).

Garrett held that " the 'G' factor which appears strongly at the elementary school level is, in large part, verbal or linguistic in nature." He stressed the importance of reading in any

https://doi.org/10.1017/S1120962300790263 Published online by Cambridge University Press

type of schoolwork and suggested that solving " arithmetic problems is contingent upon ability to read and understand directions; hence a fifth grade child high in verbal facility may do as well in arithmetic as a child of much greater native aptitude for numbers " (Ibid., p. 80).

Nevertheless, if the results of the various studies are condensed into four major categories, as Gallagher (1964) has done with Oetzel's data (Fig. 3), clear sex differences do emerge.

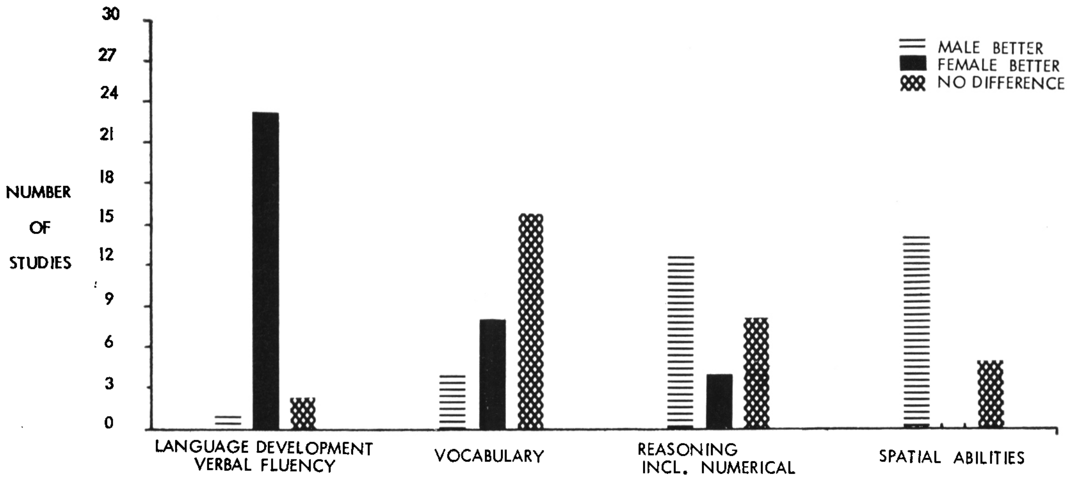

Fig. 3. Sex differences in intellectual abilities. [*Adapted from Gallagher 1964*].

In the category entitled *Language Development and Verbal Fluency*, girls were found to be significantly better than boys in 23 out of 26 studies; in only a single study were boys found to be better than girls; in the remaining 2 studies no significant difference was observed.

The sex difference in *Spatial Abilities* is equally dramatic — and in just the opposite direction — boys scored better than girls in 14 out of 19 studies; in not a single study did girls score better than boys; in 5 studies investigators could demonstrate no significant difference between the sexes. (See Maccoby and Jacklin 1974, Chapter 3, for more in-depth discussion of sex differences in both verbal and spatial abilities.)

In the remaining two categories, the differences between the sexes are not so clear-cut. Generally there was no significant difference in *Vocabulary*, 16 out of 28 studies, to be exact; yet, 8 out of the remaining 12 studies found girls to score significantly higher and only 4 of them observed a difference in favor of boys. For *Reasoning*, including both verbal and numerical reasoning tasks, more studies showed a difference in favor of boys than girls (13 out of 25, *vs.* 4 out of 25).

Clearly, these graphs show only gross trends. After all, what we have done, in essence, was a simple nose-count. The points refer merely to the number of studies in which one or the other sex did statistically significantly better. No analysis of the direction of the differences (using all of the studies) was possible, although in a nose-count this would undoubtedly be more meaningful. So would control of age groups, types of tests and adequacy of samples. Unfortunately, we have to take the data as they are.

https://doi.org/10.1017/S1120962300790263 Published online by Cambridge University Press

SEX DIFFERENCES IN STANFORD-BINET AND WAIS

But there are other data. The standardization groups for the Stanford-Binet, for example, provide us with scores which *are* comparable in terms of IQ (Terman-Merrill 1960). After 30-odd tests had been eliminated because they discriminated in favor of one or the other sex (McNemar 1942), the results were as follows: between the ages of 2 and 5 years, girls had the

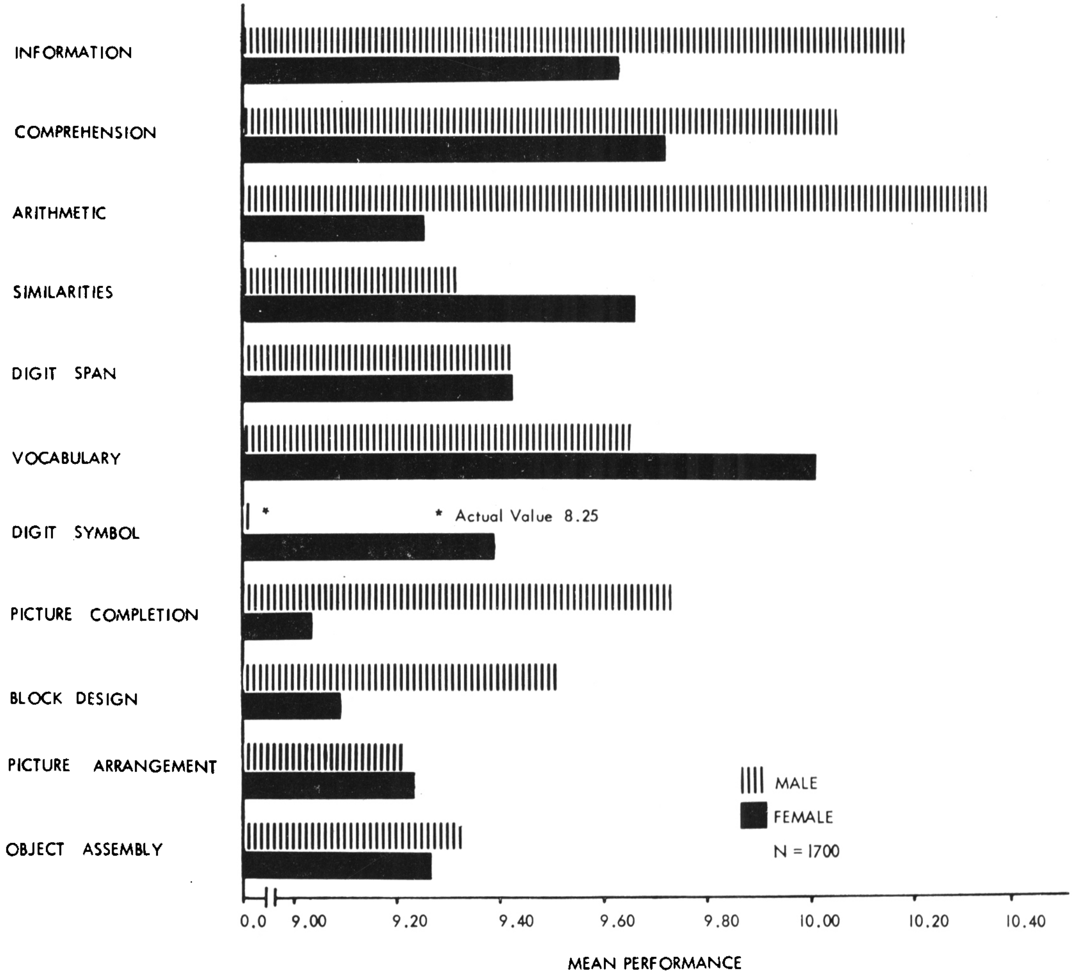

Fig. 4. Means on WAIS subtests (850 males and 850 females, ages 16-64). [*Adapted from Wechsler 1958*].

higher IQs; between the ages of 5½ and 15 years, boys did. These differences were statistically significant.

There are also the standardization data for the WAIS, ages 16-64 years. Here again, we have actual scores and are dealing with a single study of a presumably representative white American population, and not the conglomerates presented earlier (Figs. 1-3). Those who, like myself, were familiar with the old Wechsler-Bellevue and did not pay particular attention

https://doi.org/10.1017/S1120962300790263 Published online by Cambridge University Press

to the changes in the WAIS, may be surprised to see that on only 2 subtests did males and females obtain similar mean scores (Fig. 4). These 2 subtests were Digit Span and Picture Arrangement. On 6 of the remaining 9 subtests, males scored higher than females, the most striking differences being on the Arithmetic subtest where the females obtained a weighted score of about 9.2 and males of about 10.3. The 3 tests on which females obtained the higher mean scores were Similarities, Vocabulary, and Digit Symbol Substitution, with the most marked difference in favor of women on the Digit Symbol test. (The value obtained by men fell below the scale used in Fig. 4.) With the exception of Object Assembly, the sex differences were all statistically significant.

What is perhaps even more impressive than the statistical significance reached by the differences for all ages combined, is the remarkable consistency with which the sex differences were displayed by the 7 age groups into which Wechsler separated his sample. On Information and Arithmetic, mean scores for males were higher than for females in each one of the age groups, while for Comprehension Picture Completion, and Block Design a difference in favor of males occurred in 6 out of the 7 age groups. Higher mean scores for females were consistently achieved for all 7 age groups on Vocabulary and Digit Symbol Substitution and for 5 of the 7 age groups on Similarities.

These clear-cut sex differences on subtests of the most widely used test of general intelligence may come as a surprise to some readers. They did to me. To someone who has carefully read the WAIS manual, however, they are well known. Wechsler devotes an entire chapter to the discussion of sex differences in intelligence. He was himself impressed with these findings and constructed a masculinity-femininity (MF) index from the differentiating subtests. The masculine tests are Information, Arithmetic and Picture Completion; the feminine tests are Vocabulary, Similarities and Digit Symbol Substitution. By deducting the sum of the weighted scores on the feminine tests from the sum of the weighted scores in the masculine tests, an MF score is obtained. A postive MF score signifies a masculine, and a negative score a feminine trend. I leave to the reader the interpretation of the implications of that scale.

Perhaps it is not fair to dwell at such great length upon sex differences on subtests of the WAIS. After all, the WAIS was constructed to yield a total IQ, and verbal and performance IQs. It is only for these scores that equality has been, if not claimed, then at least assumed by most users of the test. Wechsler has broken down the age range from 16 to 64 years into 11 age groups. For 9 of them, full scale IQs are higher for males than for females. Perhaps even more surprising, in view of the data we have seen showing greater verbal ability for females than for males, males also exceed females in verbal IQs in 9 of the 11 age groups. Males exceed females in only 7 of the 11 age groups in performance IQs, which must be due largely to the Digit Symbol Substitution test, a test with a high verbal loading (Jarvik et al. 1962), on which women did strikingly better than men. Wechsler (1958) himself makes the following comment:

> ... The differences are small, at least small enough to make unnecessary separate sex norms, but sufficient to warrant further analysis of test findings... There are systematic, but for the most part negligible differences in verbal, performance, and full scale score in favor of the male subject. (p. 144).

I wonder if we can consider a trend as consistent as the one exhibited in this test as "negligible." The differences may be negligible; the trend surely is not!

Incidentally, in the construction of the Wechsler-Bellevue Intelligence Scale, tests that

https://doi.org/10.1017/S1120962300790263 Published online by Cambridge University Press

discriminated against one sex or another were discarded. For example, a cube analysis test was excluded after being given to over 1000 subjects because it showed large sex differences in favor of men. In assembling the Stanford-Binet, as mentioned earlier, more than 30 tests were eliminated because they discriminated in favor of one or the other sex.

According to Mellone (1944-1945), boys were so superior to girls on block counting tasks, that this test was eliminated from the Scottish mental survey (1933) as a measure of general intelligence. Mellone likewise found that girls did so poorly on maze tests that she concluded the young schoolgirls who were her subjects lacked a " spatial factor " that the boys called upon in dealing with the tests. She suggested that other tests involving a spatial factor often had higher verbal loadings and that girls could succeed by employing compensatory verbal thought mechanisms.

Finally, the sex differences on another test used widely throughout the world, Thurstone's Primary Mental Abilities test (1957), were so significant that severe criticism was levelled against it for failing to provide separate sex norms (Hobson 1947, Herzberg and Lepkin 1954). As far as I have been able to determine, it still fails to do so.

What factors account for the observed sex differences in intellectual functioning?

PERSONALITY VARIABLES AND SEX DIFFERENCES IN INTELLIGENCE

Several personality variables have been proposed in an attempt to explain sex differences in intellectual functioning. As we can see in Fig. 5, the number of studies for each category is smaller than those for various subtests of intelligence. Moreover, there are a fair number of categories in which there appear to be no significant sex differences, among them divergent thinking, task persistency, and need achievement (as measured by observations, self-reports and projective tests). Nonetheless, there are clear differences as well. Of 4 studies on curiosity, 3 found males to be more curious, none found females to be more curious, and the remaining one detected no significant difference between the sexes. Males also seem to be more field-independent in their cognitive style, surpassing women in this respect on 11 out of 13 studies. The tests generally used in judging field-independence/dependence are the Embedded Figures and Rod-and-Frame Tests (EFT, RFT). Witkin demonstrated the greater field dependence of girls compared to boys in a total of eight cultures (Witkin 1962 and 1966.) More recent studies of field-independence are in accord with the earlier work (Maccoby and Jacklin 1974, Table 3.8, p. 95-97). Nonetheless, MacArthur (1967) failed to find sex differences in the two age groups he studied, 9-12 and 12½-15½ years; the subjects were Western Eskimos who were given the EFT. MacArthur thus replicated Berry's (1966) results with Eastern Eskimo children. The lack of sex differences in this population remains unexplained, although Maccoby and Jacklin (1974) suggest that the Eskimos' permissive child-rearing practices may be responsible for equality on field-independence between the sexes. Maccoby and Jacklin support this interpretation with Berry's (1966) report of significant sex differences in field-independence in the Temne, a restrictive African tribe with males exercising strong control over females.

Using a different series of tests to measure analytic style (other than field-dependence) Kagan, Moss and Sigel (1963) found that on their Word Association, Serial Learning and Figure Sorting tests, " analytic responses are of different significance for boys and girls " (p. 87). In another study, they noted a remarkably high stability for girls'

https://doi.org/10.1017/S1120962300790263 Published online by Cambridge University Press

conceptual style but significant change for the boys in the direction of increasing analytic conceptualization. For boys, hyperkinetic activity, impulsivity (both negative), and attention span (positive) were correlated with analytic response; these correlations did not appear for girls. Thus, they concluded: " It is possible that analytic and nonanalytic responses are the

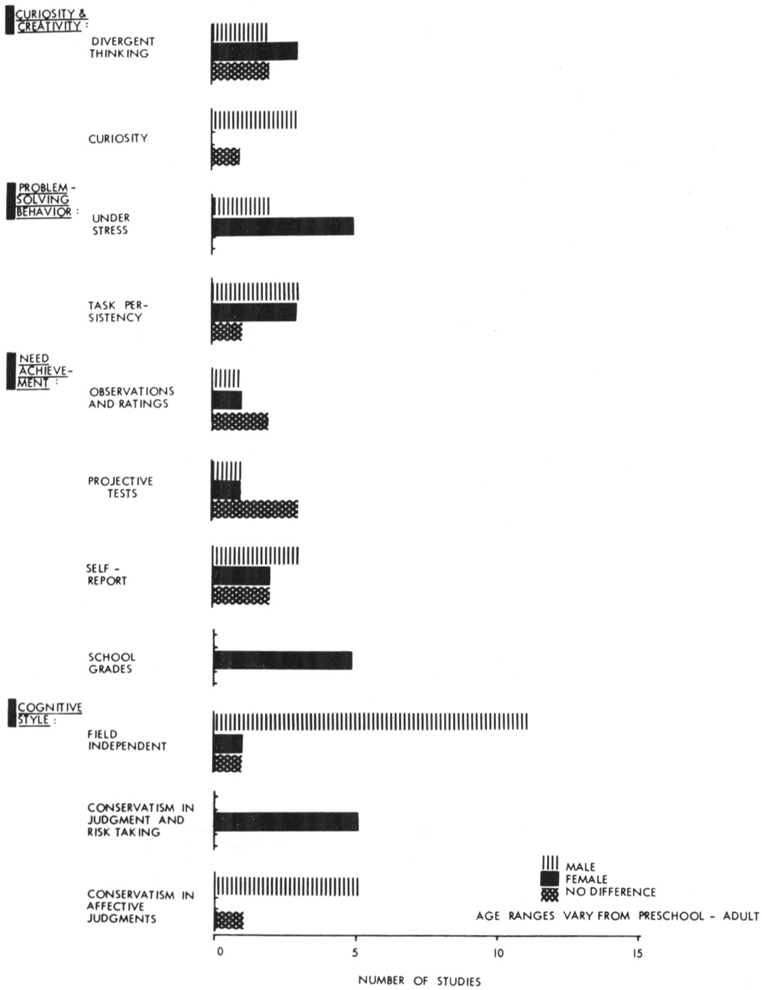

Fig. 5. Sex differences. Personality variables affecting cognitive abilities. [*Adapted from Oetzel 1966*].

product of different casual agents in boys and girls " (p. 111). They advised that cognitive process data should be analyzed separately for each sex and pooled only when directions of relationships hold for each sex. Incidentally, " analytic " children tend to be self-sufficient almost to the point of isolation, while the more globally experiencing individuals excel at remembering people's faces (Crutchfield et al. 1958, cited by Witkin 1962); more " global " children are better on the verbal-comprehension cluster of tests on the Wechsler Intelligence

https://doi.org/10.1017/S1120962300790263 Published online by Cambridge University Press

Scale for Children, or WISC (Wechsler 1949); and again, girls surpass boys on such verbal measures.

Returning to Fig. 5, we can see that males were also rated more conservative on *affective judgements* in 5 of 6 studies; in no study were females more conservative in this regard, and only 1 study failed to find a significant difference. With regard to conservatism in judgment and *risk-taking*, however, all 5 studies reported females to be *more* conservative. Five of the studies reported that school grades were better for girls than for boys. In 4 out of 6 studies, girls also did better in solving a problem under stress.

To sum up the information in Fig. 5, boys tend to be more curious than girls, field-independent rather than dependent, and less subject to their emotions in making decisions. Girls, by contrast, are less likely to take risks, have better grades in school, and when under stress do better in problem-solving.

Some investigators (Sigel et al. 1963, Kagan et al. 1963, Kagan 1964) emphasize that emotional control leads to better performance with regard to analytical concepts in boys, but not in girls. Sontag et al. (1958) also reported greater variability for boys than for girls in the Fels Study, both with regard to range of IQ and inconsistency in IQ from age to age. They, therefore, investigated emotional or personality factors correlated with IQ-change and noted, in addition to the sex-specific patterns in these attributes, that the emotional correlates for boys and girls of ascending/descending IQ patterns were different. They also found that in their group (N = 140), many more boys developed ascending IQs (boys N = 23, girls N = 12), whereas more girls developed descending IQs (boys N = 13, girls N = 22). Parental emphasis was important for boys but not significant for girls at age 10 years; independence was, however, important for both sexes at age 6 years. (For the later differential effects of *early* parental attention to same- and opposite-sex children, and correlated socioeconomic variables, see Honzik 1967). Others have reported (Kagan et al. 1963, Sutton-Smith et al. 1964, cited in Maccoby 1966) that high activity, independence, competitiveness, and lack of fear or anxiety are correlated with intellectual achievement in girls, while in boys the correlation is with timidity, anxiety, lack of overt aggressiveness, and lower activity level.

There arises, then, the confusing picture of intellectual performance as being incompatible with femininity in the girl and also incompatible with masculinity in the boy. At least, there are a number of papers describing the brighter boys as considerably more feminine than their less intellectual peers and the achieving girls much more masculine than their typically feminine companions. Although intellectually oriented girls may have gender-appropriate interests in the opposite sex, their activities, manner, or personality do not jibe with current role-appropriate sexual stereotypes. According to Oetzel (1961, in Maccoby 1966), analytical thinking, creativity, and high general intelligence are associated with cross-sex typing. Torrance (1959, in Anastasi 1967) suggested that sex role typing is a block to creativity, since creativity requires sensitivity — a female trait — as well as independence and autonomy — male traits. He concluded that creativity may require freedom to espress cross-sex interests (Torrance 1962; cf. Getzels and Jackson 1962). A recent report by Honzik and McFarlane (1973) provides support for Torrance's conclusion, based on the finding that over a 22-year period (ages 18 to 40) those subjects with substantial IQ gains were significantly ($p < 0.05$) less extreme in their (Q-sort) appraisal of masculinity and femininity than the remainder of the group. In addition, as children the IQ "gainers" had been judged less gregarious than the others, and as adults these same subjects tended to maintain distance from other people, turn inward (not out to others), and fail to arouse nurturant feelings in others. Further

https://doi.org/10.1017/S1120962300790263 Published online by Cambridge University Press

studies will be needed to investigate this intriguing negative association of intellectual enhancement and warm relationships! It has also been suggested (Coleman 1961, Crandall et al. 1962) that social pressures are such as to encourage bright boys to do well, while girls, bright or not, are not expected to excel in scholarship. Indeed, the evidence of a drop-off in achievement among girls as they reach maturity seems to be linked to the adult female sex role, just as the increase in male achievement at the high school level and thereafter appears to be linked to the masculine sex role. As a Russian proverb has it: " It is what girls don't know that adorns them. "

SEX DIFFERENCES AND MATURATION

It is difficult, if not impossible, to sort out the cultural input from the physiological input in such sex differences as discussed in the preceding sections. Gesell and his collaborators (Gesell et al. 1940 and 1949) reported distinct sex differences in development from infancy on. Not only did they observe somewhat earlier maturation in motor and verbal skills in female babies (see also Wilson and Harpring 1972), but also distinct differences in block-building preferences, earliest use of some toys, development of handedness pattern, picture drawing preferences, and attention to detail. For example, at age 2 years only ¼ of the boys did not try to build a block train, but ½ the girls failed to do so (Gesell et al. 1940, p. 116). At age 4 years, 75% of the boys were able to build the block gate compared to only 42% of the girls; yet at age 5 years, 93% of the girls, but only 60% of the boys built it from the model (Ibid., p. 119). There are clearly early differences between the sexes in attentiveness, perception of form, and manual skill.

There are other distinctions that appear early: girls can manipulate objects with finer control, and so are able to copy writing earlier, dress earlier, tend to eat more neatly, etc., but boys can throw a ball better, and their advantage appears as early as the age of 3½ years (Ibid., p. 86). By age six, girls tend to be better than boys in reading, writing, and drawing, and boys are better than girls in number work and conservation tasks (Gesell et al. 1949, p. 124; Hooper 1969). Their interests also seem to be different: girls draw people and houses, boys draw vehicles (cf. Haworth 1966). In the years preceding puberty, girls' play preferences tend to be diversified and balanced; boys are more likely to develop an " obsessive preoccupation " with a single pastime (Gesell et al. 1949, p. 364). According to these authors: " Girls as a rule, with a greater fluidity of mental structure and with a more flexible but continuing contact with their environment, do not experience the more extreme patterns of disorganization that boys exhibit. Girls are better at conforming " (Ibid., p. 125). Finally, they report on the pronounced sex differences between 10-year-old boys and girls: " The girl has more poise, more folk wisdom, and more interest in matters pertaining to marriage and family. This difference appears to be fundamental. Under current cultural conditions other sex differences (also) become obvious... " (Ibid., p. 213; cf. Garai and Scheinfeld 1968).

Because boys mature more slowly, speak later, and attain fine muscle coordination at an older age than girls, their early inferiority in intelligence tests has been attributed to their delayed maturation; eventually boys do catch up and often surpass girls (Bruner and Oliver 1963). Tanner (1962) suggests that many of the apparent intellectual differences are consequences of hormonal differences determined by genetic sex and operant from birth, if not before; there are sex distinctions in size, shape, skeleton, dentition, and age of puberty. He also documents a number of cultural factors which produce differential

https://doi.org/10.1017/S1120962300790263 Published online by Cambridge University Press

rates of maturation across cultures and within sexes, such as nutrition, climate, race, reaction to environmental stresses (e.g., illness, war dislocation, malnutrition), and social class within a culture. There are an enormous number of biological differences between the sexes, other than the obvious distinctions and well-known Basal Metabolic Rate and Basal Heart Rate levels, most of them starting at puberty, the point at which intellectual changes measured by our current tests and achievement indices often tend to show a spurt in boys and a decline or levelling off in girls. Although it is not known whether anatomical or physiological changes occur in the brain at puberty, according to Tanner (1962) it is possible that they do, and lead to the sexual differentiation in specific abilities, intellectual performance, and specialization of interests characteristic of the adult sex roles (pp. 210-212). Individual variations in the physiological parameters may have personality correlates related to intellectual achievement.

SEX DIFFERENCES AND GENETIC FACTORS

From hormonal and other physiological differentiation we get to more fundamental variation at the genetic level. Although no one will dispute that differences in phenotypic sex reflect differences in genotype, there are many who would dispute that differences in intellectual abilities have anything to do with genetic make-up. Nonetheless, the evidence for genetic factors is quite strong.

It is important to point out, however, that whether we consider genetic factors in intellectual abilities as such, or genetic factors in sex differences in intellectual abilities, there are many other influences upon our measurements. Among the factors which undoubtedly influence the levels of measured abilities, besides age and health, are such exogenous ones as socio-economic status, cultural input, and performance expectations, and such endogenous factors as drive, activity level, and cognitive style. Eventually, with sophisticated computer techniques, we may be able to look at the interactions of all the relevant factors and assign them appropriate weights. To date, this has not as yet been achieved, and we have to look at the individual factors one by one.

Some time ago, Erlenmeyer-Kimling and Jarvik (1963) surveyed the literature on familial correlations in intelligence and found that the degree of intellectual similarity increased in direct proportion to the degree of genetic relationship. The studies examined then had many of the same defects as the studies discussed in the present paper. The samples were far from homogeneous, being unequal in size, age structure, ethnic composition and socio-economic stratification. The data were collected in eight countries, on four continents, during a time span covering more than two generations. Moreover, the investigators had different backgrounds and contrasting views regarding the importance of heredity. Nonetheless, a clearly consistent trend emerged from the data. And what is more, for most of the categories of relationship, the median of the empirical correlations closely approached the theoretical values predicted on the basis of genetic relationship alone.

Familial correlations for intelligence parallel remarkably closely those for height, not only theoretically but also empirically (Fig. 6). This observation has led to the hypothesis that both reflect a multifactorial mode of inheritance (cf. Sontag et al. 1958, p. 122).

There is another line of evidence (based on studies of persons with abnormalities of the sex chromosomes) which suggests that genetic factors operate in the determination of sex differences in intellectual abilities. The first such reports, from Money and his collaborators at Johns Hopkins University, concerned the intellectual performance of patients with Turner's

https://doi.org/10.1017/S1120962300790263 Published online by Cambridge University Press

syndrome (Schaffer 1962, Money 1963). This disorder had been well-known to pediatricians for many years before the chromosome abnormality was discovered. Affected individuals are almost always females characterized by dwarfism, webbing of the neck, and frequently associated cardiac anomalies, particularly coarctation of the aorta. In the 1950s it was discov-

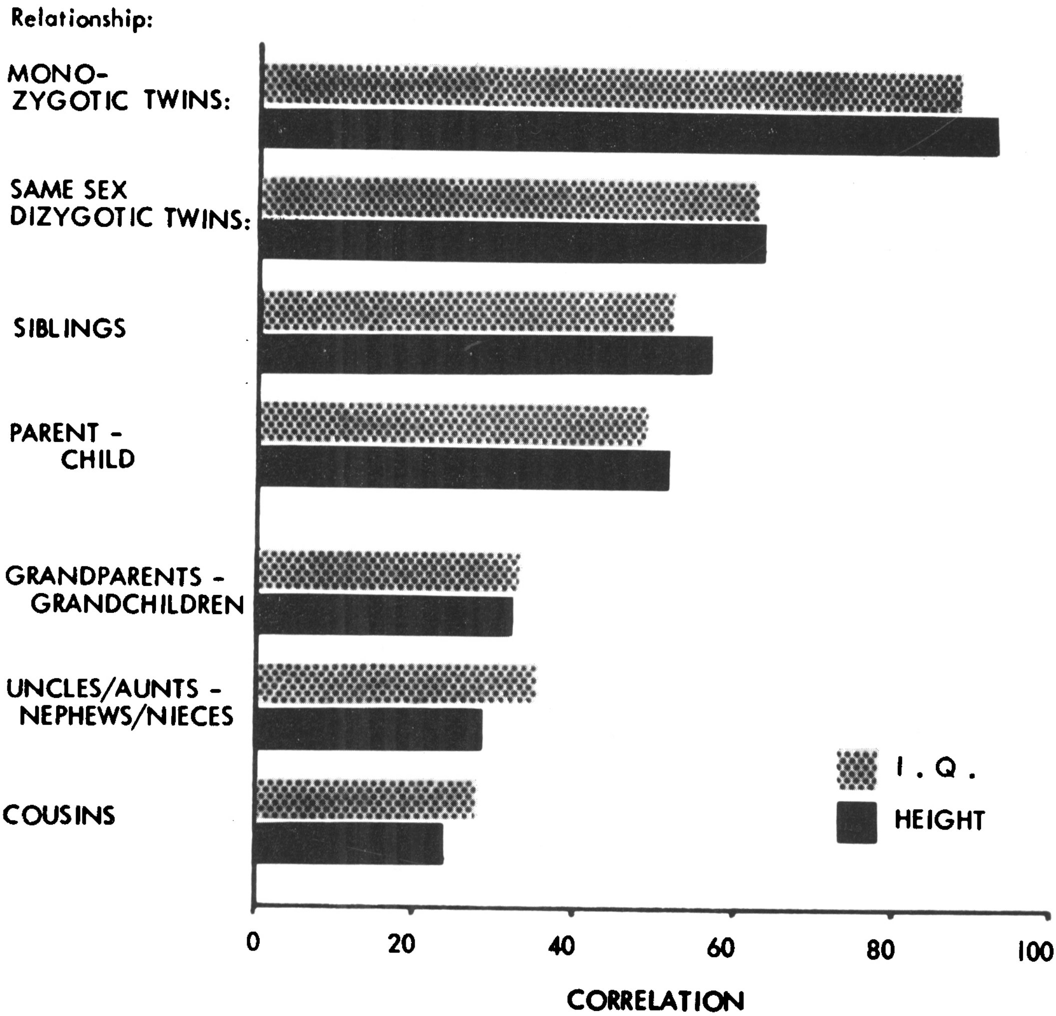

Fig. 6. Familial correlations for intelligence and height. [*Adapted from Morgan 1971*].

ered that patients with Turner's syndrome lacked one of the sex chromosomes, having a total of only 45 rather than 46 chromosomes. They had an XO chromosome constitution (sometimes XO/XX mosaicism) rather than the normal XX (female) or XY (male) genotype. The above description is a simplified one since, in fact, more than two dozen clinical and chromosomal variants of the syndrome have already been described (Hauser 1963, Hamerton 1971).

Children with Turner's syndrome were found to be generally of normal intelligence — some

https://doi.org/10.1017/S1120962300790263 Published online by Cambridge University Press

of them were of superior intelligence — but they were extraordinarily poor on certain performance tests involving spatial organization, and right-left orientation. Even though not all cases were affected with equal severity, the defect was sufficiently pronounced to lead Money and his collaborators to use the terms " space-form blindness " and " spatial agnosia " to describe the disorder in these girls (Money and Alexander 1966). Girls with Turner's syndrome also performed poorly on tests involving number sense and were described as suffering from dyscalculia. By contrast, they tended to do well on verbal tests. Incidentally, on spatial tasks these girls were not compared with boys but did more poorly than students of nursing. The original reports were based on the examination of 18 patients with Turner's syndrome (Alexander et al. 1964 and 1966).

In 1969 Garron and Vanderstoep's studies of 48 patients with Turner's syndrome — 29 between the ages of 5 and 16 years, and 19 older than 16 years — were published. A similar defect in spatial organization was noted, although the impairment was said to be in the copying of the material rather than in the memory for forms, and in the eventual competence attainable rather than in the rate of learning. The younger group lagged behind matched controls and this lag increased with age. It was noted that verbal cues were often used to compensate for the deficiency in spatial organization.

In contrast to patients with dwarfism due to Turner's syndrome patients with dwarfism due to other causes, such as hypopituitarism, did not show the same discrepancy between verbal and performance IQs (Money et al. 1967).

Jakubowska et al. (1969) in a study of patients with Turner's syndrome, ranging in age from 15 to 42 years, found their IQs to be below normal — in the dull normal range — and further noted a low verbal IQ in 20% of the sample.

A third line of evidence for genetic determination of sex differences in intelligence comes from Stafford's genetic analysis of aptitude for spatial visualization in normal families. According to Stafford (1961) a recessive gene for space-form aptitude is carried on the X chromosomes. Therefore, males having only one X chromosome, have better spatial ability whenever this gene has been transmitted whereas females (with two X chromosomes) must inherit a double dose of the gene for increased spatial ability. Bock and Kolakowski (1973) estimate the probability of occurrence of this gene at approximately 0.5 in both males and females. At the phenotypic level, the probability translates to 0.25 for females, whereas it remains 0.5 for males. One could, of course, also postulate that there is a gene for spatial organization on the Y chromosome, although it is still unpopular to locate *any* genes on the Y chromosome other than those concerned with sex determination as such.

Another study specifically designed to investigate genetic factors in spatial orientation was performed by Annenkov (1969) who found that 30 of 38 monozygotic (but only 3 out of 19 dizygotic) twin pairs resembled each other closely in parameters of spatial ability. In the 8 monozygotic pairs who did not resemble one another, Annenkov attributed the dissimilarity to a history of injury in one of the twins. The author thus concluded that genetic factors were significant in the development of those structural and functional systems of the brain concerned with spatial orientation.

Working with Raven's Progressive Matrices, Guttman (1974) found that the single spatial visualization item (E-8) had the specific parent-offspring correlational pattern suggested by Bock and Kolakowski (1973) as evidencing X-linkage; for no other item did this relationship obtain.

There is a genetic disorder, much publicized recently, in which persons have two Y chro-

https://doi.org/10.1017/S1120962300790263 Published online by Cambridge University Press

mosomes and one X chromosome (cf. review Jarvik et al. 1973). These men have been characterized as unusually tall, generally subject to episodes of uncontrollably aggressive behavior (which often leads to criminality), and frequently below average in intelligence — their IQs being generally in the dull-normal range (Court-Brown 1968, Baker et al. 1970). Unfortunately, there are as yet few detailed psychological studies on these individuals, and the few that are reported give at best IQs separately for verbal and performance scales but not subtest scores. In most of the cases, the performance IQ is higher than the verbal IQ, which is not what we find in the standardization sample for the WAIS, where verbal IQ is slightly higher than performance IQ, even for men, and it is the exact opposite of what we find in Turner's syndrome (cf. Money 1964).

Incidentally, girls with Turner's syndrome tend to be very feminine while boys with an extra Y chromosome tend to approach the ideal of maculinity, at least in our culture — they are tall, strong, muscular, often very good-looking, aggressive, but, unfortunately, frequently not too bright.

The question next arises of how we can bridge the gap from chromosomal level to the intellectual level. The most obvious way would be through hormonal influences, particularly the influence of sex hormones.

There is one disorder in which genetic males — individuals with both an X and a Y chromosome — are phenotypic females, the so-called testicular feminization syndrome. In this disorder, patients have all the female secondary sex characteristic, are interested in marriage, are maternal, have feminine attitudes toward homemaking, marital role, pregnancy and raising a family (Money et al. 1968, Masica and Money 1969). In four cases of married patients, the husbands, who were interviewed as well, considered their wives unmistakably feminine in behavior and outlook. Fifteen of these patients, ranging in age from 5 to 27 years, had mean IQs of 108.3 with a range of 88 to 128. The difference between verbal IQ (mean 111.8) and performance IQ (mean 102.3) was statistically significant and implies that these patients, genetic males-phenotypic females, showed an essentially normal female pattern on intelligence testing.

In the testicular feminization syndrome, target organs, presumably also including the central nervous system, are insensitive to androgenic hormones. In the *adreno-genital* syndrome, by contrast, an autosomal recessive factor involves inhibition of cortisone production with a consequent excess of circulating androgens. These children assume the normal appearance of their genetic sex, but have from early life increased androgenic stimulation. Fifty-three girls and 17 boys, ranging in age from 2½ to 48 years, had psychological tests (Money and Lewis 1966). The mean IQ for the group was 109.9 with a range from 38 to 154. There was a clear-cut excess of high IQ scores — for example, 60% instead of the expected 25% had IQs above 110. One of the conclusions sometimes drawn from these data is that a high androgen level is conducive to better intellectual development. As is well-known, the androgen level in boys is normally higher than that in girls, certainly in the years after puberty, and possibly in the preceding period of childhood, as well (Tanner 1962, Broverman et al. 1968, Lewis et al. 1968).

Baker and Ehrardt (1974) hypothesized that children with adrenogenital syndrome (AGS) had been prenatally exposed to an excessive amount of androgen and would, therefore, exhibit higher IQs than either their parents or siblings. It is possible that males are exposed to greater prenatal amounts of androgen than are females; therefore, male AGS data presented by Baker and Ehrhardt (1974) have been omitted from this discussion which is restricted to

https://doi.org/10.1017/S1120962300790263 Published online by Cambridge University Press

their data on the 17 female AGS subjects plus sisters and mothers. The results showed that girls with AGS did not have higher IQs than their mothers or unaffected sisters; however, girls with AGS and their sisters, but not their mothers, had mean IQs significantly greater than the normal mean IQ of 100 ($p < 0.05$). Even among the mothers, 50% had IQs above 110, whereas one would expect only 25% in that category.

This finding suggests that the elevation in IQ may be due to the single recessive gene responsible for the adrenogenital syndrome. Two-thirds of the apparently normal sisters are expected to be carriers of the recessive gene for adrenogenital syndrome and would, therefore, be expected to show a corresponding increase in IQ. The remaining 1/3 of the sisters are without the recessive gene and their IQs should not differ from normal.

The mechanism by which the IQ effect is exerted is unknown. It is possible that carriers of the single recessive gene produce excess androgen during fetal life which affects the developing central nervous system in such a way as to enhance subsequent intellectual performance. It is equally likely that the increased IQ could result from some other, as yet unidentified, pleiotropic effect of the gene responsible for the adrenogenital syndrome. Broverman et al. (1968) suggest that sex differences in cognitive abilities are at least partially due to differential effects of androgens and estrogens on the sympathetic and parasympathetic nervous systems. At this time the precise relationships between these hormones and CNS functioning remain unknown as does the validity of the thesis proposed by Broverman et al. (For further discussion of this theory see Maccoby and Jacklin 1974, pp. 122-125.)

The effect of hormones on the central nervous system is just beginning to be investigated, and I expect that we will hear much more about it in the years to come. There is another area that has intriguing possibilities for research: Investigation of the various regions of the brain in control of sensory and intellectual functions, and their interconnections.

If a verbal factor tends to predominate in girls and a spatial factor in boys, then we would expect to find corresponding differences in regional development of the brain, ultimately even at the cellular level. Verbal representation resides primarily in the left hemisphere, spatial representation in the right (Geschwind 1970, Gazzaniga 1970). Are there then sex differences in the development of the respective regions? As of today we do not know, although the first study providing suggestive evidence has now been published: Wada (1974) noted a significantly less consistent pattern of asymmetry in female brains than in male brains. However, there is still considerable disagreement as to the differential degree of brain lateralization between the sexes, which will probably not be resolved until adequate anatomical data are examined.

Maccoby and Jacklin (1974) cite Buffery and Gray (1972) as proponents of greater lateralization in females. Buffery and Gray hypothesize that " the earlier and stronger development of lateralization in females facilitates their verbal development, but that spatial skills call for a more bilateral cerebral representation and hence is facilitated in men, in whom laterality is not so strong or developed so early " (p. 126). By contrast, in an exhaustive review of the literature, Harshman and colleagues (personal communication, 1975) cogently argue for greater lateralization in males rather than females. These researchers do not find the Buffery and Gray position unreasonable, but point out that Buffery and Gray based their theory mainly on a review of developmental data from children. The Harshman papers cite clinical (e.g., unilateral brain damage studies reported by Lansdell 1961 and 1973), anatomical (e.g., the Wada 1974 study noted above), electrophysiological, tachistoscopic, and dichotic listening evidence in support of greater male lateralization.

https://doi.org/10.1017/S1120962300790263 Published online by Cambridge University Press

Harshman et al. note that the developmental lag displayed by boys relative to girls necessitates consideration of data on lateralization in children separately for the two sexes. Lenneberg (1967) hypothesizes a critical period for language development marked off by the supposed completion of lateralization (around puberty). Occasionally, an individual case provides an opportunity for the study of brain lateralization in terms of fixed critical periods. One such case is that of Genie, a child isolate who received virtually no verbal stimulation until almost 14 years of age (Curtiss et al. 1974). The data obtained from Genie can, of course, only be taken as suggestive, but they are nonetheless of interst. She has been acquiring language and continues to do so. However, in dichotic listening tasks she has been found to process verbal material (material familiar to her by the time of testing) entirely in the *right* hemisphere. This result is exactly opposite to the usual left hemispheric processing of verbal stimuli. It is possible, then, that Genie can no longer use the left hemispheric verbal centers; however, it is also possible that she suffered some physical trauma earlier in life which precluded the appropriate development of left hemispheric functions. Continued observation of Genie and others like her may shed light on the existence of a critical period for language acquisition as well as the modes of cerebral dominance.

CONCLUSIONS

While awaiting the results of research yet to be done, what can we conclude from the knowledge accumulated to date? I do not have an answer; I can only share my thoughts with you.

First, it seems to me, that with the information now at hand, it is as unrealistic to deny the existence of intellectual differences between the sexes as it would be to negate their physical dissimilarities. As Wechsler (1958) put it nearly two decades ago:

> The findings on the WAIS suggest that women seemingly call upon different resources or different degrees of like abilities in exercising whatever it is we call intelligence. For the moment, one need not be concerned as to which approach is better or " superior. " But our findings *do* confirm what poets and novelists have often asserted, and the average layman long believed, namely, that men not only behave but " think " differently from women. (p. 148).

Second, despite all the evidence, we have *systematically and intentionally ignored* sex differences in intellectual functioning. Among the fruits of this ostrich policy, we, in the United States, have reaped tests like the National Merit Scholarships, so heavily weighted with items at which boys excel that nearly all girls would be eliminated in equal competition (Garai and Scheinfeld 1968). What happens next? The results of a discriminatory test are partly vitiated by adding a discriminatory practice. Somehow, somewhere, it was apparently decided that the final group should include 25% girls. Why 25% and not 50%, I don't know. Except, perhaps, it seemed like a generous quota to the decision-makers, considering how poorly girls did on these tests. So, no matter what the test results, the magic ratio had been fixed: 75% boys, 25% girls. Such is the end result of a tedious selection procedure — such is the hypocrisy of our times!

What can we do about it?

The time has come for us to give serious consideration to the meaning of sex differences in our society. The hope of our future lies in our ability not to deny but to harness the products of our genetic diversity.

https://doi.org/10.1017/S1120962300790263 Published online by Cambridge University Press

It seems to me, that our society belongs to those, who, in the words of the poet Kahlil Gibran, have been standing " in the sunlight, but with their backs to the sun. They see only their shadow, and their shadows are their laws " (1938, p. 52). Let us, instead, as Gibran says, " stand together, and yet, not too near together,

For the pillars of the temple stand apart, and the oak tree and the cypress grow *not* in each other's shadow. " (p. 20).

REFERENCES

Alexander D., Walker H.T. Jr., Money J. 1964. Studies in direction sense: Turner's syndrome. Arch. Gen. Psychiatry, 10: 337-339.

Alexander D., Ehrhardt A.A., Money J. 1966. Defective figure drawing, geometric and human, in Turner's syndrome. J. Nerv. Ment. Dis., 142: 161-167.

Alexander T., Stoyle J., Kirk C. 1968. The language of children in the 'Inner City.' J. Psychol., 68: 215-221.

Anastasi A., D'Angelo R.Y. 1952. A comparison of negro and white preschool children in language development and Goodenough Draw-A-Man IQ. J. Genet. Psychol., 81: 147-165.

Anastasi A. 1967. Individual Differences. New York: John Wiley and Sons.

Annenkov N.I. 1969. Studies in systems of spatial orientation and its hereditary nature. Zh. Nevropatol. Psikhiatr., 69: 1520.

Baker D., Telfer M., Richardson C.E., Clark G.R. 1970. Chromosome errors in men with antisocial behavior: comparison of selected men with Klinefelter's syndrome and XYY chromosome pattern. JAMA, 214: 869-878.

Baker S., Ehrhardt A. 1974. Prenatal androgen, intelligence, and cognitive sex differences. In R.C. Friedman, R.M. Richart and R.L. Vande Wiele (eds.): Sex Differences in Behavior. New York: Wiley.

Bayley N. 1970. Development of mental abilities. In P.H. Mussen (ed.): Carmichael's Manual of Child Psychology. New York: Wiley.

Beard D.B. 1968. Some characteristics of recent memory of centenarians. J. Gerontol., 23: 23-30.

Berry J.W. 1966. Temne and Eskimo perceptual skills. Int. J. Psychol., 1: 207-229.

Blum J.E. 1969. Psychological changes between the seventh and ninth decades of life. Doctoral Diss. New York: St. John's Univ.

Blum J.E., Jarvik L.F., Clark E.T. 1970. Rate of change on selective tests of intelligence: a twenty-year longitudinal study of aging. J. Gerontol., 25: 171-176.

Blum J.E., Fosshage J.L., Jarvik L.F. 1972. Intellectual changes and sex differences in octogenerians: a twenty-year longitudinal study of aging. Dev. Psychol., 7: 178-187.

Blum J.E., Clark E.T., Jarvik L.F. 1973. The New York Psychiatric Institute study of aging twins. In L.F. Jarvik, C. Eisdorfer and J.E. Blum (eds.): Intellectual Functioning in Adults. New York: Springer.

Blum J.E., Jarvik L.F. 1974. Intellectual performance of octogenerians as a function of education and mental ability. Hum. Dev., 17: 364-375.

Bock R.D., Kolakowski D. 1973. Further evidence of sex-linked major-gene influence on human spatial visualizing ability. Am. J. Hum. Genet., 25: 1-14.

Broverman D.M., Klaiber E.L., Kobayashi Y., Vogel W. 1968. Roles of activation and inhibition in sex differences in cognitive abilities. Psychol. Rev., 75: 23-50.

Bruner J.S., Oliver R.R. 1963. Development of equivalence transformations in children. In J.C. Wright and J. Kagan (eds.): Basic Cognitive Processes in Children. Report of the 2nd Conference sponsored by the Committee on Intellective Process Research of the Social Science Research Council. Monogr. Soc. Res. Child Dev.

Coleman J.S. 1961. The Adolescent in Society. Glencoe, Ill.: Free Press.

Cornell E.L., Coxe W.W. 1934. A Performance Ability Scale. Yonkers, New York: World Book Co.

Court-Brown W.M. 1968. The development of knowledge about males with an XYY sex chromosome complement. J. Med. Genet., 5: 341-359.

Crandall V.J., Katkovsky W., Preston A. 1962. Motivational and ability determinants of young children's intellectual achievement behaviors. Child Dev. 33: 643-661.

Crutchfield R.S., Woodworth D.G., Albrecht R.E. 1958. Perceptual performance and the effective person. Lackland AFB. Texas: Personnel La. Rep. WADC-TN-58-60 ASTIA Doc. No. AD151. 039.

Curtiss S., Fromkin V., Krashen S., Rigler D. Rigler M. 1974. The linguistic development of Genie. Language, 50: 528-554.

Doppelt J.E., Wallace W.L. 1955. Standardization of the Wechsler Adult Intelligence Scale for older persons. J. Abnorm. Soc. Psychol., 51: 312-330.

Eichhorn D.W. 1973. The Institute of Human Development studies, Berkeley and Oakland. In L.F. Jarvik, C. Eisdorfer and J.E. Blum (eds.): Intellectual Functioning in Adults. New York: Springer.

https://doi.org/10.1017/S1120962300790263 Published online by Cambridge University Press

Erlenmeyer-Kimling L., Jarvik L.F. 1963. Genetics and intelligence: a review. Science, 142: 1477-1479.
Feingold L. 1950. A psychometric study of senescent twins. Doctoral Diss. New York: Columbia Univ.
Ferguson-Smith M.A. 1970. Chromosomal abnormalities II: sex chromosome defects. JAMA, 212: 88.
Gallagher J. 1964. Productive thinking. In I.M. Hoffman and L. Hoffman (eds.): Review of Child Development Research. New York: Russell Sage Foundation.
Garai J.E., Scheinfeld A. 1968. Sex differences in mental and behavioral traits. Genet. Psychol. Monogr., 77: 169-299.
Garrett H.E. 1946. A developmental theory of intelligence. Am. Psychol., 1: 372-378.
Garron D.C., Vanderstoep L.R. 1969. Personality and intelligence in Turner's syndrome: a critical review. Arch. Gen. Psychiatry, 21: 339-346.
Gazzaniga M.S. 1970. The Bisected Brain. New York: Appleton-Century-Crofts.
Geschwind N. 1970. The organization of language and the brain. Science, 170: 940-944.
Gesell A., Halverson H.M., Thompson H., Ilg F.L., Castner B.M., Ames L.B., Amatruda C.S. 1940. The first five years of life, a guide to the study of the preschool child. In: Yale Clinic of Child Development. New York, London: Harper & Bros.
Gesell A., Ilg F.L., et al. 1949. Child Development: An Introduction to the Study of Human Growth. Book I: Infant and Child in the World Today. Book II: The Child from Five to Ten. New York: Harper & Bros.
Getzels J.W., Jackson P.W. 1962. Creativity and Intelligence: Explorations with Gifted Students. New York: John Wiley.
Gibran K. 1938. The Prophet. New York: Alfred A. Knopf.
Guttman R. 1974. Genetic analysis of analytical spatial ability: Raven's Progressive Matrices. Behav. Genet., 4: 273-284.
Hamerton J.L. 1971. Human Cytogenetics. New York: Academic Press.
Hauser G.A. 1963. Gonadal dysgenesis. In C. Overzier (ed.): Intersexuality. New York: Academic Press.
Haworth M.R. 1966. The Cat-Facts About Fantasy. New York: Grune & Stratton.
Herzberg R., Lepkin M. 1954. A study of sex differences on the primary mental abilities test. Educ. Psychol. Meas., 14: 687-689.
Hess R.D., Shipman V.C. 1965. Early experiences and the socialization of cognitive modes in children. Child Dev., 36: 869-886.
Hobson J.R. 1947. Sex differences in primary mental abilities. J. Educ. Res., 41: 126-132.
Honzik M.P. 1967. Environmental correlates of mental growth: predictions from the family setting at 21 months. Child. Dev., 38: 337-364.
Honzik M.P., McFarlane J.W. 1973. Personality development and intellectual functioning from 21 months to 40 years. In L.F. Jarvik, C. Eisdorfer, and J.E. Blum (eds.): Intellectual Functioning in Adults. New York: Springer.
Hooper F.H. 1969. Piaget's conservation tasks: the logical and developmental priority of identity conservation. J. Exp. Child Psychol., 8: 234-239.
Jakubowska T.K., Graczykowska K., Koczorowska A., Zienkiewicz H. 1969. Psychological examinations in the Turner syndrome. Psychiatr. Pol., 3: 311-318.
Jarvik L.F., Kallmann F.J., Falek A., Klaber M.M. 1957. Changing intellectual functions in senescent twins. Acta Genet. Stat. Med., 7: 421-430.
Jarvik L.F., Kallmann F.J., Lorge I., Falek A. 1962. Longitudinal study of intellectual changes in senescent twins. In C. Tibbits and W. Donahue (eds.): Social and Psychological Aspects of Aging. New York: Columbia Univ. Press.
Jarvik L.F. 1963. Sex differences in longevity. In H.G. Beigel (ed.): Advances in Sex Research. New York: Harper & Row.
Jarvik L.F., Falek A. 1963. Intellectual stability and survival in the aged. J. Gerontol., 18: 173-176.
Jarvik L.F. 1967. Survival and psychological aspects of aging in man. In N.W. Woolhouse (ed.): Some Aspects of the Biology of Aging. Cambridge: Cambridge Univ. Press.
Jarvik L.F., Altschuler K., Kato T., Blumner B. 1971 Organic brain syndrome and chromosome loss. Dis. Nerv. Syst., 32: 159-170.
Jarvik L.F., Klodin V., Matsuyama S.S. 1973. Human aggression and the extra Y chromosome - fact or fantasy? Am. Psychol., 28: 674-682.
Jones H.E., Conrad H.W. 1933. The growth and decline of intelligence: study of a homogeneous group between the ages of ten and sixty. Genet. Psychol. Monogr., 13: 223-298.
Jones H.E. 1959. Intelligence and problem-solving. In J.E. Birren (ed.): Handbook of Aging and the Individual. Univ. of Chicago Press.
Kagan J., Moss H.A., Sigel I.E. 1963. Psychological significance of styles of conceptualization. In J.C. Wright and J. Kagan (eds.): Basic Cognitive Processes in Children. Report of the 2nd Conference sponsored by the Committee on Intellective Process Research of the Social Science Research Council. Monogr. Soc. Res. Child Dev.
Kagan J. 1964. Acquisition and significance of sex typing and sex role identity. In M. Hoffman, L. Hoffman (eds.): Review of Child Development Research. I. New York: Russell Sage Foundation.
Kallmann F.J., Sander G. 1949. Twin studies on senescence. Am. J. Psychiatry, 106: 29-36.
Lansdell H. 1961. The effect of neurosurgery on a test of proverbs. Am. Psychol., 16: 448.
Lansdell H. 1973. Effect of neurosurgery on the ability to identify popular word associations. J. Abnorm. Psychol., 81: 255-258.
Lenneberg E. 1967. Biological Foundations of Language. New York: Wiley.

https://doi.org/10.1017/S1120962300790263 Published online by Cambridge University Press

Lewis V., Money J., Epstein R. 1968. Concordance of verbal and nonverbal ability in the adrenogenital syndrome. Johns Hopkins Med. J., 122: 192-195.
Ludwig E.G., Collette J.C. 1971. Some misuses of health statistics. JAMA, 216: 493-499.
MacArthur R. 1967. Sex differences in field dependence for the Eskimo: replication of Berry's findings. Int. J. Psychol., 2: 139-140.
Maccoby E.E. 1966. Sex differences in intellectual functioning. In E.E. Maccoby (ed.): The Development of Sex Differences. Stanford: Stanford Univ. Press.
Maccoby E.E., Jacklin C.N. 1974. The Psychology of Sex Differences. Stanford: Stanford Univ. Press.
McNemar Q. 1942. The Revision of the Stanford-Binet Scale: An Analysis of the Standardization Data. Boston: Houghton-Mifflin.
Masica D.N., Money F. 1969. IQ, fetal sex hormones and cognitive patterns: studies in the testicular feminizing syndrome of androgen insensitivity. Johns Hopkins Med. J., 124: 34-43.
Mellone M.A. 1944-45. A factorial study of picture tests for young children. Br. J. Psychol., 35: 9-16.
Money J. 1963. Cytogenetic and psychosexual incongruities with a note on space-form blindness. Am. J. Psychiatry, 119: 820-827.
Money J. 1964. Two cytogenetic syndromes: psychologic comparisons. I. Intelligence and specific factor quotients. J. Psychiatr. Res., 2: 223
Money J., Alexander D. 1966. Turner's syndrome: further demonstration of the presences of specific cognitional deficiencies. J. Med. Genet., 3: 47-48.
Money J., Lewis V. 1966. IQ, genetics and accelerated growth: adrenogenital syndrome. Bull. Johns Hopkins Hosp., 118: 365-373.
Money J., Drash P.W., Lewis V. 1967. Dwarfism and hypopituitarism: statural retardation without mental retardation. J. Ment. Defic. Res., 72: 122-126.
Money J., Ehrhardt A.A., Masica D.N. 1968. Fetal feminization induced by androgen insensitivity in the testicular feminizing syndrome: effect on marriage and maternalism. Johns Hopkins Med. J., 123: 105-114.
Morgan C.T. 1971. Introduction to Psychology [4th edition]. New York: McGraw-Hill.
Norman R.D. 1953. Sex differences and other aspects of young superior adult performance on the Wechsler-Bellevue. J. Consult. Psychol., 17: 411-418.
Oetzel R. 1961. The relationship between sex role acceptance and cognitive abilities. Master's thesis. Stanford: Stanford University.
Oetzel R. 1966. Classified summary of research in sex differences. In E.E. Maccoby (ed.): The Development of Sex Differences. Stanford: Stanford University Press.
Price B. 1933*a*. A direction test arranged as an interview and a determination of adult age effects therewith. Doctoral Diss. Stanford: Stanford University.
Price B. 1933*b*. Grasping of spoken directions as an age function in adults. Psychol. Bull. 30: 588-589.
Repucci N.D. 1969. Social class, sex differences, and performance on cognitive tasks among two-year-old children. Proceedings, 77th Annual Amer. Psych. Assoc., 4: 553-554.
Riesman D., Glazer N., Denney R. 1950. The Lonely Crowd: A Study of the Changing American Character. New Haven: Yale University Press.
Russel B. 1927. Philosophy. New York: Norton & Co.
Schaffer J.W. 1962. A specific cognitive deficit observed in gonadal aplasia (Turner's syndrome). J. Clin. Psychol., 18: 403.
Sigel I.E., Jarmen P., Hanesian H. 1963. Styles of categorization and their perceptual, intellectual and personality correlates in young children. Unpublished paper, Merrill-Palmer Institute.
Sontag L.W., Baker C.T., Nelson V.L. 1958. Mental growth and personality development: a longitudinal study. Monogr. Soc. Res. Child Dev., 23: 2.
Stafford R.E. 1961. Sex differences in spatial visualization as evidence of sex-linked inheritance. Perceptual and Motor Skills 13: 428.
Sutton-Smith B., Rosenberg B.G., Morgan E.F. Jr. 1963. Development of sex differences in play choices during preadolescence. Child Dev., 34: 119-126.
Sutton-Smith B., Crandall V.J., Roberts J.M. 1964. Achievement and strategic competence. Paper presented at the Eastern Psychol. Assoc.
Tanner J.M. 1962. Growth at Adolescence [2nd edition]. Oxford: Blackwell Scientific Publications.
Terman L.M. 1916. The Measurement of Intelligence. Boston: Houghton-Mifflin.
Terman L.M., Merrill M.A. 1960. Stanford-Binet Intelligence Scale Manual for 3rd Revision Form L-M. Boston: Houghton-Mifflin.
Thurstone L.L. 1957. Primary Mental Abilities. Chicago: University Press.
Torrance E.P. 1959. Current research on the nature of creative talent. J. Counsel. Psychol., 6: 309-316. In A. Anastasi (ed.): Individual Differences. New York: John Wiley & Sons.
Torrance E.P. 1962. Guiding Creative Talent. Englewood-Cliffs: Prentice-Hall.
Wada J.A. 1974. Morphologic asymmetry of human cerebral hemispheres: temporal and frontal speech zones in 100 adult and 100 infant brains. Neurology, 24: 349.
Wechsler D. 1944. The Measurement of Adult Intelligence. Baltimore: Williams & Wilkins.
Wechsler D. 1949. Wechsler Intelligence Scale for Children. New York: Psychological Corp.
Wechsler D. 1958. The Measurement and Appraisal of Adult Intelligence. Baltimore: Williams & Wilkins.
Wilson R.S., Harpring E.B. 1972. Mental and motor development in infant twins. Dev. Psychol., 7: 277-287.

https://doi.org/10.1017/S1120962300790263 Published online by Cambridge University Press

Witkin H.A. 1962. Psychological Differentiation: Studies of Development. New York: John Wiley & Sons.

Witkin H.A. 1966. Cultural influences in the development of cognitive style. In Cross-Cultural Studies in Mental Development. Symposium 36, 18th Int. Congr. Psychol., Moscow.

RIASSUNTO

L'Intelligenza nell'Uomo: Differenze Sessuali

Un'ampia rassegna bibliografica sul problema delle differenze sessuali nell'intelligenza conduce alla conclusione che vi sono chiare indicazioni di differenze sessuali nell'elaborazione dell'informazione verbale e dell'informazione spaziale. I pochi studi genetici disponibili indicano tutti un meccanismo di trasmissione legato al sesso per alcune capacità spaziali.

RÉSUMÉ

L'Intelligence chez l'Homme: Différences Sexuelles

Une revue du problème des différences sexuelles dans l'intelligence conduit à la conclusion qu'il existent de claires indications pour des différences sexuelles dans l'élaboration des informations verbales et des informations spatiales. Les rares études génétiques indiquent toutes un mécanisme d'hérédité liée au sexe pour quelques abilités spatiales.

ZUSAMMENFASSUNG

Die Intelligenz beim Menschen: Geschlechtsunterschiede

Eine Übersicht über die Literatur, die sich mit dem Problem der Geschlechtsunterschiede in der Intelligenz befassen, führt zum Ergebnis, dass deutliche Anzeichen von Geschlechtsunterschieden in der Verarbeitung der verbalen Information und der Rauminformation bestehen. Die wenigen verfügbaren Erbuntersuchungen darüber geben für einige Raumfähigkeiten alle einen geschlechtsgebundenen Übertragsmechanismus an.

L.F. Jarvik, M.D., Ph.D., 760 Westwood Plaza, Los Angeles, California 90024, USA.

https://doi.org/10.1017/S1120962300790263 Published online by Cambridge University Press