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Assortative Marriage and the Familiality of Cognitive Abilities in Families of Extremely Gifted Students*

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The top 1% of the extremely bright students identified by the Study of Mathematically Precocious Youth (Benbow & Stanley, 1980b) were tested along with their parents, using a battery of specifically designed cognitive tests. These students represented the top 0.03% of their age group in intellectual ability. The results showed that the parents were extremely able and resembled one another significantly more than parents in the general population. In addition, the intellectually precocious children resembled their parents to a lesser extent than children of average ability resemble their parents. These results suggest that considerable assortative mating has occurred among the parents of these extremely gifted youth, but that extreme giftedness cannot be predicted reliably solely as a result of the mating of bright parents.

The Study of Mathematically Precocious Youth (SMPY) identified approximately 10,000 junior high school students of high mathematical reasoning ability in a 7 year period (Benbow & Stanley, 1980b, 1981). A small fraction of these students (1%) attained extremely high scores on the mathematics and/or the verbal portions of the Scholastic Aptitude Test (SAT-M and SAT-V) (Angoff, 1971;

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Messick & Jungeblut, 1981). The present study examined these students and their parents on a battery of difficult cognitive tests designed for extremely bright individuals (see Benbow, Stanley, Kirk, & Zonderman, this issue).

Familial resemblance, or the familiality of cognitive abilities in families scoring within three standard deviations of the mean of the population, has been studied for some time (Erlenmeyer-Kimling & Jarvik, 1973; Plomin & DeFries, 1980). Strong evidence for a heritable contribution to individual differences in intelligence has been found. In general, these studies suggest that approximately one-half of the differences among individuals is due to genotypic differences. Moreover, the evidence is as similar for specific cognitive abilities as for intelligence in general (DeFries, Johnson, Kuse, McClearn, Polovina, Vandenberg, & Wilson, 1979; DeFries, Vandenberg, & McClearn, 1976). These studies are based on samples in the average range of scores. Evidence is lacking, however, for the relative influences of these factors at the high end of the intellectual abilities distribution. This study is the first attempt to examine whether the genetic and environmental components of variation in cognitive abilities in the high range of the distribution of intellectual abilities are similar to those already found in the middle range.

METHOD

Benbow et al. (this issue) present a detailed description of the methods used to gather the data for this study. Since all the information provided there, except for the actual analysis, is the same as needed for background for this paper, only a summary of the methods is provided here.

Subjects

Students were selected from the SMPY program, which identified mathematically precocious students by administering the SAT-M and SAT-V[1] to intellectually talented youth between 12 and 14 years of age residing in the mid-Atlantic region (Benbow & Stanley, 1980a, 1982).[2] Selection for participation was based on "precocity quotients" derived from SAT scores (see Benbow, et al., this issue; Kirk, 1978, 1980). "Precocity quotients" ranged from approximately 120 to 235. They are conceptually similar to Stanford-Binet IQ's. Students with "precocity quotients" greater than 170 (100 boys and 14 girls) and their parents were declared eligible for further cognitive testing. Approximately 1% of talent search participants met this selection criteria, representing an estimated frequency of less than 1 in 3000 of their age group.

[1]In two of the annual talent searches, 1972 and 1974, the SAT-V was not administered.

[2]Usually, the SAT is taken by college-bound seniors, who are 4 to 5 years older than the SMPY students were when tested.

Of the 114 students invited to participate, 12 girls (86%) and 60 boys (60%) attended one of three identical testing sessions conducted during the Summer and Fall of 1979. Although the youth and both parents were invited to participate, approximately one-half of the students were tested with only one of their parents. Thirty-five trios (i.e., students and their mothers and fathers) were tested. Including the single-parent administrations, 46 mothers and 45 fathers were tested. Eighteen students were tested without their parents.

The average ages of the children in this sample at the time of testing was 15.1 years for boys and 13.5 for girls.[3] The average ages of their parents were 45.5 years for fathers and 42.5 years for mothers. The boys had an average of 10 years of education; the girls had an average of 8. Fathers averaged 17 years of education, mothers 16.

Cognitive Tests

Listed below is the battery of tests administered to all subjects. A detailed description of the tests, and the comparability of these tests to other tests, is not repeated here, since it is included in Benbow et al. (this issue). The testing sessions were conducted using a standardized format, requiring approximately 5 hours.

1. Stake's *Quantitative Evaluative Device* (QED) predicts competence in the quantitative aspects of graduate research and study.
2. Owens and Bennett's *Mechanical Comprehension Test* (MC) measures the ability to understand physical and mechanical relationships. Form CC, the most difficult, was used.
3. Terman's *Concept Mastery Test* (CMT) was designed to assess abstract reasoning ability in adults of an average age of 40, most of whom had scored at least 140 on the Stanford-Binet as children.
4. *California Test of Mental Maturity* (CTMM) measues mental maturity in adolescent and adult populations. Three language subtests, two that consist of verbal items and one of arithmetic reasoning items, were utilized.
5. Kirk's *Synonym-Antonym* Test (SA) measures vocabulary at a "general reading," rather than technical, level. Form Ce, consisting of 100 items, was used.
6. Kirk's *General Information Test* (GI) measures knowledge of facts, concepts, and terminology in three content areas: mathematics and hard science, social science, and humanities. Form Cel was used.

[3]The girls tended to be younger than the boys because in the early years of this study few girls scored high enough on SAT-M to meet the criterion for inclusion in this study. In 2 of the 3 early years (1972 and 1974), only SAT-M scores were available, thus they were the only component in the precocity quotient.

7. Kirk's *Test of Semantic Comprehension* (SC) measures the ability to comprehend conceptually complex passages that employ a high school vocabulary. Form Cel was used.
8. Kirk's *Cubes Test* (C) assesses the ability to form and manipulate spatial images. Form Be was used.
9. Kirk's *Rotation-Inversion* Test (RI) assesses spatial ability, using a format similar to but more difficult than the Cubes Test mentioned above. Form Cel was used.

Designed specifically for testing extremely gifted subjects, the latter five tests form an experimental battery. The subjects were extremely able, so these tests were designed to be sufficiently difficult for them—that is, they were designed to avoid "ceiling effects." The entire test battery[4] was hand-scored by one researcher and rescored by another. Discrepancies were resolved by a third scorer.

RESULTS

Benbow, et al. (this issue) present descriptive statistics for this sample, which showed no restriction of range in scores. Since test scores showed a significant relationship to age, they were adjusted for second-degree polynomial age effects by separate groups regression for fathers, mothers, sons, and daughters. Separate age regression analyses were performed for the children, mothers, and fathers, and all subsequent analyses used scores adjusted for age separately within each of these groups.

The assortative marriage (phenotypic similarity between spouses) and familiality results for the nine tests are displayed in Table 1. Assortative marriage was assessed by correlating the parents' age-adjusted test scores. Parents' scores were significantly correlated on all nine tests. Correlations ranged from .32 on the Cubes test to .58 on the Mechnical Comprehension Test. The median between-spouses correlation was .46. (The correlations were *not* corrected for attentuation due to errors of measurement.)

This is similar to the results Jensen (1978) found in his review, but substantially higher than was found by DeFries, et al. (1979). Jensen (1978) reported that the unweighted mean of 43 spouse correlations for various tests of mental ability was .45. This figure may have been inflated because there was no adjustment for age. Marked age effects will inflate correlations between husbands and wives because the scores of spouses are highly correlated for age (Johnson, DeFries, Wilson, McClearn, Vandenberg, Ashton, Mi, & Rashad, 1976; Zonderman, Vandenberg, Spuhler, & Fain, 1977). Thus, if Jensen's figure is inflated and if, for the general population, the figure obtained by DeFries et al.

[4]These tests are available upon request from Marshall K. Kirk, Department of Psychology, Harvard University, Cambridge, MA 02138.

(1979) is more reliable (i.e., between .10 and .13), it can be concluded that among intellectually talented parents assortative marriage is stronger.

Familiality was assessed by calculating the regression of offspring on parents (DeFries, 1967; DeFries, et al., 1978). Three sets of these regressions are shown: offpsring on fathers, offspring on mothers, and offspring on mid-parents (the average of father and mother's scores). The third regression, offspring on mid-parent, is included because, as an estimate of familiality, it is not influenced by assortative mating in the data (Plomin, DeFries, & Roberts, 1977). It was not expected that the three sets of regressions would yield exactly parallel results, since they could not be based on identifical samples of families. Although approximately one-half of the sample is comprised of full families, there is insufficient overlap to expect nearly identical results in all three regressions. The present sample, however, has sufficient overlap to expect similar results, in an absence of effects due to sex.

The median values for the father, mother, and mid-parent regression coefficients were .17, .09, and .11, respectively. These are considerably lower than has been reported for populations selected without regard to ability (DeFries, et al., 1979; Plomin & DeFries, 1980; Scarr & Weinberg, 1977, 1978; Williams, 1975). These investigators found that in unselected populations the regressions

TABLE 1
Age-adjusted Spouse Correlations and Parent-Offspring Regressions for Nine Cognitive Tests Among an Extremely Intelligent Segment of the Population

	Spouse Correlation	Regression of Child on Father	Regression of Child on Mother	Regression of Child on Mid-parent
Quantitative Evaluative Device	0.38*	0.11	0.03	0.11
Mechanical Comprehension	0.58**	−0.08	0.09	−0.12
Concept Mastery Test	0.32*	0.17	0.21	0.27
CTMM-Language	0.41**	0.41**	0.13	0.32
Synonym-Antonym	0.31*	0.19	−0.01	0.10
General Information	0.44**	0.40**	0.05	0.41**
Semantic Comprehension	0.33*	0.15	−0.03	0.02
Cubes	0.27	0.37**	0.33**	0.47**
Rotation-Inversion	0.44**	0.06	0.14	0.09
n	35	42	44	34

$^{*}p < .05$
$^{**}p < .01$

of offspring on mid-parent were in the .42 to .60 range. As judged by performance on the CTMM and the associated standard deviations, our results were not due to restriction of range.

In order to study whether there was differential heritability among various mental ability tests, the regressions for each test were grouped according to whether the test was verbal or primarily nonverbal. No important differences were seen in the reliabilities of the verbal versus nonverbal tests. Yet, the median regression coefficient for the verbal tests was .17, and for the nonverbal tests .10. Of the nonverbal tests, Cubes, a measure of spatial ability, had the largest regression coefficients. These figures may be indicative of differential heritability among various mental ability tests. Such findings may support the work of DeFries, et al. (1979), but not Loehlin and Nichols (1976). Our data are only suggestive, however, since a relatively small number of different mental ability tests was utilized and the differences were small.

DISCUSSION

Benbow, et al. (this issue) showed that the top 1% of the extremely bright students identified by SMPY (i.e., representing a frequency of less than 1 in 3000 in intellectual ability) tended to have less intelligent parents than themselves, but nonetheless quite able ones. Vernon's (1961) model of intelligence best fits the data. His verbal-educational and practical-spatial-mechanical factors explained most of the variance in the scores on tests of specific mental abilities of these students and parents. In addition, there was some evidence for *g*. Moreover, among the children, who were for the most part past puberty, the development of verbal abilities, but not spatial or mechanical abilities, was related to age. Males were found to score higher than females on tests of spatial ability and mechanical comprehension. The present study investigated the degree of familiality and assortative marriage among the most extremely intellectually talented segment of the population. Although the sample size appears rather small, one must consider how rare such extremely bright individuals are in the population. Yet, of course, the stability of the statistics used will be influenced by this small N.

Evidence was found which suggests that, in the high-ability segment of the population, the degree of assortative marriage may be greater than in the general population, but the degree of familiality less. Several other possible explanations of the results are pursued below.

The median correlation between age-adjusted spouses was .46, compared to between .10 and .13 found by DeFries, et al. (1979). Our correlation may be higher than would be expected in typically highly-gifted families because of the selection criteria for this study. We first identified students who reasoned extremely well mathematically, or both mathematically and verbally. Their mean IQ on a heavily verbal test was found to be approximately 165 (Benbow, et al., this issue). Having identified the youths, we then located the parents, who were also bright (i.e., the IQs of both fathers and mothers averaged about 150). It appears then, as expected, that the probability for highly precocious children to have extremely able parents is much greater than for them to have average-ability parents.

It also seems logical that bright individuals may have a higher degree of assortative marriage than individuals of average ability. Meredith (1973) showed how parents who are gifted in verbal ability could provide their children with both genes and environment conducive to the development of verbal ability. The parents in our study may have grown up in similar environments that foster high intellectual ability. Moreover, it has been shown that education is the chief characteristic by which assortment takes place and that parental SES is relatively unimportant (Watkins & Meredith, 1981). The parents in this study tended to be highly educated. A limiting factor in our results is that the parents volunteered to attend the testing session. It is not known why some parents came and some did not. There was no evidence, however, that some systematic factor influenced the choice to attend the testing session.

Among our extremely gifted subjects, the degree of familiality was lower than in the general population. Part of the reason for this may be an active genotype-environment interaction (Plomin, DeFries, & Loehlin, 1977). The students in this study were so extremely bright that even their bright parents found it virtually impossible to provide home and educational environments compatible with their child's abilities. Thus, the bright children may actively manipulate the environment to make it congruent with their abilities. For example, one of the most precocious students SMPY has ever identified has a father who is manual laborer and a mother who had not attended college. The parents could not, by themselves, provide an environment compatible with this boy's ability, because by age 12 he had already surpassed them educationally and intellectually. Thus, the boy began manipulating the environment to make it fit his needs. For example, when the boy wanted books or desired to attend a special course, he told the parents and they provided the means to do so. These parents had unusually little formal education, considering how brilliant their son was. Better educated families, however, are often equally perplexed.

Since the parents in this study were bright as judged by their IQs, it appears almost essential that at least one, or usually both, the parents be bright in order to have an extremely gifted child. It is unpredictable, however, as to whether any given child of bright parents will be extremely precocious. These extremely bright children must be viewed as unpredictable combinations of alleles or environments. Our findings are limited by the relatively small sample size, the experimental nature of some of the tests, and the fact that only a few primary mental abilities were tested.

We conclude that parent-offspring similarity at the high end of the distribution of cognitive ability is probably less than parent-offspring similarity over the remainder of the distribution. This indicates that the etiology of individual differences at the high end of the distribution may be somewhat dissimilar to that in the rest of the distribution. Moreover, the degree of assortative marriage appeared higher than is normally reported for the general population.

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