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Effects of Inbreeding on Raven Matrices

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Indian Muslim school boys, ages 13 to 15 years, whose parents are first cousins, were compared with classmates whose parents are genitically unrelated on the Raven Standard Progressive Matrices, a nonverbal test of intelligence. The inbred group (N = 86) scored significantly lower and had significantly greater variance than the noninbred group (N = 100), both on raw scores and on scores statistically adjusted to control for age and socioeconomic status. Genetic theory predicts both of these effects for a polygenic trait with positive directional dominance.

KEY WORDS: inbreeding depression; intelligence; Raven matrices; heritability; polygenic theory.

INTRODUCTION

The effect of inbreeding on the mean of a quantitative trait conditioned by polygenic factors is directly related to the amount of directional dominance deviation involved in the trait and to the coefficient of inbreeding. The coefficient of inbreeding, f, is the average probability over all gene loci that the same allele on both homologous chromosomes comes from the same ancestor (Crow and Kimura, 1970, pp. 64–65). If the alleles which enhance the phenotypic expression of the trait are dominant, the effect of inbreeding is to lower the mean of the trait in the inbred group relative to the mean of a noninbred but otherwise comparable population. This phenomenon is known as *inbreeding depression*. Also, because inbreeding brings out previously hidden recessive factors which contribute to the phenotypic variance, the variance of the trait is increased by in-

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breeding. The theory of the genetic mechanism responsible for these statistical effects of inbreeding on polygenic traits has been explicated elsewhere (Crow and Kimura, 1970; Jensen, 1978).

The effects of inbreeding in humans have been investigated by studies of the offsprings of incestuous matings ($f = \frac{1}{4}$), and of double first cousins ($f = \frac{1}{8}$), first cousins ($f = \frac{1}{16}$), first cousins once removed ($f = \frac{1}{32}$), and second cousins ($f = \frac{1}{64}$). Effects of inbreeding which are consistent with the theoretical genetic expectations have been reported in 11 studies (Adams and Neel, 1967; Bashi, 1977; Böök, 1957; Carter, 1967; Cohen *et al.*, 1963, Neel, 1970; Reed and Reed, 1965; Schull and Neel, 1965, 1972; Seemanova, 1971; Slatis and Hoene, 1961). These studies have been reviewed in an article by Jensen (1983), which also showed that variation in the degree of inbreeding depression found on the various subtests of the Wechsler Intelligence Scale for Children (WISC) is directly related to the subtests' loading on the general factor, *g*, which is common to all the subtests. Performance on tests with the largest and purest saturation of *g* is subject to the greatest degree of inbreeding depression. This finding is consistent with a polygenic theory of intelligence in which there is positive directional dominance; that is, dominant genes enhance phenotypic intelligence. The fact that inbreeding depresses intelligence is evidence for genetic dominance of intelligence-enhancing genes. The presence of directional dominance also suggests that intelligence is a fitness character which has been subjected to natural selection in the course of human evolution. It is of considerable interest that our present standard psychometric tests are capable of reflecting to some extent this biological aspect of human intelligence. This theory is spelled out in greater detail elsewhere (Jensen, 1983).

A problematic feature of a number of studies of inbreeding depression of psychometric intelligence arises from the fact that, in certain populations, inbreeding is negatively correlated with socioeconomic status (SES); that is, consanguineous matings occur more frequently among persons of lower SES than among persons of higher SES. Because SES is usually positively correlated with intelligence measurements, interpretation of the lower mean scores of inbred groups, as compared with noninbred groups, is rendered somewhat ambiguous. Although statistically controlling SES has had little effect on the magnitude of inbreeding depression of the IQ, it has been argued, however unconvincingly, that perhaps not all of the relevant SES factors have been fully taken account of (Kamin, 1980). A study of inbreeding in Israeli Arabs, however, found a significant degree of inbreeding depression of intelligence scores despite the fact that inbreeding was more prevalent in the upper socioeconomic classes than in the lower classes of Arab society (Bashi, 1977).

While the third author was a visiting lecturer at the University of Rajasthan, in Jaipur, India, he learned that marriage between cousins was a not uncommon custom in Jaipur's Muslim community. (However, consanguineous marriages are quite rare among Hindus.) But more important, cousin marriages are also more frequent among the well-to-do Muslim classes, as a means of preserving wealth in family lines. As this seemed an ideal population in which to examine the effects of inbreeding on mental test scores, the present study was initiated.

METHOD

Subjects. The *S*s were 186 male students in two government higher secondary schools in Jaipur, Rajasthan, India. All the *S*s were Indian Muslims. With their parents' consent, they volunteered to participate in the study. Consanguinity of the *S*s' parents was ascertained by interview and a questionnaire given to the parents. A total of 86 inbred *S*s was found. All were offsprings of first-cousin matings. There were no double first cousins. Also, a noninbred control group was secured, consisting of 100 *S*s whose parents claimed no genetic kinship.

All the *S*s were between 13 and 15 years of age. The means and standard deviations of age (in years) of the inbred and noninbred groups are 13.6, SD = 0.60, and 13.7, SD = 0.59, respectively—a nonsignificant difference (t = 1.73, df = 184, P = 0.085).

Mental Test. The Standard Progressive Matrices (Raven, 1960) is a nonverbal test of reasoning ability consisting of figural patterns and geometric forms which are found in virtually all cultures. When factor analyzed among other diverse tests of mental ability, the matrices test is highly loaded on the general factor, g, which is common to all complex tests of cognitive ability and is the largest source of variance in all tests of intelligence.

The test was administered according to the standard instructions in the test manual (translated into Hindi), with a 1-h time limit. *S*s were tested in groups of six by the first author.

Socioeconomic Status. An index of SES was derived from information obtained in a questionnaire filled out by the *S*s' parents. The questionnaire sought information considered most indicative of SES in the Indian Muslim population of Jaipur: father's education (years), mother's education, father's occupation, father's monthly income, number of siblings, home owned vs. rented, number of rooms in house/number of persons in household, monthly food expenditure/number of persons, and ownership of a car, TV, or refrigerator. The items were quantified by rating the responses to each item on a Likert-type scale varying from two

Table I. Correlations Between Variables in the Inbred (Above Diagonal) and Noninbred (Below Diagonal) Groups

Variable	Age	SES	Matrices
Age		0.219*	0.193*
SES	0.076		−0.110
Matrices	0.145	0.039	

* $P < 0.05$.

to six points. These ratings were transformed to standard scores and the overall SES index is expressed as a T score, with a mean of 50 and a standard deviation of 10 in the combined groups ($N = 186$).

RESULTS

Socioeconomic Status. The means and SDs of the T-score index of SES of the inbred and noninbred groups are 50.45, SD = 9.90, and 49.62, SD = 10.12. The SES difference of 0.083σ is nonsignificant ($t < 1$). (All group differences in this study are expressed as σ units, where σ is the square root of the N-weighted mean of the variances of each of the groups.)

Correlation Between Variables. Table I shows the correlations among age (in months), SES, and raw scores on the progressive matrices.

Progressive Matrices. Figure 1 shows the relative frequency distribution of raw scores of the inbred and noninbred groups. The shape of the distribution differs significantly ($\chi^2 = 32.41$, df = 9, $P < 0.001$). The significant difference in the shapes of the distributions is mainly the result of the inbred group's disproportionately larger frequency of lower scores. Scores of 25 and below were obtained by 44% of the inbred group and by only 11% of the noninbred group—a significant difference ($\chi^2 = 19.33$, df = 1, $P < 0.001$).

To control for the slight group differences in age and SES, the matrices scores were adjusted for these variables by multiple regression, in the combined groups regressing age (in months) and SES out of every subject's Raven score. (Analysis of covariance was also applied and yielded identical results.) Table II shows the statistics, both for raw scores and for adjusted scores. The group means differ significantly, by slightly more than half of a standard deviation, favoring the noninbred group. This finding is in accord with the prediction from genetic theory.

Genetic theory also predicts greater variability among inbred than among noninbred individuals. This prediction is tested by the variance

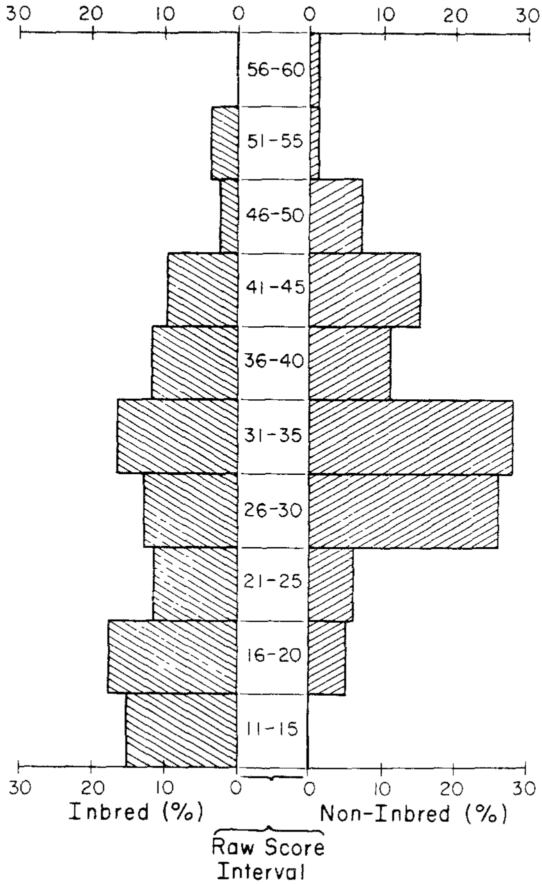

Fig. 1. Relative frequency distributions of Standard Progressive Matrices raw scores in the inbred and noninbred groups.

Table II. Group Statistics on Matrices Raw Scores and Scores Adjusted for Age and SES

	Noninbred		Inbred			
Score	Mean	SD	Mean	SD	σ difference	t test
Raw	34.02	8.19	28.30	10.96	0.597	3.97*
Adjusted	33.75	8.21	28.62	10.66	0.545	3.63*

* Two-tailed t test, $P < 0.001$.

ratio, F (i.e., variance of inbred/variance of noninbred) using the variances adjusted for age and SES. The prediction is borne out significantly (F = 1.69, df = 85/99, $P < 0.01$).

The correlation between inbreeding (quantitized as inbred = 1, noninbred = 0) and matrices, with SES and age statistically controlled, is −0.263 ($P < 0.001$).

DISCUSSION

Both genetic predictions of the effects of inbreeding on a polygenically conditioned trait with positive directional dominance were significantly borne out: the inbred group (the male offsprings of firsts cousins) shows a lower mean and larger variance than a noninbred group on a highly *g*-loaded test of mental ability. Statistically controlling the slight group differences in age and SES did not affect the results appreciably. In any case, the lower mean mental test score of the inbred group could not be attributed to SES, because the inbred group was of slightly (but nonsignificantly) higher SES than the noninbred group.

A study by Schull and Neel (1965) of the offsprings of consanguineous parents in Japan showed inbreeding depression of 3.7 IQ points on the Wechsler Full Scale IQ. But the inbred Japanese sample comprised offsprings of second cousins and first cousins once removed (with inbreeding coefficients of $\frac{1}{64}$ and $\frac{1}{32}$, respectively) as well as offsprings of first cousins ($f = \frac{1}{16}$). Inbreeding depression in offsprings of first cousins in the Japanese sample amounts to about 5 IQ points, or one-third of a standard deviation ($1\ \sigma$ = 15 IQ points). The inbreeding depression in the present study is 0.55σ, or equivalent to about 8 IQ points. The difference of 3 IQ points between the Japanese and the Indian samples could be due to smaller within-group standard deviations in the Indian samples, making for a relatively larger difference between their means when the difference is expressed as σ units. Or it could be due to the fact that the matrices test is more highly *g* loaded than the Wechsler IQ, which, in addition to *g*, also reflects verbal and performance factors. As shown elsewhere (Jensen, 1983), the magnitude of inbreeding depression is directly related to the Wechsler subtests' loading on the *g* factor and inversely related to their loadings on the performance factor (independent of *g*).

The results of the present study are consistent with those of at least 11 other studies which have reported the genetically predictable effects of inbreeding depression and increased variance in psychometric assessments of intelligence. Not a single empirical study has yet been reported in the literature which contradicts the effects of inbreeding on intelligence predicted by genetic theory.

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