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NATURE WITH NURTURE: A REINTERPRETATION OF THE EVIDENCE

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Although Jensen's (1969a, 1969b) argument claiming genetically-based race differences in intelligence has been repeatedly and forcefully attacked (e.g., Scarr-Salapatek, 1971a), his thesis that 80 percent of the variation in intelligence is determined by heredity has been generally accepted (e.g., Scarr-Salapatek, 1971b). Since Jensen takes this thesis as the foundation both for his argument for innate differences in ability between the races, and for his contention that intervention programs with disadvantaged groups have little hope of success, it becomes important, both from the point of view of science and of social policy, to examine the evidence and line of reasoning that underlie his initial thesis. Jensen's argument rests on inferences drawn primarily from three sets of data:

1. Studies of resemblance between identical twins reared apart.
2. Studies of resemblance between identical vs. fraternal twins reared in the same home.

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3. Studies of resemblance within families having own children vs. adopted children.

Identical twins reared apart. The findings for this group are generally regarded as making the strongest case for genetic influence primarily because of the striking similarities in abilities, temperament, and other characteristics shown by twins separated from each other early in life. The most important index of this similarity, because it can be interpreted in terms of the proportion of variation accounted for, is the *intraclass r*. First proposed by R. A. Fisher, this measure differs from the conventional correlation coefficient in being interpretable in percentage terms. The smaller the difference between the two members of a twin pair, the closer r_I will come to its maximal value of 1.00. In the four published studies of identical twins reared apart the interclass r's were as follows: .66 (Juel-Nielsen, 1964), .67[1] (Newman, Holzinger, and Freeman, 1937), .77 (Shields, 1962), and .87 (Burt, 1966). Taking .75 as an average figure, Jensen draws the following conclusion:

> Since MZ twins develop from a single fertilized ovum and thus have exactly the same genes, any difference between them must be due to nongenetic factors. And, if they are reared apart in uncorrelated environments, the difference between a perfect correlation (1.0) and the obtained correlation (.75) gives an estimate of the proportion of the variance in IQs attributable to environmental differences: $1.00 - 0.75 = 0.25$. Thus, 75 percent of the variance can be said to be due to genetic variation (this is the heritability) and 25 percent to environmental variation (Jensen, 1969a, p. 50).

The conclusion drawn by Jensen rests on two fundamental assumptions. The first is acknowledged in the foregoing passage by the short but critical qualifying phrase: "in uncorrelated environments." *This condition requires that there be no relation between the quality of the environment into which one twin is placed and that into which the other twin is placed.* Otherwise any psychological resemblance between the twins would be due not only to their identical genetic endowment but also to their similar environments both before and after separation. By the same token, any tendency to place twins in similar environments would reduce the environmental variation between them, and, hence, any corresponding intra-pair difference in ability, which is the only variance attributed to environment in Jensen's model. It is therefore a matter of considerable importance whether the stipulated condition of "uncorrelated environments" is actually met.

The second assumption is necessary if one is to generalize, as Jensen and others do, from findings derived from samples of twins to the general population. To make this generalization, *one must assume that the range of environments into which separated twins are placed is as great as that for unrelated children of the same sex and age.* For, if the settings into which separated twins go are in fact restricted to some segment of the total environment in which families are found, then the power of the environment to effect variation in abilities is also restricted in proportionate degree. Such environmental restriction would arise if there were some selection of foster families, for example, in terms of social status, educational resources, age of parents, family structure, or values and practices of child rearing. Under such circumstances, the possible contribution of differences in environment to variability among foster children (including separated twins) would necessarily be smaller than among children in the general population distributed across the full range of existing environments.

Although the two basic assumptions are theoretically independent, their relevance for the issue at stake can be summarized in a single principle: for identical twins reared apart, the intraclass r can be interpreted as the proportion of variance attributable to genetic influence for the general population, *if, and only if, the variability of environments into which twins are separated is as great as that for unrelated children of the same sex and age.*

To what extent does the foregoing assumption hold for the samples on the basis of which Jensen and others draw their conclusions? The data most relevant to this issue come from the first and, from a number of points of view, the most carefully analyzed study of identical twins reared apart, that of Newman, Holzinger, and Freeman (1937) conducted at the University of Chicago. In their study, ratings of educational, social, and physical environmental differences for each twin pair were made by five judges. Although the reliability of ratings was "highly satisfactory" (.90 or above in each of the three areas), the majority of the differences were very low. Intraclass r's cannot be computed for these ratings, since they were published only in difference form. The individual case reports, however, provided information on the number of years of schooling for each twin. The intraclass r for this variable was .55. Taken as a whole, these data indicate a definite tendency for the members of a twin pair to be placed in somewhat similar social, educational, and health settings. The consequences of this fact are emphasized by the original authors:

> These distributions [of differences] have a very important bearing on the comparisons which follow because the effect of each type of environment on the whole group of twins will not be so pronounced as if each pair had marked differences in environment (Newman, Holzinger, and Freeman, 1937, p. 337).

It necessarily follows that the obtained intraclass r for the separated twins reflects not only the influence of identical genetic endowment but also of some similarity of environment. The magnitude of this environmental component would be reflected by the correlations between ratings of the environment and the child's IQ. Unfortunately, neither such correlations nor the data necessary for calculating them are cited by Newman, Holzinger, and Freeman, or any other investigator of identical twins reared apart. Some indication of the magnitude of the relationship is provided, however, by correlations reported in the Chicago study between differences in IQ for each pair of identical twins and differences in their social and educational milieus. The two coefficients were .51 and .79 respectively. Had the differences in the environment not been reduced by the tendency to place the separated twins in similar settings, the obtained values would presumably have been even higher. In the words of the original investigators, "Since the environmental difference was not great for a majority of the separated cases, its relative effect could have been much greater for twins all reared under widely different conditions" (p. 347).

The psychological significance of such correlations becomes more readily apparent in concrete form. For example, of the 19 pairs of separated twins in this study, there were 8 pairs who had the same number of years of school; the average IQ difference for this group was 1.45. The remaining 11 pairs differed in amount of schooling for an average of 5 years; the corresponding average difference in IQ points was 10.4. The greatest single pair-difference in schooling was 14 years with an IQ difference of 24 points. Since all of these are identical twins, these differences in score cannot be genetic in origin and are therefore the product of varying educational environments. Accordingly, Newman, Holzinger, and Freeman (1937) conclude from their data that "differences in education and social environment produce undeniable differences in intelligence" (p. 341).

Turning to the remaining studies, Juel-Nielsen (1965) unfortunately provides no quantitative data bearing on the issue of differences in environment among separated twins. Shields (1962), in his study of 44 identical twins reared apart, reports that 30 of them were "brought up in different branches of the same family" (p. 47). In addition, he points out:

> Large differences in social class do not often occur in the present material. While the social and cultural level of the branches of a family tend to be similar, the same is also generally true of adoptive parents who obtain children from the same Children's Home (Shields, p. 48).

Jensen gives special weight to the Burt study (1966), primarily because in this English sample there was no significant correlation between social class ratings of environments for separated twins. Again, the problem is one of restricted environmental variability, since over two-thirds of Burt's cases fell in the lowest two of five social class groups. Similarly, correlations between differences in IQ and rated "differences in cultural conditions" were relatively low (.26 for an individual intelligence test and .43 for a group test of intelligence). But neither the parents' social class nor their cultural background constitute the only or the most influential ecological factors that can both affect intellectual development and become the basis for environmental correlation. For example, in the Chicago study, differences in the level and quality of the child's own education were the most productive of differences in IQ ($r = .79$), and there was a clear correlation between the educational environments of the separated twins. This correlation represents a specific instance of the more general phenomenon of *selective placement* observed in the assignment of children to foster homes (Skodak and Skeels, 1949). The phenomenon is manifested in a relation between the characteristics of the child and his family and social background on the one hand, and, on the other, the characteristics of the foster home into which he was placed, particularly in terms of such variables as religion, ethnicity, family structure, and—above all—values and practices of child rearing. The selective placement is brought about by a variety of factors, including the initiative and sophistication of the child's parents and relatives, systematic differences in clientele served by different agencies (both in terms of families *from* and *to* which children are referred), and, in particular, the desire of the staff members, often mandated by agency policy, to achieve some kind of a match between the child's background and his foster home.

The phenomenon of selective placement not only produces a correlation between the environments in which children of similar family backgrounds are placed, but also restricts significantly the range of these environments. Thus, in a comprehensive survey of the research literature on adoption both in the United States and Great Britain, Kellmer-Pringle (1966) reports "a surprising uniformity among adoptive parents" (p. 15). The implications of this fact for studies of identical twins reared apart has been pointed out by Fehr (1969):

> The selection of foster homes by agencies gives preference to families who have sufficient financial resources to adequately care for the child and who show signs of intellectual and emotional understanding of the child's needs and the problems of adoption. Consequently, separated MZ twins placed for adoption through a professional agency are placed in selective and relatively homogeneous home environments as compared to the diversity that would result from random placement (p. 575).[2]

It is significant that all of Burt's separated twins were apparently placed through professional agencies of the London County Council. According to available information (Kellmer-Pringle, 1966; Shields, 1962), the practices of English placement agencies are not dissimilar to those of the United States.

The importance of degree of environmental variation in influencing the correlation between identical twins reared apart, and hence the estimate of heritability based on this statistic, is revealed by the following examples:

a. Among 35 pairs of separated twins for whom information was available about the community in which they lived, the correlation in Binet IQ for those raised in the same town was .83; for those brought up in different towns, the figure was .67.

b. In another sample of 38 separated twins, tested with a combination of verbal and non-verbal intelligence scales, the correlation for those attending the same school in the same town was .87; for those attending schools in different towns, the coefficient was .66. In the same sample, separated twins raised by relatives showed a correlation of .82; for those brought up by unrelated persons, the coefficient was .63.

c. When the communities in the preceding sample were classified as similar vs. dissimilar on the basis of size and economic base (e.g. mining vs. agricultural), the correlation for separated twins living in similar communities was .86; for those residing in dissimilar localities the coefficient was .26.

d. In the Newman, Holzinger, and Freeman study, ratings are reported of the degree of similarity between the environments into which the twins were separated. When these ratings were divided at the median, the twins reared in the more similar environments showed a correlation of .91 between their IQ's; for those brought up in less similar environments, the coefficient was .42.

The foregoing examples by no means exhaust the environmental variables in terms of which selection can occur in the placement of separated twins. As a result, the possible contribution of environment to differences between separated twins is considerably less than it would be in a population of unrelated children.

In view of these facts, the correlation of .75 or higher between IQ's of identical twins reared apart cannot be interpreted as reflecting the proportion of variance attributable solely to heredity. There is no question that genetic factors play a significant role in the determination of intelligence. Witness the fact that the correlation in IQ between identical twins reared apart is greater than that for fraternal twins raised in the same home. But, for the reasons given, the conclusion that 70 to 80 percent of the variance in mental ability is due to heredity represents an inflated estimate.[8]

In summary, the data from studies of identical twins reared apart lead to the following conclusions relevant to our concern. First, contrary to the assumption made by Jensen and others, the environments of separated twins are not uncorrelated. Second, as evidenced by the influence of ecological factors in producing differences between identical twins reared apart, the presence of correlated environments for such twins could make a significant contribution to their similarity in IQ. Hence the intraclass r for separated identical twins reflects environmental as well as genetic variance. To obtain a true estimate of the proportion of variance attributable to genetic factors among twins reared apart, one would have to partial out the correlation between the average IQ for a pair of twins and the degree of similarity in all aspects of their environment affecting intellectual development. This partialing would clearly reduce the estimate below the 75 percent figure claimed by Jensen. Finally, even though the reduced figure might be valid for a population of identical twins reared apart, it would not be generalizable to the population of children at large because of the restricted range of environments into which identical twins are separated as compared with the possibilities existing for unrelated children of the same age and sex. The effect of this restriction is to reduce variance attributable to environment and increase the relative influence of genetic factors compared to what it would be in the general population. For all these reasons, the interpretation of the intraclass r for separated identical twins as representing the proportion of variance attributable to heredity among children in general is unwarranted. While, as we shall see, there can be no question of the substantial role of genetic factors in the development of intelligence, the conclusion that they account for as much as 75 to 80 percent of the variance cannot be sustained on the basis of the evidence.

Own vs. adopted children. Because they similarly focus on the critical factor of the separation of the child from his biological parents, we come next to evidence from studies of resemblance within families having own vs. adopted children. Taking as his point of departure the correlation in IQ between unrelated (i.e., adopted) children raised in the same home (median intraclass r from five studies is cited as .24), Jensen (1969a) argues as follows:

> Now let us go to the other extreme and look at unrelated children reared together. They have no genetic inheritance in common, but they are reared in a common environment. Therefore the correlation between such children will reflect the environment . . . this correlation is 0.24. Thus, the proportion of IQ variance due to environment is .24; and the remainder, 1.00 − .24 = .76 is due to heredity. There is quite good agreement between the two estimates of heritability (pp. 50–51).

Once again, the conclusion is based on an untenable assumption, in this instance, rather glaring in character. Jensen's argument requires that any difference between two children reared in the same home be due only and entirely to differences in heredity and not at all to possible differences in treatment or experience at home, in school, in the neighborhood, or elsewhere. Clearly this assumption is unwarranted.

Jensen and his colleagues also lean heavily on the consistently higher magnitude of parent-child correlations for true vs. adoptive parents (Burks, 1928; Honzik, 1957; Lawrence, 1931; Leahy, 1935). Particular emphasis is placed on the widely cited conclusions of Honzik, based on an investigation conducted a decade earlier by Skodak and Skeels (1949). These investigators had carried out a longitudinal study with a sample of 100 children who had been placed in foster homes because of the psychological and social inadequacy of their parents. In their original study, Skodak and Skeels related the characteristics of true mothers and foster mothers to the intellectual level of the child, who had been separated from his true mother under six months of age. The correlations between the child's IQ and the IQ and educational level of his true mother rose gradually over successive testings from two to thirteen years reaching maxima of .44 and .32 respectively. The corresponding coefficients for foster mothers were essentially zero. On the basis of the correlational data, Honzik concluded that "the education of the parents per se is not an environmentally important factor" and that the results "reflect individual differences that are largely genetically determined" (p. 227).

Although Jensen cites the above correlations he fails to mention what is perhaps the most striking finding obtained by the original investigators and also mentioned by Honzik; namely, the average IQ of the children's true mothers was 86, whereas the mean IQ for their children was 106. Skodak and Skeels confronted this apparent contradiction posed by their data in the following terms.

> . . . it is possible to throw the weight of interpretation in the direction of either genetic or environmental determinants. If the former point of view is accepted, then the mother's mental level at the time of her examination is considered to reflect her fundamental genetic constitution, and ignores the effects of whatever environmental deprivations or advantages may have influenced her own mental development. Thus it would be assumed that the children of brighter mothers would in turn be brighter than the children of less capable mothers regardless of the type of foster home in which they were placed. The increasing correlation might be interpreted to support this point of view, since the occupational differences between foster parents are not large. It is, however, inconsistent with the evidence that the children's IQ's substantially exceed those of their mothers and that none of them are mentally defective even though a number of the mothers were institutional residents (p. 111).

In their effort to resolve the dilemma, the original investigators compared the characteristics of those foster homes in which children had shown significant gains in IQ over a ten-year period, and those in which the IQ had remained relatively constant. Neither the education nor the occupational background of the foster parents discriminated between the two sets of homes. Instead, two other critical factors emerged.

The first was selective placement. The children ending up in the "better" foster homes had true mothers with higher IQ's and more education. As the original investigators point out, such selective placement would have tended to produce correlations between the child's IQ and the IQ and education of his true mother; hence the observed significant relationships "cannot be attributed to genetic determinants alone" (Skodak and Skeels, 1949, p. 114).

Second, the "better" foster homes differed markedly from the others in the type of atmosphere and social interaction that took place within the family. This same difference was even more striking when all the foster homes as a group were contrasted with the family situation typical of the homes into which the children had been born. Skodak and Skeels describe the key elements as follows:

> There is considerable evidence for the position that as a group these children received maximal stimulation in infancy with optimum security and affection following placement at an average of three months of age. The quality and amount of this stimulation during early childhood seemed to have little relation to the foster family's educational and cultural status (p. 111).

In their conclusions, the original investigators weigh the relative importance of genetic vs. environmental factors in the development of this group of adopted children born of inadequate parents, and emphasize what they view as the major theoretical and practical implications of their findings:

> Judging from the trend of correlations between mother's and child's IQ's, one might conclude that a relationship exists which became increasingly apparent with age. This is complicated by the evidence of selective placement, yet without a parallel relationship between foster parent education and child IQ. This one set of figures must not be permitted to overshadow the more significant finding that the children are consistently and unmistakably superior to their natural parents and in fact, follow and improve upon the pattern of mental development found among own children in families like the foster families. . . .
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> The intellectual level of the children has remained consistently higher than would have been predicted from the intellectual, educational, or socioeconomic level of the true parents, and is equal to or surpasses the mental level of own children in environments similar to those which have been provided by the foster parents.

> The implications for placing agencies justify a policy of early placement in adoptive homes offering emotional warmth and and security in an above average educational and social setting (pp. 116–117).

It is noteworthy that none of the foregoing conclusions drawn by the original investigators is noted by Honzik in her article based primarily on Skodak and Skeels' work, nor are they mentioned by Jensen or other authorities dealing with the specific issue, even though they claim familiarity with the primary data. For example, in two highly respected textbooks on human genetics (Lerner, 1968, pp 159–160; Stern, 1973, p. 709) reference is made to Skodak and Skeels' work as supporting the interpretation that the intelligence of adopted children has a high genetic component virtually uninfluenced by characteristics of the foster home.

In summary, a re-examination of data from studies of own vs. adopted children leads to the same conclusion indicated by research on identical twins reared apart. While there is clear evidence for the importance of genetic factors in the development of intelligence, the data do not support the claim that as much as 75 to 80 percent of the variance in mental ability is genetically determined.

Identical vs. fraternal twins. The most widely employed method for estimating the proportions of variance attributable to genetic factors is based on the comparison of within-pair differences for identical vs. same-sex fraternal twins, both groups reared in their own homes. The basic argument runs as follows. Differences between identical twins can be attributable only to environment since their genetic endowments are the same. Differences between fraternal twins, however, reflect both environmental and genetic effects, and are larger for that reason. Accordingly, if one subtracts the former variance from the latter, the resulting difference is the amount of variance attributable to heredity. By expressing this variance as a fraction of total variance of individuals in the sample of same-sex fraternal twins, one obtains an estimate of the proportion of total variation attributable to genetic factors. This ratio is referred to as *heritability*, and is usually designated as h^2, after Holzinger (1929), who first developed the index. The value of h^2 can also be calculated from intraclass r's for identical vs. fraternal twins through application of the following formula:[4]

$$h^2 = \frac{r_i - r_f}{1 - r_f}$$

According to published summaries of kinship correlations (Erlenmeyer-Kimling and Jarvik, 1963; Burt, 1966), the median intraclass r for identical twins reared together (14 studies) is approximately .89; for same-sex fraternals (11 studies), .56. Substituting these values in the formula yields an h^2 of .75. Jensen (1969a) presumably working from the same data, reports a coefficient of .80.[5]

As with identical twins reared apart, an estimate of genetic variance (represented in this case by the heritability coefficient) derived from a comparison of identical and fraternal unseparated twins also rests on certain assumptions. The first is analogous to the assumption of uncorrelated environments made in the case of separated twins; namely, *genetic differences are assumed to be randomly distributed in the environment so that there is no tendency, for example, for better genes to end up in better environments, or vice versa.* Newman, Holzinger, and Freeman, in discussing the relative contributions of nature and nurture, acknowledge that this assumption is not entirely warranted with the result that measures of heritability "probably weight the nature influences somewhat too heavily" (1937, p. 115).

In contrast, Jensen, although going even farther in acknowledging a substantial correlation between genetic ability and the quality of the environment, ends up crediting the effects of this correlation completely to genetic influences:

> Such covariance undoubtedly exists for intelligence in our society. Children with better than average genetic endowment

> for intelligence have a greater than chance likelihood of having parents of better than average intelligence who are capable of providing environmental advantages that foster intellectual development. Even among children within the same family, parents and teachers will often give special attention and opportunities to the child who displays exceptional abilities. A genotype for superior ability may cause the social environment to foster the ability, as when parents perceive unusual responsiveness to music in one of their children and therefore provide more opportunities for listening, music lessons, encouragement to practice, and so on. A bright child may also create a more intellectually stimulating environment for himself in terms of the kinds of activities that engage his interest and energy. And the social rewards that come to the individual who excels in some activity therefore reinforce its further development. Thus the covariance term for any given trait will be affected to a significant degree by the kinds of behavioral propensities the culture rewards or punishes, encourages or discourages. For traits viewed as desirable in our culture, such as intelligence, hereditary and environmental factors will be positively correlated. . . .
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> In making overall estimates of the proportions of variance attributable to hereditary and environmental factors, there is some question as to whether the covariance component should be included on the side of heredity or environment. But there can be no "correct" answer to this question. To the degree that the individual's genetic propensities cause him to fashion his own environment, given the opportunity, the covariance (or some part of it) can be justifiably regarded as part of the total heritability of the trait. But if one wishes to estimate what the heritability of the trait would be under artificial conditions in which there is absolutely no freedom for variation in individuals' utilization of their environment, then the covariance term should be included on the side of environment. Since most estimates of the heritability of intelligence are intended to reflect the existing state of affairs, they usually include the covariance in the proportion of variance due to heredity (1969a, pp. 38, 39).

A second assumption underlying the interpretation of the heritability coefficient is generally acknowledged as not entirely valid, but this fact is not accorded much importance. Specifically, *the* *greater similarity of identical over fraternal twins is interpreted as due only and entirely to their greater genetic similarity (i.e., they have 100 percent rather than 50 percent of their genes in common). This means that the environments for identical twins are presumed to be no more or less alike than they are for same-sex fraternal twins.* Almost all investigators concede that this is not in fact the case, since identical twins are more likely to be placed in similar environments and to be treated more alike. For example, Burt (1966) states:

> Now it is well known that identical twins tend to keep together far more than fraternal twins, particularly since about half the fraternal twins are of different sex. The environmentalist therefore naturally argues that the higher correlation for intelligence found in the case of identical twins can be fully explained by the greater similarity in their life-histories (p. 139).

Nevertheless, neither Burt nor any other investigators who have relied on the heritability coefficient as a measure of genetic influence have taken this confounding factor very seriously. The general view is that the difference in environmental context for the two groups of twins is so small as to be negligible in its consequences. For example, Newman, Holzinger, and Freeman assert that the environmental variance for fraternal twins will be only "slightly" larger than that for identical twins (1937, pp. 114, 121).

There is evidence to indicate, however, that the confounding factor is considerably more important than has been acknowledged. This evidence comes from three sources: (1) data on the differential experiences of identical vs. fraternal twins; (2) comparisons of heritability coefficients for different abilities and traits; and (3) variations in heritability coefficients for different groups (sexes, socioeconomic classes, and races).

(1) *Differential socialization of identical vs. fraternal twins.* Over twenty-five years ago, Jones (1946), in a comprehensive review of twin research, stated:

> Several studies have shown that identical twins spend more time together, enjoy more similar reputations, are more likely to be in the same classroom . . . and in many other respects share a more common physical and social environment than that ordinarily experienced by fraternal twins (p. 613).

Subsequent research (Husen, 1959; Koch, 1966; Scarr, 1968; Shields, 1954) has both confirmed and strengthened this conclusion. For example, Koch found that identical twins are more likely to be dressed alike and are less often separated. More general findings along this same line are reported in the study by Scarr, who found that fraternal twins were perceived and treated more differently by their mothers than identical twins. In addition, she demonstrated that these differences in treatment were operative even when the mothers had misclassified their twins (i.e., thought them to be identical when they were really fraternal, and *vice versa*). In other words, identical twins tend to be treated more alike because they look more alike. Here is another instance of correlation between heredity and environment; specifically, a greater degree of genetic homogeneity evokes increased homogeneity in environmental reactions.

To what extent does the environmental difference thus engendered give rise to differences in the psychological development of identical vs. fraternal twins? We turn next to an examination of this question.

(2) *Variation in heritability coefficients for different abilities and traits.* If the greater similarity in treatment of identical twins results in greater psychological similarity between them, then the effects of this should be more marked for certain psychological variables than for others. Specifically, similarity between identical twins should be greatest for those characteristics in relation to which twins are most likely to have common experiences, especially in the context in which they are most likely to be treated alike—namely, the family. From this point of view, we should ex-

pect the greater similarity of identical twins to be more pronounced, for example, in verbal as against non-verbal abilities.

Available data are in accord with this expectation. Thus, Husen (1959), in a study of 900 twin pairs located through the Swedish draft system found that, in contrast to fraternal twins, identicals were more alike in verbal than in non-verbal group tests of intelligence. The median value of h^2 calculated from Husen's samples was .49 for verbal tests and only .23 for the non-verbal Matrices test. Independent confirmation comes from data on an American White middle class sample of 280 twin pairs (Scarr-Salapatek, 1971b). Heritability coefficients for verbal and non-verbal tests of intellectual aptitude were .52 and .25 respectively.

Turning to the realm of personality traits, one would again expect the greater similarity of identical twins to be maximized for those characteristics which are most likely to be the product of common experiences in the family. The principal kind of experience that twins are likely to share within the family is social interaction. From this point of view, one would predict that coefficients of heritability should be higher for personality variables reflecting social orientations, such as introversion-extraversion, or dominance-submissiveness, than for emotional or intrapersonal qualities such as anxiety or self-control. Again, the expectation is confirmed, this time in a number of independent investigations. For example, Gottesman (1966), using a series of personality questionnaires, obtained substantially higher heritability coefficients for such variables as Dominance (.49) and Sociability (.49) than for Flexibility (.15), Self-control (.27), or Intellectual Efficiency (.18). Similarly, Loehlin (in press) found that twin studies of introversion-extraversion had higher median heritability coefficients than studies of any other personality characteristics. Scarr (1969), using both questionnaires and observational measures, reported that "social introversion . . . was estimated to be more heritable than any other trait (e.g., activity, curiosity, intelligence) in this population" (p. 826). She then cited nine other twin studies yielding confirmatory results.

It is of course possible that the foregoing pattern of results is the product solely of genetic factors uninfluenced by genetically-induced environmental reactions. If so, one must be prepared to conclude that the genetic component is greater in verbal intelligence than in non-verbal, in social personality characteristics than in emotional traits. Moreover, at least as yet, genetic theory provides no basis for anticipating such a pattern or explaining how it comes about. In contrast, an interactive hypothesis, which views the genetically-determined similarity of twins as a stimulus for setting in motion patterns of environmental treatment which are selective in "homogenizing" certain twin behaviors but not others, does provide a basis for anticipating and testing the emergence of differentiated patterns of similarity in identical twins. Moreover, the hypothesis predicts differences in similarity not only as a function of psychological content but also of the social context in which the twins are brought up.

(3) *Variations of heritability coefficients in different social contexts.* From an interactive perspective, it would follow that identical twins are most likely to be similar in those traits which parents select out for special attention. Or, to put it in another way, parents are most likely to treat identical twins similarly with respect to those behaviors and characteristics which they regard as important. The findings already reported are consistent with this principle. We can now carry the argument one step further. It is a well-established fact that parents view different experiences, behaviors, and abilities as appropriate for the two sexes (for a general summary see Mussen, 1969; Mischel, 1970). Thus boys are expected to do well in mathematics, girls in English. In terms of personality traits, the socialization of boys, at least in America, focuses around problems of aggression, competition, and dominance, whereas for girls the emphasis is on nurturance and social adaptation. Accordingly, in line with our guiding hypothesis,

heritability coefficients for the two sexes should differ along the lines indicated above with male identical twins being especially similar in one set of characteristics and female identical twins the other. Data most directly relevant to these predictions are available from two studies. Nichols (1965a, 1965b) analyzed performance on the National Merit Scholarship Test for a sample of over 1500 sets of twins. Heritability coefficients for the test as a whole were virtually identical for the two sexes ($h^2 = .72$ for boys, .74 for girls). Two of the five sub-tests, however, showed marked sex differences. Heritability on the English Usage test was substantially higher for girls (.67) than for boys (.27); a reverse trend appeared in the test for Mathematics Usage with a coefficient of .80 for boys and .65 for girls. Gottesman (1966), in his study of heritability of personality traits in a Boston sample, reported markedly higher heritability coefficients for females than males in Sociability, whereas males emerged as more heritable in Dominance and Self-acceptance.

The same line of reasoning may also be applied to predict differences in heritability coefficients by social class. Thus, at a general level, one can argue that identical twins brought up in different social contexts are likely to vary in similarity as a function of the intensity of the socialization process in that context. More specifically, identical twins will be most alike in those settings in which parent-child interaction is most frequent, sustained, and actively focused on the child's development. Studies of social class differences in child rearing reveal that it is precisely in these respects that middle class families differ from those in lower class. (For a summary of the evidence see Hess, 1970.) As one descends the social class ladder, parent-child interaction becomes both less frequent, less consistent, and more diffuse. Moreover, because the disorganizing forces of lower class status are most severe for Black families, the disruption of the socialization process is likely to be more marked in Blacks than in Whites. Our general hypothesis would therefore predict decreasing heritability coefficients for groups of twins as one moved from upper to lower class and from White to Black populations.

Data bearing precisely on this two-dimensional hypothesis is provided in a study by Scarr-Salapatek (1971b). Working with a sample of over 1500 twin pairs in the Philadelphia public schools, she computed heritability coefficients separately by race and two social class levels (above and below the median). Consistent with our expectations, intra-pair similarity for all types of twins was greater among White than among Black families, and in the upper as against the lower half of the social class distribution. The general pattern of results showed consistently higher measures of heritability for White than for Black families and for advantaged as against disadvantaged groups of both races. Indeed, the observed genetic effects in the lower socioeconomic groups were so small as to prompt Scarr-Salapatek to conclude that ". . . genetic factors cannot be seen as strong determinants of the aptitude scores in the disadvantaged groups of either race" (p. 1292).

Scarr-Salapatek's interpretation of her results focuses on the impact of suppressive environments on genetic expression. She takes as an analogue for her own study with human subjects Henderson's (1970) ingenious experiment with mice reared in standard cages vs. enriched environments. The percent of genetic variance for the former group was one-fourth that for the latter. In addition, mice from the enriched environment performed far better in a learning task than did the deprived group. In other words, to find expression, genetic differences require an appropriately complex and stimulating environment (as in Skodak and Skeels' foster homes). In the absence of such an environment, genetic potential remains undeveloped both in terms of absolute level of ability and of individual differences. It is for this reason, Scarr-Salapatek argues, that both lower class and Black groups, who in our society live in suppressive environments, exhibit both lower levels of ability and reduced genetic variability as reflected in low heritability coefficients.

Our own interpretation is fully consistent with this view, but goes one step further in describing the environmental mechanism whereby genetic potentials find expression in the particular case of identical twins. The argument holds that the degree of similarity between identical twins is *substantially* a function of the extent to which they are actively treated alike; that is exposed to the same stimulating and complex environments. If the environments are impoverished, inconsistent, and diffuse, the similarity between the twins will be much reduced. Scarr-Salapatek's data provide strong support for this argument. Presumably, identical twins are equally identical genetically whether they are Black or White and whether they grow up in advantaged or disadvantaged homes. Yet the heritability coefficient for general aptitude in Scarr-Salapatek's data was .40 for middle class Whites and .25 for middle class Blacks. The contrasts for advantaged vs. disadvantaged children, both Black and White, were even more pronounced. Obviously, such marked variations, in the expression of genetic variance, are a function of environmental factors. Thus Scarr-Salapatek concludes: ". . . the major finding of the analysis of variance is that advantaged and disadvantaged children differ primarily in what proportion of variance in aptitude scores can be attributed to environmental sources" (p. 1292).

In the light of the foregoing analysis, the explanation and remedy for observed differences in intellectual performance by race and class would seem to lie far more in the direction indicated by Scarr-Salapatek's demonstration of the role of the environment in realizing genetic potential, than in the more simplistic theories of Jensen and others who, with no evidence to support them, posit unequal allocation of genetically-rooted capacities among different races and social groups.

With respect to race differences in intelligence, independent confirmation of the decisive role of environmental factors comes from recent studies of intellectual development in children of mixed Black-White marriages. From the point of view of genetic theory, which parent is of which race should make no difference for the child's mental capacity. The research results indicate, however, that the IQ of the child correlates more with the race of the mother than that of the father. Since it is the mother who is a primary agent of child rearing, this finding is consistent with the conclusion that the suppressive environment in which Blacks grow up in our society disrupts the process of socialization with the result that the child of the impoverished environment fails to realize his genetic potential.

We have now offered several sets of facts and arguments for calling into question the second major assumption critical to Jensen's estimate of genetic influence from the comparison of identical and fraternal twins. This is the assumption that the greater similarity in the environment of identical twins is a negligible factor in producing their psychological similarity.

As we have seen, this influence is in fact substantial. A similar conclusion has been reached by Loehlin (in press), who, on the basis of an empirical analysis, concluded that the within-family environmental variance for identical twins was about 62 percent that of fraternal pairs. Schoenfeldt (1968), relying on Loehlin's empirical work, developed a formula for heritability which adjusts for this inequality. Estimates of heritability for a test of general aptitude in a large sample of twins ranged from .60, on the basis of the conventional formula, to .26, using Schoenfeldt's adjustment. On this and other grounds, Schoenfeldt concluded that:

> . . . *genetic components are not as large a proportion of the total variance as previously believed*. Since up to the present time virtually all heritability estimates from twin samples have been computed using procedures shown to be inadequate, it should be no surprise that psychologists have been overestimating the genetic component for a long time (p. 17).

But serious problems of interpretation remain even if Schoenfeldt's corrected values are taken as the estimates of genetic effect.

First of all, as Scarr-Salapatek's data indicate, the impact of environmental similarity for identical twins varies across social contexts and is substantially greater among families in upper as against lower socioeconomic strata. But even if this variation were taken into account, a major problem still remains. Before we can generalize any estimate of heritability from a population of twins to people at large, a third critical assumption must be met. As in the case of identical twins reared apart, the generalization is valid only if the *environmental differences that occur between twins are as great as those that occur for unrelated children of the same sex and age*. Obviously, the realities of life do not accord with this condition. In view of this fact, values of h^2 cited by Jensen and other investigators, to the extent that they are valid measures of genetic influence, reflect the relative contribution of heredity and environment in accounting for individual differences *between children of the same sex and age being raised in the same family*.

The implications of these restrictions are rather far-reaching. It is obvious, for example, that, within the same family, children of the same sex but of different ages are just as alike genetically as same-sex fraternal twins, but experience far more varied environments in the course of growing up. The importance of this greater environmental difference for estimates of genetic influence can be illustrated by computing a heritability coefficient from the comparison of IQ similarity between siblings and between unrelated children reared together. The respective median intra-class r's, as given by Jensen, are .55 and .24. Applying Jensen's (1967) formula for computing heritability from any two kinship correlations yields a value for h^2 of .56, compared to .80 computed by the same formula from twin data.

Even more consequential is the environmental restriction imposed by the fact that the children are brought up in the same home. As Shields (1962, p. 8) has pointed out, the coefficient of heritability computed from data on twins is based on the environmental variance that occurs within families but not between them.

Yet, most of the environmental variation affecting human development that does or could occur takes place precisely between families rather than within them. It is difficult for children growing up in the same family to experience, as unrelated children do, widely differing environments—one enriched, and the other impoverished. But if this were to happen, the heritability coefficient would obviously be reduced.

This important point was recognized by Newman, Holzinger, and Freeman in their pioneering research. After pointing out that h^2 in their study could have been "of the order of .50 or smaller" for more varied environments, they concluded, "The relative role of heredity and environment is thus a function of the type of environment" (1937, p. 347).

Although few other twin researchers have been aware of this limitation, ironically enough it was acknowledged by Jensen (1969). In his theoretical discussion of heritability, he stated "H [the heritability coefficient] will be higher in a population in which environmental variation relevant to the trait in question is small, than in a population in which there is great environmental variation" (p. 43). Unfortunately, Jensen did not take this important principle into account in interpreting empirical values of heritability coefficients based on the relatively limited environmental variations that occur within families. In particular, he failed to consider the implications of this restriction for estimating the probable impact of social and educational programs designed to reduce intellectual differences *among* families living in *widely differing environments.*

We have now concluded our re-examination of evidence and assumptions underlying the thesis of Jensen and others that 80 percent of the variation in human intelligence is genetically determined. The results of our analysis lead to rejection of this thesis both on theoretical and empirical grounds. But what of the fundamental question to which Jensen was so ready to supply an answer? What can be said about the relative contributions of heredity and environment to psychological development? On the basis of the analysis we have undertaken, several conclusions appear to be in order:

1. There can be no question that genetic factors play a substantial role in producing individual differences in mental ability. Many findings summarized in this account testify to the validity of this statement. Perhaps the most impressive is the fact that the similarity of identical twins reared apart (median $r_I = .75$) was clearly greater than that of fraternal twins reared together (median $r_I = .56$).
2. It is impossible to establish a fixed figure representing the proportion of variation in intelligence, or any other human trait, independently attributable to heredity vs. environment. Even if one assumes the absolute degree of genetic variation to be a constant, the fact that the contribution depends on the degree of variability present in a given environment and its capacity to evoke genetic potential means that the relative contribution of genetic factors will vary from one environmental context to another. Moreover, any attempt to establish the range of the relative contribution in terms of existing environments cannot predict what might occur in some new environment that might come about or be deliberately constructed.
3. It follows from the above principle that, contrary to Jensen's contention, a high heritability coefficient for a particular ability or trait cannot be taken as evidence that the ability or trait in question cannot be substantially enhanced through environmental intervention. An instructive example is cited by Gage (1972) in a reply to Shockley and Jensen. Gage calls attention to the striking gain in stature exhibited by adults in Western countries over the past 200 years as a function of improved conditions of health and nutrition.[6] He notes further that the heritability of height as determined from twin studies is about .90—higher than that for IQ. "If this high heritability index had been derived in the year 1800, would it then have been

safe to conclude that height cannot be increased through environmental influences? If that conclusion had been drawn, it would have been wrong" (Gage, 1972, p. 422).

4. Any attempt to identify the independent contribution of heredity and environment to human development confronts the fact of a substantial correlation between these two factors. Moreover, the relation is not unidirectional. It is true, as Jensen points out, that parents of better genetic endowment are likely to create better environments for their children, and that the child as a function of his genetic characteristics in fact determines the environment that he experiences. The genetic similarity of identical twins is a case in point. But Scarr-Salapatek's research on this same phenomenon provides dramatic evidence that the environment can also determine the extent to which genetic potential is realized. This reverse relationship calls into question the legitimacy of including covariance between heredity and environment in the proportion of variance due solely to genetic factors. The impossibility of assigning this covariance unequivocally to one or the other source is further ground for the conclusion that a fixed figure representing the proportion of variance attributable to genetic factors cannot be established.
5. For genetic potential to find expression, both in terms of level and diversity, requires an appropriately complex and stimulating environment. This fact leads to a new and somewhat ironic interpretation of measures of heritability. Since heritability coefficients are lowest in environments that are most impoverished and suppressive, and highest in those that are most stimulating and enriched, *the heritability coefficient should be viewed not solely as a measure of the genetic loading underlying a particular ability or trait, but also as an index of the capacity of a given environment to evoke and nurture the development of that ability or trait.*
6. Finally, with respect to the problem posed by the substantial

differences in intellectual performance exhibited across class and race, our refutation of Jensen's thesis also argues against reliance on methods of selective mating and population control and in favor of measures aimed at improving, and even creating, environments better suited to evoke and nurture the expression of genetic potential.

Thus, our analysis has brought us to a paradoxical conclusion. An inquiry into the heritability of inborn capacities has shed new light on the power and potential of the environment to bring about the realization of genetic possibilities.

NOTES

1. Jensen reports this correlation as .77 (Jensen, 1969a, p. 52). This figure is never cited in Newman, Holzinger, and Freeman's published work, but appears in a table presented by Burt with the comment: "Raw figures were corrected for age and range by McNemar, and the slight changes this involves have been accepted by Holzinger" (Burt, 1966, pp. 145–146).
2. The restricted range of environments into which separated twins are placed should presumably be reflected in some reduction in variability of IQ's for this group as compared with the population as a whole. Since the standard deviation of the Stanford-Binet is reliably established as 16.4 points (Terman and Merrill, 1937, p. 37), it is possible to test this expectation in the two studies which employed that instrument as the measure of intelligence. Newman, Holzinger, and Freeman report a standard deviation of 13.0 for their sample of 38 twins (1937, p. 336). Burt, in a private communication, reports a standard deviation of 14.7. This conflicts with the value of 15.3 cited in his published paper (1966, p. 144), but a computation from the original data ($N = 35$ pairs) generously provided to the author by Burt confirms the 14.7 figure.
3. Similar considerations apply to the interpretation of data on adopted vs. own children. The fact that intrafamilial correlations in IQ tend to be higher for families with own than with adopted children is in part a function of the greater homogeneity of adoptive parents as a group both in terms of social background characteristics and values. Hence the greater similarity among blood related vs. adoptive family members cannot be attributed solely or even primarily to genetic factors.
4. This is the formula developed by Holzinger and used in most of the published studies. There are other formulas for h^2 based on somewhat different assumptions about the amount of assortative mating in the pop-

ulation (Jensen, 1967; Nichols, 1965a; Scarr-Salapatek, 1971a), but all are subject to the difficulties of interpretation discussed below.

5. The higher value is due primarily to the fact that "the correlations from which this heritability estimate was derived were corrected for unreliability" (Jensen, 1969a, p. 51). This procedure involves estimating how much higher the correlations would have been if the intelligence tests employed had been perfectly reliable. In general, the higher the correlation, the greater the effect of correcting for unreliability. According to Newman, Holzinger, and Freeman, such correction formulas "overestimate the corrected coefficient for high correlations" (p. 118). If correction for unreliability is not introduced, the application of Jensen's own formula (Jensen, 1967), which takes into account assortative mating, yields a value for h^2 of .72. Following a similar procedure, Jensen applied his heritability formula to all the kinship correlations cited above, this time obtaining a value of .81 (again corrected for unreliability) which he describes as "probably the best single overall estimate of heritability of measured intelligence that we can make." Unfortunately, this estimate rests on the same questionable assumptions (see below) as that derived from data on twins alone.
6. Jensen's (1969b) argument that "the variance in *adult* height may be almost entirely attributable to genetic factors" has been specifically refuted by two geneticists (Cavalli-Sforza and Bodmer, 1971, pp. 609–610).

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