From A. R. Jensen (1970). Behaviour Genetics, *Vol 1, No. 2*, 133–146, *by kind permission of the author and Plenum Publishing Corporation*

IQ's OF IDENTICAL TWINS REARED APART

Arthur R. Jensen

Institute of Human Learning
University of California, Berkeley

ABSTRACT—A new analysis of the original data from the four largest studies (Newman, Freeman and Holzinger, 1937; Shields, 1962; Juel-Nielsen, 1965; Burt, 1955) of the intelligence of monozygotic twins reared apart, totaling 122 twin pairs, leads to conclusions not found in the original studies or in previous reviews of them. Statistical analysis of the twin differences reveals no significant differences among the twin samples in the four studies; all of them can thus be viewed statistically as samples from the same population. They can therefore be pooled for more detailed and powerful statistical treatment.

The 244 individual twins' IQ's are normally distributed, with the mean $= 96.82$, $SD = 14.16$. The mean absolute difference between twins is 6.60 ($SD = 5.20$), the largest difference being 24 IQ points. The frequency of large twin differences is no more than would be expected from the normal probability curve. The overall intraclass correlation between twins is .824, which may be interpreted as an upper-bound estimate of the heritability (h^2) of IQ in the English, Danish, and North American Caucasian populations sampled in these studies. The absolute differences between twins (attributable to nongenetic effects and measurement error) closely approximate the chi distribution; this fact indicates that environmental effects are normally distributed. That is, if $P = G + E$ (where P is phenotypic value, G is genotypic value, and E is environmental effect), it can be concluded that for this population P, G, and E, are each normally distributed. There is no evidence of asymmetry or of threshold conditions for the effects of environment on IQ. The lack of a significant correlation ($r = -0.15$) between twin-pair means and twin-pair differences indicates that magnitude of differential environmental effects is not systematically related to intelligence level of twin pairs.

Comparison of monozygotic (MZ) twins reared apart is conceptually the simplest method of estimating the broad heritability of a characteristic. Theoretically, the characteristic's total phenotypic variance (V_P) in the population is analyzable into a genetic component (V_G), a nongenetic (or "environmental") component (V_E), a component attributable to the covariance of genotypes and environments (V_{GE}), a component due to the interaction (i.e., the non-additive effects) of genetic and environmental factors (V_I), and a variance component due to measurement error (V_e). Thus:

$$V_P = V_G + V_E + V_{GE} + V_I + V_e.$$

Heritability in the broad sense is defined as $h^2 = V_G/V_P$, or, if corrected for attenuation (errors of measurement), as $h_c^2 = V_G/(V_P - V_E)$.

The correlation between pairs of individuals can be expressed as the proportion of the variance components that the members of each pair have in common:

$$r = \frac{\text{Sum of Variance Components in Common}}{\text{Total Variance}}$$

In an idealized experiment to estimate h^2, therefore, we would assign each member of a pair of genetically identical individuals to different environments entirely at random at the moment of conception, and then determine the correlation between the pairs at some later stage of their development. Since the environmental conditions are randomized there would be no correlation between pairs due to environmental effects and there would be no correlation between genotypes and environments, at least at the outset. (Different genotypes can influence the environment differently, thereby producing some genotype X environment covariance. This component is usually regarded as part of the genetic variance in heritability studies of socially conditioned characteristics.) V_G, therefore, is the only component our idealized pair would share in common, and so the correlation between them would be equal to $V_G/V_P = h^2$.

The closest approximation to this idealized experiment in reality is the study of MZ twins separated soon after birth, or in infancy and early childhood, and reared separately. Unfortunately, in such studies there is always some uncertainty about the degree to which the nongenetic variance components are common to the separated twins. There is little, if any, real doubt in the major studies about the genetic component. Errors in the determination of zygosity in these studies are highly improbable. Any such errors, of course, would subtract from V_G and thus would result in a lower value of h^2. The nongenetic components are much more questionable. There is never truly random assignment of separated twins to their foster homes. Some separated twins are reared, for example, in different branches of the same family. And twins put out for adoption rarely go into the poorest homes. Furthermore, separated twins have the same mother prenatally, and to whatever extent there are favorable or unfavorable maternal conditions that might affect the twins' intrauterine development, these conditions are presumably more alike for twins than for singletons born to different mothers. On the other hand, twin correlation due to common nongenetic factors is counteracted to some unknown extent by effects occurring immediately after fertilization which create inequalities in the development of the twins. Darlington (1954) points to nuclear, nucleocytoplasmic, and cytoplasmic differences occurring in the first stages of cell division that would cause MZ twins to be less alike than their genotype at the moment of fertilization. Some of these conditions of embryological asymmetry do not affect singletons or dizygotic (DZ) twins. Partly for this reason DZ twins are more alike in birth weight than MZ twins. Although the biologic discordances referred to by Darlington affect only a minority of MZ twins, he concludes that their total effect is sufficient to lead to a gross underestimate in all twin studies of the force of genetic determination.

The correlation between MZ twins reared apart, therefore, cannot be taken at its face value as the most valid estimate of h^2. It must be checked against estimates of h^2 obtained by other means which involve more complex formulas (and often additional assumptions) for estimating heritability from a variety of kinship correlations, including unrelated children reared together and the comparison of correlations for MZ and DZ twins. Estimates of h^2 from MZ twins reared apart are, so to speak, cross-validated when similar values of h^2 are found by other methods,