matters arising

Estimation of heritability from IQ data on twins

IN a recent paper[1] a nationally representative sample of twins born in one week of March 1958 was investigated to estimate kinship correlations in mental test performance for monozygotic and dizygotic twins. The authors concluded that their study offered "supportive evidence for zero or low upper limit heritabilities of mental test performance". We have received several critiques of the paper which we publish below, together with a response from the authors.

ADAMS *et al.*[1] have used a method[2] of estimating heritability, that is not reliable. The formula $h^2 = (r_{MZ} - r_{DZ})/(1 - \rho_{00})$ was stated by Jensen[2], without any theoretical justification, to measure heritability. In this formula r_{MZ} and r_{DZ} are the phenotypic correlations between monozygotic and dizygotic twins, respectively, and can be observed directly, but ρ_{00}, the genetic correlation between sibs, cannot be observed. It can be obtained from their phenotypic correlation if heritability is known, which, of course, it is not.

To overcome this difficulty, Jensen[2] suggests that the formula $\rho_{00} = (1 + \rho_{pp})/(2 + \rho_{pp})$, where ρ_{pp} is the genetic correlation between mates should be used to find ρ_{00}. He gives Li[3], chapter 13, as reference for this formula. However, it does not appear there, and Professor Li informs me (personal communication) that he had never seen it before I brought it to his notice. This formula seems to have no theoretical justification. Moreover, it does not resolve the problem of finding genetic correlation. We now require the genetic correlation between mates which can be obtained from their phenotypic correlation if heritability is known. Thus, to use Jensen's formula for finding heritability of a trait, an estimate of that heritability is required.

Jensen[2] resolves the dilemma by assuming that the genetic correlation between mates is 0.25, without telling his readers how this figure is obtained from their phenotypic correlation of 0.6 (ref. 4). The value of ρ_{DZ}, actually ρ_{00}, which Adams *et al.*[1] use is based on this assumed genetic correlation. The value of 0.8 for the broad heritability of IQ which is often quoted by Jensen and others is also based on this value. It is difficult to find a scientific justification for the method or to have any faith in estimates of heritability based on it.

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[1] Adams, R., Ghodsian, M. & Richardson, K. *Nature* **263**, 314 (1976).
[2] Jensen, A. R. *Proc. natn. Acad. Sci. U.S.A.* **58**, 149 (1967).
[3] Li, C. C. *Population Genetics*, chapter 13 (University of Chicago).
[4] Jensen, A. R. *Harv. Educ. Rev.* **39**, 1 (1969).

THE report by Adams *et al.*[1] is noncontributory to the estimate of heritability of mental test performance for three reasons:

(1) No adequate information is given on the zygosity of the twin pairs. With a small sample (<100 like sex pairs) there would have been little difficulty in testing the twins for genetic markers such as blood groups, or at least having the twins examined by an experienced human geneticist, with special tests on those difficult to assign. It is true that a competent questionnaire to the parents will enable the correct type of twinning to be established in some 90% of cases. But merely to ask the parents their opinion is unreliable. Parents tend to be influenced by what they are told in the neonatal period by the midwife or obstetrician who usually erroneously assume that dichorionic twins must be DZ. Any errors in the assignment of the type of twinning will lead to an underestimate of heritability by the twin comparison method.

(2) An estimate of heritability based on the difference between the intraclass correlations of MZ and DZ twins is confounded by any substantial degree of assortative mating of the parents for the character in question. Insofar as any parental resemblance is genetic this will raise the DZ correlation, but not the MZ correlation, and so lower the estimate of heritability below the true value. Assortative mating for intelligence test score in most surveys is high, about 0.5. Adams *et al.* claim that the effect of such assortative mating on the estimates of heritability is likely to be small. This is not correct. For example, on the simple model of purely additive inheritance, with 100% heritability of intelligence test score, and 0.5 genetic parental correlation, the expected genetic DZ correlation is not 0.5 but 0.75. To assume the value of 0.5 would give an h^2 of only 50% and not 100%. Jensen's quoted estimate of an expected DZ correlation of 0.55 seems implausibly low. It is the difficulty of estimating the expected genetic DZ correlation that make twin comparisons an unsatisfactory method of estimating heritability for any character for which there is substantial assortive mating.

(3) Estimates of h^2 from twin correlations based on only 140 pairs have a large sampling error.

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[1] Adams, B., Ghodsian, M. & Richardson, K. *Nature* **263**, 314–316 (1976).

ADAMS *et al.* estimate[1] of an upper limit of 0.373 is based on a sample consisting of 41 MZ and 95 DZ twin pairs. This estimate is subject to sampling error, and if one calculates a 95% confidence interval for the population value of the heritability one obtains an interval ranging from about zero to over 0.6. An exact interval is difficult to establish, but using an estimated s.e. of about 0.2, the value of 0.6 can be regarded as a conservative upper limit.

Thus, while the data the authors present are an interesting contribution to this subject and do not seem to support a heritability value as high as 0.8, the assertion of a 'low' upper limit is not really justified.

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[1] Adams, R., Ghodsian, M. & Richardson, K. *Nature* **263**, 314–316 (1976).

IT is perhaps surprising that the authors of a study[1] comparing 'mental abilities' in MZ and DZ twins should place such reliance on tests which are not validated, and were administered in a group situation, where contamination effects are difficult to control. If, as is probable, pairs of same-sexed twins sit next to one another in a classroom during the test, it is perhaps