Short Report
Still No Convincing Evidence of a Relation between Brain Size and Intelligence in Humans

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Lynn (1993) takes exception to my conclusion (Peters, 1991) that for individuals in the normal range with respect to nutrition and intelligence, there is no unequivocal evidence for a relation between brain size and psychometrically measured intelligence. In order to make the case, he lists a number of studies that show a positive correlation between intelligence and cranial capacity. In addition, he specifically refers to a very recent study that, in his mind, provides proof positive for such a positive correlation (Willerman, Schultz, Rutledge, & Bigher, 1991). In view of such a lengthy list of studies with positive findings, and there are many more in the literature, why would anybody remain sceptical? The answer is simple. The nature of the available evidence is not strong enough to accept the unqualified proposition that intelligence and cranial capacity are positively correlated. Because it is not possible to address each single study in the literature, my concerns about methodological issues are best illustrated with reference to a few selected studies. I will begin with the methodologically strongest study on Lynn's list (Passingham, 1979). Passingham reported a correlation of $r = .14$ between brain weight and intelligence in his study. However, Passingham also reported that when height was partialled out, the correlation coefficient became $r = .03$ (ns).

In discussing his findings, Passingham commented that other studies had not partialled out factors like height, weight and age when relating IQ and brain size. In addition, socio-economic class, which enters the equation both in terms of nutrition and environmental influences, had not been taken into consideration. Like others, Passingham was also concerned with the problem of being able to measure either IQ or brain weight directly, but not both in the same sample. For instance, in his living sample, IQ was measured directly and brain weight was estimated through external cranial measurements. In Passingham's sample of deceased persons, brain weight was measured directly, and intelligence was estimated on the basis of the socio-economic status of the individuals. Lynn appears to think that the estimate of brain size by means of external cranial measures does not pose a problem, citing

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Brandt's (1986) finding that head size has a correlation of r = .80 with brain size. Lynn does not mention that Brandt's work is exclusively concerned with infant development. Brandt (1986) is careful to state that "There is a close relationship between head circumference growth and brain development in the normally growing infant *up to 2 years of age*" (p. 452). In adults, the relation between external skull measurements and brain measurements is much less reliable, as the extensive anatomical studies of Hoadley and Pearson (1929) show. That there is a problem with regard to indirect brain size measures and or indirect intelligence measures is indicated by the fact that for Passingham's sample of deceased individuals (these were drawn from the 1964 Pakkenberg and Voigt study), the brain weight for persons from different socio-economic classes did not differ significantly, while significant differences were found for the living sample. It comes of little surprise that Passingham concludes "But that they (brain size and intelligence) are in fact related can be proved only by a better study than the present one" (p. 268). It may be noted in this context that Binet's initial attempt to find a psychometrically reliable measure that would correlate well with school performance began with an effort to correlate head circumference with school performance, an effort which he soon abandoned (Gould, 1981, pp. 146-147). Binet also commented on the danger of bias in taking external head measurements, a comment that remains topical for contemporary researchers.

Any expectation that the most recent work on the brain size/IQ issue avoids methodological pitfalls will be disappointed. Lynn cites a very recent study that overcomes some of the concerns raised above because the IQ of living subjects was obtained, together with a relatively direct estimate of brain size, based on MRI scans (Willerman et al., 1991). The study has a further strength because all subjects were of similar age, and height was considered as confounding factor. In spite of these methodological improvements, the study has a fundamental flaw. Willerman et al. compared the brain sizes of a sample of university students with an average IQ with brain sizes of a sample with high IQ's. The mean IQ of his "average IQ" group was given as $M = 90.5$ (!), while the mean of the "high IQ" group was $M = 136.4$. Thus, Willerman et al. present as an average IQ level for university students an IQ mean that is significantly below the population mean, and must be very markedly below the mean of the student population at the Texas A&M university from which the sample was drawn. It is difficult to accept the control sample as a proper control under these circumstances. The most recent study published on this topic to date is the one by Rushton (1992a). Rushton (1992a) presented correlations between head circumference and psychometric intelligence of r = .14 for 73 "Orientals" and r = .21 for 211 "Whites". However, and quite inexplicably in view of the known heterogeneity of head circumferences for males and females, Rushton only presented data on head circumference and intelligence that was summed across the sexes. Practices of this kind continue to bedevil the research in this area.

In summary, the work in the literature, including the most recent work, does not allow the confident acceptance of a significant correlation between brain size and IQ. Future research addressing this issue will have to meet the following minimal conditions:

1) Subjects should be matched by height and weight and age in order to avoid unresolved issues (Holloway, 1980; Jerison, 1979; Passingham, 1979; Peters, 1991) of brain size scaling to body parameters. The importance of age is illustrated by a comparison of analyses done by Jerison (1979) and Passingham (1979) on the Pakkenberg and Voigt (1964) data set. Pakkenberg selected a sample of male subjects aged 18 - 45 years, and found a significant correlation between brain weight and body height. Jerison selected, from the same data set, only those males aged between 29 and 41 years, thereby ensuring that effects of incomplete growth at the lower age range and effects of aging at the upper age range could be excluded. Jerison failed to find a positive correlation between brain weight and body height. Tocher (1924) has also shown that there is significant increase in measures of cranial length and breadth between the ages of 18 and 20. In support of this, our own unpublished data on head breadth show that there is a significant increase in head width for males (but not for females) between the ages of 18 and 20. For this reason, studies that show correlations between cranial and psychometric measures without controlling for the change of cranial measures in this crucial age range (Susanne, 1979) must be considered flawed. The control of age is not only important relative to age related changes in cranial measures and brain size, but also in terms of age cohort effects in the psychometric measures (cf. Passingham, 1979).

2) Data should not be collapsed across the sexes. This point is made quite clearly in Passingham's (1979) work. He showed that brain sizes between males and females in his sample differed drastically, *but the IQ's did not.* Peters (1991) has argued that comparisons of brain sizes across sex cannot be made in any meaningful way because there are no appropriate scalars of body parameters that allow brain size/body size comparisons across the sexes.

3) Subjects should not have different prenatal and early-life nutritional backgrounds (Balazs et al., 1986; Brandt, 1986) because nutritional history, which is confounded with social class, does have an impact on brain size. This variable must be controlled for when it is not certain that the population subsamples to be compared, e.g., different racial groups or rankings within an army (Rushton, 1992b) have been drawn from comparable demographic backgrounds.

4) IQ levels of the subjects to be studied should not be appreciably be below the population mean. This is a serious consideration because the risk that organicity is involved in below average intelligence has to be considered. Until quite recently,

individuals with below average intelligence, but within 1 or 2 standard deviations of the mean, were considered to represent the lower end of the normal spectrum. However, the relatively recent discovery of syndromes like the fetal alcohol syndrome (Streissguth et al., 1980) and the fragile-x syndrome (Davies, 1989), associated with reduced brain size, has changed this. Individuals affected by these syndrome may have IQ levels in the lower normal range, but organicity is involved. Because these syndrome are common, and because others may be discovered as well, the comparison of brain sizes of groups of individuals below and above average levels could involve heterogenous groups.

5) Brain size measurements, be they indirect by means of head circumference measures or indices based on brain scans, or direct by means of actual brain weight determinations have to be carried out blind procedure. "Blind" is meant to be relative to ability measures. Obviously, when head circumference measures of living individuals are made, blind procedure cannot be used in relation to racial descent and the effects of bias are uncontrolled (Rushton, 1992b). The use of a single circumference measure from occiput to forehead is especially inappropriate when comparisons across different racial groups are made (cf. Rushton, 1992a). This is so because there are systematic differences among populations in the ratio of cranial breadth to cranial length, as any handbook of physical anthropology will show. Adequate measures of the cranium should include width, length and height as minimal measures. However, even here, problems arise. Very minimal measurement variations due to quite unintentional biases can have large effects on the cranial volume estimate. This is illustrated with the formula given by Rushton (1992b). He describes Lee and Pearson's (1901) procedure, where estimated cranial capacity in cm^3 = .00037(Lmm - 11mm)(Bmm - 11mm)(Hmm - 11mm) + 406.01. "L", "B" and "H" are length, breadth and height of the scull, measured from landmarks that are commonly used, and the subtraction of the 11mm from each is to correct for skin and skull thicknesses. For an individual with length, breadth and height measures of 193, 152 and 129mm, the estimated cranial capacity is 1426.5 cm^3. If the person making the measurement fits the measuring calliper a bit more snugly, so that each of the three measures is reduced by 1 mm, to 192, 151 and 128 mm, and this is well within the measurement error, the estimate of cranial volume becomes 1405.1 cm^3. A difference of only 2 mm in each measure, easily produced by differences between a snug and a loose fit, produces differences in estimates of some 42 cm^3. The differences given by Rushton (1992b) between cranial volumes for blacks and whites could be obtained by a difference of just one millimetre in each of the three measures. Allowing for the fact that individuals who do the measurements cannot be assumed to be free of racial bias, even small, unconscious and quite minute differences in applying the callipers can lead to very large systematic differences in cranial volume.

Once the minimal methodological requirements set out above have been met in the design of a brain size/IQ study, the results can be viewed with some confidence. To my knowledge, no study exists that reports unqualified significant correlations between brain size and intelligence and in which all the variables mentioned above have been controlled to an adequate extent. It is appropriate to comment on the broader context of the arguments surrounding the relation between brain size and intelligence. Even if the correlation coefficients reported in Lynn's Table 1 were taken at face value, the average correlation coefficient for these 15 studies ($M = 0.145$) means that differences in brain size account for only 2.1 % of the variation in intelligence. If the uncertainties about the validity of the reported correlation coefficients, as discussed above, are taken into consideration, there is a legitimate question as to why some researchers place such strong emphasis on the putative correlation between brain size and intelligence for individuals belonging to the same species.

In terms of theoretical expectations as to why brain size should be related to intelligence in comparable samples within a species, too little is known about anatomical differences in the cerebral cortex between large and small brains, and male and female brains (e.g., Haug, 1987, 1985) to justify any speculations about the significance of differences in brain size across individuals, sex, or race.

Since this note was written, and additional important paper appeared. The study (Andreasen et al., 1993) suggests a significant relationship between brain size and intelligence, and resolves many of the methodological problems which were criticized in this note. Sample selection remains a problem because of self-selection of subjects; the findings need to be replicated with a properly drawn random sample.

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