Race, head size, and intelligence

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We review recent research which estimates racial differences in cranial capacity by measuring head dimensions of living persons. We describe errors in published reports, and find that American whites have greater head height than American blacks, but that blacks have greater head length and greater head circumference. Estimates of cranial capacity are determined by racial differences in head shape. Possible relations between head size and measured IQ are so small that they cannot possibly explain black-white differences in IQ. Why, despite this, does 'scientific' interest in race differences in cranial capacity persist?

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The attempt to measure racial differences in cranial capacity has a long, if not creditable, history, summarised by Broca (1873), by Todd (1923), and more recently by Gould (1997). The first published estimate of cranial capacity, by Soemmering in 1785, used a primitive technique of filling skulls with water (see Todd, 1923, p. 99). The crudeness of his technique did not prevent Soemmering from reporting that the cranium of a white was more capacious than that of a black. Racial comparisons continued to animate the work of craniologists for many years. The Paris Anthropological Society in 1861, with Broca playing a leading role, discussed and debated the relations between differing brain volumes and differing intelligence levels among races, and the effect of slavery on the American Negro's brain was solemnly deliberated (Todd, 1923). The concern with cranial size was undoubtedly due to a sometimes unspoken assumption – that cranial size was related to brain size, which was in turn related to intelligence. Thus race differences in cranial capacity could serve to explain race differences in intelligence, and to justify a racial hierarchy in social and economic position.

The early craniologists developed progressively more refined techniques of measurement by filling skulls with materials such as mustard seed or lead shot. But Lee and Pearson (1901) proposed a procedure which could be used to estimate cranial capacity of the living head from a few linear measurements. Working with ancient skulls, they derived linear regression formulas which predicted the skull capacities as measured with mustard seed. The formulas yielded capacity estimates well within the measurement error of the mustard seed technique. The Lee and Pearson formulas were sporadically employed by subsequent researchers, but as craniological work passed out of fashion they fell into disuse. They have now reappeared in a recent series of papers which, echoing the labours of the Paris Anthropological Society of 1861, are again concerned with race differences in cranial capacity and intelligence (Jensen, 1994; Jensen & Johnson, 1994; Lynn, 1990, 1993b; Rushton, 1992, 1993, 1994; Rushton & Osborne, 1995). The authors of these papers had already achieved prominence in North American and European psychology as leading advocates of the view that (a) intelligence is genetically inherited, and (b) that blacks, for genetic reasons, are less intelligent than whites. Rushton and Lynn have argued further that, for genetic reasons, blacks are more sexually promiscuous, more criminal, and less altruistic than whites. We review their recent craniometric articles in detail, focusing on black-white comparisons. We discuss more briefly a body of evidence which, without reference to race, suggests the possibility that there might be a very modest relation between head size and measured intelligence. We demonstrate that the published research reports are rife with errors – and that the errors fall in a direction which is not entirely surprising.

Head sizes of children

The papers to be reviewed deal in some cases with children and in others with adults. The studies of children involve complications due to differing body (and head) sizes in children of differing ages. Those complications are largely absent from studies of adult blacks and whites. We therefore review the two groups of studies separately.

Lynn (1990) calculated mean head circumferences for 17,241 white and 18,907 black 7-year-olds, from a table given by Broman, Nichols, Shaughnessy, and Kennedy (1987, p. 161). He asserted that whites averaged 51.72 cm and blacks 50.91 cm in circumference. The difference of 0.81 cm was, according to Lynn, about 0.5 *SD* in magnitude – clearly, in view of the large sample sizes, significant. However, Lynn's arithmetic is wrong. His erroneous arithmetic was further biased by his failure to recognize that the male-female proportions differed significantly between the black and white samples.

The correct means calculated from the Broman *et al.* table are 51.46 for whites and 51.19 for blacks. Lynn's arithmetic produced too high a value for whites and too low a value for blacks. The correctly calculated white-black difference is a not very impressive 0.27 cm, one-third the magnitude reported by Lynn, and about one-sixth of an *SD*.

That small apparent difference, however, is itself erroneously inflated. The Broman *et al.* table pools data for boys and girls. The white sample contained a higher proportion of boys than the black sample – and boys have a larger head circumference than girls. There is no way of retrieving sex differences from the data as reported in Broman *et al.*

Jensen and Johnson (1994) subsequently analysed basically the same data set which formed the basis of the Broman *et al.* table, and of Lynn's errors. They retrieved head circumference data for both 4- and 7-year-olds, for both boys and girls, from the data bank of the National Collaborative Perinatal Project. The conclusions are similar for each age, so we here describe only the results for 14,443 white and 14,549 black 7-year-olds. These sample sizes are slightly smaller than those reported by Broman *et al.*, but Jensen and Johnson included only 'children that were

normal and healthy' in their analysis. They adjusted the data for differences in age, height, and weight. For boys the white mean was larger than the black – 51.93 vs. 51.39 cm. But for girls the white mean was *smaller* than the black – 50.95 vs. 51.04 cm. Pooling sexes, whites averaged 51.43 and blacks 51.21, very close to the averages which can be correctly calculated from the Broman *et al.* table. The net effect of Jensen and Johnson's exclusions and adjustments was very minor. Jensen and Johnson concluded (p. 329):

> The race difference in head circumference is highly significant but differs markedly for males and females, white males having about one-third of an SD larger circumference than black males and white females having about one-eighth SD *smaller* head circumference than black females.

They suggested, without evidence, that the disordinal race× sex interaction was most likely related to race and sex differences in growth rates during childhood.

The race × sex interaction for measures of head circumference, wholly ignored in Lynn's erroneous analysis, had in fact been observed as early as 1899. Paterson (1930, pp. 86–89) described an early study by MacDonald of some 17,000 white and 'colored' school children in Washington, D.C. The children, about 70% of them white, ranged in age from 7–17 years. Paterson's Table 16 presents means calculated from MacDonald's 1899 work for each race × sex catgeory for each of 11 ages. The sample of 7-year-olds included 399 white boys, 372 white girls, 240 black boys, and 239 black girls. At that age, as in the Jensen and Johnson data, white boys had the larger circumference, 51.84 vs. 51.51 cm; but white girls, again echoing the Jensen and Johnson analysis, had the smaller circumference, 50.64 vs. 52.07 cm. Although no *SD*'s are given for the MacDonald data, the *SD*'s given by Broman *et al.* (1987) for 7-year-olds indicate that the disordinal interaction is significant.

The larger circumference of black girls was observed by MacDonald at all of the 11 tested ages. However, the larger circumference of white boys at age seven years was temporary. There was no difference between white and black boys at age 8 years, and black boys had slightly larger circumferences at ages 9, 10, and 11 years. Across the 11 different ages, black boys had the larger circumference seven times, white boys three times, and one age was tied.

Paterson (1930, p. 88) drew an obvious inference from the data. He wrote:

> If one argues that head size varies directly with intelligence then it should follow that colored girls are the mental superiors of white girls and that colored boys at most ages are superior in intelligence to white boys ... MacDonald's data suggest that head size is a matter of racial heredity and relatively independent of intelligence.

Jensen and Johnson used the head circumference data from the National Collaborative Perinatal Project to estimate cranial capacities in cm^3. To do so, they employed formulas 'derived from Lee and Pearson (1901).' The formulas as given by Jensen and Johnson are:

For males: Capacity (cm^3) = 70.6C - 2464.95 (1)
For females: Capacity (cm^3) = 59.74C - 1912.18 (2)
(C = circumference in cm)

The multiplicative constants used by Jensen and Johnson are those given by Lee and Pearson (p. 262), but the subtractive constants used by Jensen and Johnson are considerably larger than those of Lee and Pearson. The effect of the change is to reduce estimated male and female capacities by 174 and 206 cm^3, respectively. Presumably the constants were changed to reflect the fact that Lee and Pearson's regression formulas had been derived from adult skulls. In any event, Jensen and Johnson made no statistical analyses of the estimated capacities, focusing instead on the raw circumference data. The white-black difference in estimated capacity, using the formulas, is of course entirely determined by the difference in measured circumferences. Jensen and Johnson asserted (p. 319) that the capacity estimates based upon their modification of the Lee and Pearson formulas are 'fairly similar to direct postmortem measures obtained on children'.

Lee and Pearson, however, did not share Jensen and Johnson's evident confidence in the ability of their circumferential formulas to provide valid measures of racial differences in cranial capacity. Formulas (1) and (2), modified by Jensen and Johnson, had been based upon analysis of 298 skulls from Theban (Egyptian) mummies. When Lee and Pearson performed a similar regression analysis on 167 ancient Naqada (Egyptian) skulls, the results differed. The differing formulas derived from the Thebans and the Naqadas gave very different (and erroneous) capacity estimates for 'Aino' (Ainu) and French skulls. Lee and Pearson concluded (p. 263) 'that it appears unlikely that a reconstruction formula, based on the circumferential measurements of the skull, can be found which will give good results, if extended from one local race to another'. The problem would be even worse if one moved from measurement of skulls to measurement of living heads, since 'there appears no obvious method of allowing for the difference between the circumferential measurements with and without the living tissues'.

Lynn (1993b) estimated cranial capacities of white and black children by applying a different set of Lee and Pearson formulas to data published by Krogman (1970), but again Lynn's work was fatally marred by errors. First, Lynn erroneously claimed (p. 90) that Krogman provided data for 'a core sample of 169 white males, 224 black males, 135 white females, and 220 black females', falling into nine age catgories, from age 7 to 15 years. Lynn indicated that in his reanalysis of Krogman's work 'The data for each age group are treated as an independent entry within each race and sex category in the analysis [of covariance] that follows.' For each age × race × sex category Krogman had given mean data for head length, head breadth, and head height, as well as for stature and weight. Thus Lynn was able to estimate cranial capacities using Lee and Pearson formulas which employ all three linear dimensions. He then used stature as a covariate in an analysis of covariance of the 36 capacity means (2 races × 2 sexes × 9 ages).

However, contrary to Lynn's assertion, the means which he analysed are not 'independent entries'. Though Krogman makes reference to a core sample in his partly longitudinal study of Philadelphia children, he indicates clearly that other subjects were added in 'a "mixed" or "modified" longitudinal approach' (Krogman, 1970, p. 2). His Table 19 indicates that for white males sample sizes at ages between 7 and 15 years varied from 223 to 23; for white females, from 283 to 33; for black males from 84 to 10; and for black females from 90 to 9. The mean values for head length, breadth, and height given by Krogman for white and black boys and girls of different ages are based on these varying sample sizes, and often (we do not know how often) the same individuals are included in the means given for different ages. That lack of independence contaminates the correlations calculated between age, stature, and cranial capacity, and thus Lynn's analysis of covariance.

Further, it is not clear that the Lee and Pearson formulas used by Lynn can appropriately be applied to white and black Philadelphia children. Lee and Pearson explained (p. 260):

> We want in fact a 'panracial' regression formula ... As it is impossible to find such a regression formula for the primitive stock from which man may be supposed to be derived, we are compelled to take the regression formulae which are least changed as we pass from race to race. The mean formula thus derived appears to give excellent results, when applied to determine the capacity of very diverse races.

The 'mean formula' referred to is an average of separate equations obtained from 199 German (medieval Bavarian), 150 Aino (from ancient Japan), and 343 ancient Naqada skulls. The final mean formula was selected after trial-and-error experimentation with other combinations of measurements. Lee and Pearson reported that the final formula, *when applied to German, Aino, and Naqada skulls*, produced errors of only about 1 or 2%. That seems a slender reed upon which to base an analysis of white-black differences in contemporary Philadelphia. In any event, the formulas used by Lynn were:

Males: Capacity (cm^3) = 0.000337(L-11)(B-11)(H-11) + 406.01 (3)
Females: Capacity (cm^3) = 0.0004(L-11)(B-11)(H-11) + 206.6 (4)

L, B, and H stand for head length, breadth, and height in mm. The subtraction of 11 mm from each dimension was an attempt by Lee and Pearson to correct for 'the thickness of the living tissues covering the skull'.

But even ignoring the lack of independence of the data, and the questionable appropriateness of the formulas, Lynn has again made grave calculational errors in his analysis of covariance. He describes its results (p. 91) as showing 'a significant effect due to race (F 1,31 = 4.27, $p < 0.054$), and to sex (F 1,31 = 4.27, $p < 0.001$), and only a marginally significant interaction between them (F 1,31 = 3.99, $p < 0.06$).' The differing p values given for identical F values suggest a typographical error, but more is involved. The observed mean cranial capacities for boys, as given by Lynn, are 1318 for whites and 1286 for blacks; for girls they are 1180 for whites and 1188 for blacks. Thus, before Lynn's analysis of covariance, white boys had larger capacities than black boys, but black girls had larger capacities than white girls. The means as adjusted by Lynn's covariance analysis were, for boys, 1313 for whites and 1286 for blacks; for girls, 1186 for whites and 1185 for blacks. The initial advantage of black girls has, after Lynn's arithmetical labours, disappeared. 'Black girls have almost as large a cranial capacity as white girls', Lynn concluded.

We have ourselves calculated estimated capacities from Krogman's non-independent means, following Lynn's procedure. Lynn has accurately reported the observed means for both black boys and girls. But he has spuriously increased the capacity of white boys (from 1308 to 1318) and of white girls (from 1176 to 1180). An analysis of covariance of the correctly calculated means, with stature as the covariate, gave F values (1,31 *df* in each case) of 1.27 for race, 429.10 for sex, and 3.75 for their interaction; only the effect of sex was significant. The adjusted means favoured white boys over blacks, 1303 to 1286, and black girls over whites, 1186 to 1182. Lynn's claim that Krogman's data indicate a significant race effect is false.

Rushton and Osborne (1995) analysed data from samples of white and black twin individuals originally studied by Osborne (1980). The subjects, ranging in age from 12 to 18, included 104 white males, 118 white females, 83 black males, and 167 black females. Osborne had collected data on head length and head breadth, as well as on head circumference, stature, and weight. Head height had not been measured. Rushton and Osborne make no mention or use of the head circumference data in their paper. Instead they employ still another set of Lee and Pearson formulas to estimate cranial capacities from head length and breadth only, each dimension measured in mm. The equations they used are:

Males: Capacity (cm^3) = 6.572(L-11)+11.421(B-11)-1434.06 (5)
Females: Capacity (cm^3) =7.884(L-11)+10.842(B-11)-1593.96 (6)

Rushton and Osborne (1995), who added the 11 mm correction to the Lee and Pearson formulas, wrote (p. 4):

> These equations give comparable results for different racial groups very similar to those derivable from Lee and Pearson's (1901) 'panracial' equation [our equations (3) and (4)], which also takes head height into account.

That claim is false. Lee and Pearson (pp. 234–236) in fact provided *two* sets of equations for estimating cranial capacity if only head length and breadth are known. The first set was derived from Aino males and females, and the second from German males and females. The German equations are our (5) and (6). With reference to all formulas which did not include all three head dimensions, Lee and Pearson reported (p. 241): 'very poor results arose when I calculated individual Germans from Aino formulae'. Further, 'It seems therefore absolutely impossible to apply successfully any one of these [formulas not using length, breadth, *and* height] to any other local race' (p. 243). But absolute impossibility did not prevent Rushton and Osborne from using one set of truncated formulas – they chose the set derived from Germans – to estimate cranial capacities of white and black American children.

We, like Rushton and Osborne, are not deterred by absolute impossibility, and so we have calculated capacities using the Aino, rether than the German, formulas. The Aino formulas, again inserting the 11 mm correction, are:

Males: Capacity (cm^3) = 13.555(L-11)+5.562(B-11)-1842.61 (7)
Females: Capacity (cm^3) = 9.084(L-11)+7.21(B-11)-1288.1 (8)

Table 1 compares the mean capacity estimates for each race, sex, and age, using the Aino and German formulas. Averaging the results over ages, the German formula credits white males with a capacity 43 cm^3 larger than black males. The Aino formula reduces that difference by almost half, to 23 cm^3. The German formula suggests that black females have a larger capacity than white females, by 9 cm^3. The Aino formula increases that difference slightly, to 11 cm^3.

Rushton and Osborne, using the German formulas, submitted their calculated capacities to an analysis of covariance, with age, stature, and weight as covariates. They concluded that the effects of race and sex were significant (whites and males had larger capacities), and that the race × sex interaction was also significant. Echoing Lynn (1993b), they concluded – on the basis of adjusted values – that 'Black females have almost as large a cranial capacity as White females'. Like Jensen and Johnson (1994), they attributed the race × sex interaction to a rapid maturing of black girls. They asserted (incorrectly, as we shall see) that no similar interaction effects on head size are observed in studies of adults. But their adjusted means (and the significance levels of race and of a race × sex interaction) would have differed if they had used the Aino, rather than the German, formula.

We have not followed Rushton and Osborne in submitting these data to an analysis of covariance. Not only is the choice of formula arbitrary, it is also not clear that covarying for stature and for weight adequately controls for the relation between body

Table 1 Mean cranial capacities (cm^3) with differing formulas

Age in years	White boys	Black boys	White girls	Black girls
German formula				
13	1247	1251	1159	1207
14	1334	1225	1151	1176
15	1324	1284	1175	1165
16	1362	1334	1195	1178
17	1358	1315	1183	1183
Mean:	1325	1282	1173	1182
Aino formula				
13	1282	1289	1206	1250
14	1360	1245	1194	1222
15	1352	1349	1223	1215
16	1377	1393	1238	1221
17	1391	1367	1220	1228
Mean:	1352	1329	1216	1227

Note: Calculated from Osborne (1980). Following Rushton and Osborne (1985) the very small samples of 12- and 18-year-olds have been collapsed into the adjacent age catgories.

size and head size (Willerman, 1991; Reed & Jensen, 1993; Jensen, 1994). Jensen and Johnson (1994, p. 311) report that 'The literature on the IQ × head size correlation is quite inconsistent in the way body size is treated, most likely because controlling for body size is theoretically problematic.' But it is in any event obvious that in the Rushton and Osborne study there is no significant difference between white and black girls in cranial capacity. We cannot interpret the observed difference between white and black boys. That difference is reduced by half if we use the Aino, rather than the German, formula. Further, there were *very* large differences in body size between white and black boys. White boys were heavier than blacks at all ages, with an overall difference of 63.0 vs. 53.2 kg. They were also significantly taller, 174.5 vs. 168.0 cm. With body size differences of this magnitude, differences in estimated cranial capacities may reflect nothing more than body size. For girls, whites were slightly taller (162.4 vs. 161.2 cm), but slightly less heavy (52.5 vs. 53.8 kg).

There are still other problems with Rushton and Osborne's analysis. The raw data for all individual subjects are available in Appendix D of Osborne (1980). Comparison of the mean observed capacities given by Rushton and Osborne with those which can be calculated from the raw data make it clear that all female capacities were incorrectly calculated. The subtractive constant used by Rushton and Osborne in calculating female capacities, supposedly from German equation (6), was mistakenly taken from the male German equation (5). The consequence is that female capacities were overestimated by an average of some 35 to 40 cm^3. This has minor effects on correlations or regressions involving females only, but large effects on those which pool males and females. Thus, even granting arbitrary use of the German formula, both the observed and adjusted means presented by Rushton and Osborne, and their analysis of covariance, are incorrect. We have ourselves calculated observed means (without adjustment for age) for the four race × sex groups, employing, as Rushton and Osborne intended to do, German formulas (5) and (6). For boys our calculations agreed exactly with Rushton and Osborne – 1340 for whites, and 1266 for blacks. For girls, our raw means favoured blacks, 1181 to 1176. Rushton and Osborne's means favoured blacks 1217 to 1215.

We noted earlier that although Osborne (1980) had collected data on head circumference, those data were not utilized in Rushton and Osborne's 1995 analysis. We have calculated from the individual data in Osborne's Appendix D mean head circumferences for the four race × sex groups (without adjusting for age or body size). Black girls had significantly ($p < 0.001$) greater head circumference than whites (55.21 vs. 54.17 cm). Black boys had nonsignificantly greater circumference than whites (56.20 vs. 56.08 cm). The greater circumferences of blacks were observed despite the fact that black children of each sex were significantly younger than the whites, and that black boys were of much smaller body size than their white counterparts. Rushton and Osborne make no mention of this embarrassment to their view. Note that the results with one purported index of cranial capacity (circumference, as employed by Jensen & Johnson, 1994) are very different from the results with another purported index (Lee and Pearson's formulas using head length and breadth, as employed by Rushton & Osborne, 1995). The conclusions drawn depend upon which index is used, and upon which data set is used. With the circumference index, the Rushton and Osborne data suggest that black boys, and certainly black girls, have larger capacities than their white counterparts. Jensen and Johnson, using the same index, had reported that white boys, but not white girls, had significantly larger capacities than blacks.

Jensen (1994) made use of a subset of Osborne's 1980 data in an effort to relate head size to 'intelligence' as measured by psychometric *g*. Osborne had given 17 mental tests to many of his twins, and for 286 individuals with 'complete data' (p. 599) Jensen correlated scores on each test with head length, head width, and head circumference. Prior to data analysis, variance associated with race, sex, and age was regressed out of test scores and out of head measurements. The three head measurements were then found to be modestly, and about equally, correlated with test scores. The average correlations were 0.19 for head length, 0.11 for head width, and 0.16 for circumference. Jensen used hierarchical factor analysis of the 17 tests to produce a second-order general factor, which he identified as *g*. The correlations of individual *g* scores with head measurements were 0.28 for length, 0.14 for width, and 0.24 for circumference. It is important to note that all these correlations were derived *within* the two racial groups; variance associated with race had been statistically removed.

Jensen now turned to an examination of race differences. He first calculated the white-black difference (in *SD* units) for each of the 17 mental tests, and reported a significant correlation between the magnitude of the race difference in test score and the test's *g*-loading. Then he reported a significant correlation between the size of the race difference in test score and the magnitude of the test's correlation with head size. That is, tests with a high *g*-loading tended to show a larger white-black difference in favour of whites, and the same tests also tended to be more highly correlated with larger head size. The obvious implication of such an analysis is that a white-black difference in test score is related to a smaller head size of blacks. That implication is false.

Though the data lay before him, Jensen chose not to report the white and black means for the head measurements he had correlated with test scores. He did not inform readers that, as we have reported above, the black children in Osborne's study had larger head circumferences than the whites. Further, Jensen's analysis of the Osborne data indicated that circumference was about as

strongly correlated with test scores as were head length and breadth. He had in the same year (Jensen & Johnson, 1994) used head circumference by itself to estimate the cranial capacities of whites and blacks. But he did not now conclude that blacks had the larger cranial capacity – and the lower test scores.

We have calculated from Osborne's Appendix D the differences among race × sex groups in head length and breadth. Averaging across ages, head length was 191 mm for both white and black boys. It was 185 mm for black girls and 184 mm for white girls. Clearly boys have longer heads than girls, but there is no race difference in head length. For head breadth white boys averaged 145 mm, black boys 142 mm. For girls, whites and blacks had identical head breadth, 140 mm. The larger breadth of white boys appears significant, since it is observed at every age. However, recall that the black boys in this study had much smaller body sizes than the whites.

It is of interest to note that differing Lee and Pearson formulas vary in the weighting they give to length vs. breadth. The multipliers in formulas (5), (6), (7), and (8) are such that, for males, head length is weighted only 50% as heavily in the German as in the Aino equation, but head breadth is weighted 105% more heavily in the German equation. The same discrepancy, in attenuated form, occurs for females; length is weighted only 87% as heavily in the German as in the Aino equation, while breadth is weighted 50% more heavily in the German equation. Put simply, the German equations, contrasted with the Aino, 'reward' small positive differences in breadth much more than they reward similar differences in length. Thus, granted that white males have greater head breadth than blacks, the German formula will favour white males more than the Aino formula. Rushton and Osborne (1985) chose the German formula.

Head sizes of adults

Rushton (1990, 1993) twice reanalysed data which had been originally presented by Herskovits (1930). The 1993 Rushton paper dealt with the same data he had discussed in 1990, but he now added the 11 mm correction for living tissue to the Lee and Pearson formulas.

Herskovitz had studied 961 American Negro adult males, and reported data for head length, breadth, and height. Herskovitz also summarised, for comparative purposes, head measurements reported by earlier investigators for 28 other male populations. The sample sizes of the other populations varied from 19 to 46,975. For almost all those populations only two head measurements – length and breadth – were available.

Rushton again used the German equations, (5) and (6), for estimating cranial capacity from head length and breadth. He calculated capacities for all the populations summarized by Herskovits, and grouped them into three categories: 'Mongoloid and Asian', 'Caucasoids and European', and 'Negroids and African'. We are primarily concerned with Herskovits's American Negroes as compared to whites. The only white American populations were 727 'Old Americans' studied by Hrdlicka, and 60 'American-born Bohemians' studied by Boas. The estimated capacities were 1454 cm^3 for Old Americans, 1423 cm^3 for American-born Bohemians, and 1422 cm^3 for American Negroes. The difference between the Negroes and Old Americans was clearly significant, but that between the Negroes and the American Bohemians was not. Parenthetically, 46,975 Swedes studied by Lundborg and Linders had a capacity of only 1393 cm^3, significantly less than the American Negroes.

What conclusions would Rushton have reached if he had employed the Aino, rather than the German, formula? The Old American capacity would have been estimated as 1476, and the American Negro capacity as 1453; a difference of 32 cm^3 is reduced to 23 cm^3. The estimate for American Bohemians would have been 1366; a difference favouring the Bohemians by 1 cm^3 is reversed to a difference favouring the Negroes by 87 cm^3. Thus the Herskovits data, despite Rushton's claims, do not support the assertion that American blacks have smaller capacities than American whites. Further, Rushton's claim that the Herskovits data show 'Negroids' to have smaller capacities than 'Caucasoids' was made without regard to differences in body size among the various populations; and since only males were measured, no evidence for a race × sex interaction could be obtained.

Rushton (1994) has reanalysed data gathered for the International Labour Office by Jurgens, Aune, and Pieper (1990). Those authors surveyed 337 anthropometric studies from across the world. They published estimated medians (as well as 5th and 95th percentiles) for head length, head breadth, and head circumference for the world population, broken down into 20 different regions. Rushton ignored the data on circumference, and again used the German version of the Lee and Pearson formulas for length and breadth to calculate an estimated capacity for each of the 20 regions. He then grouped 14 of the regions into three categories: 'East Asian or Mongoloid', 'European or Caucasoid', and 'African or Negroid'. Treating each region's median scores for each sex as independent entries, he concluded from an analysis of variance that there were significant effects both of sex and of 'race', with no interaction. Men had larger capacities than women, and Europeans had larger capacities than East Asians, who in turn had larger capacities than Africans. When median regional stature was added as a covariate, the results were basically similar, although East Asians now had a slightly larger adjusted mean than did Europeans. Rushton granted that the choice of which regions to assign to which 'racial' category was 'problematic', and he reported that 'other combinations or permutations did lead to null findings' (p. 288). He noted that the Jurgens *et al.* data had been derived from 'tens of thousands of individuals'. However, sample sizes varied enormously from region to region, and there are no data given for American blacks.

The use of the German formula to estimate capacities for every region of the world is of course arbitrary, and flies in the face of Lee and Pearson's explicit disclaimer. Before his analysis of covariance, Rushton's observed mean capacities for males were 1422 for Europeans, 1381 for East Asians, and 1339 for Africans. Female capacities followed the same racial rank ordering, with values of 1199, 1191, and 1083. The Aino formula, granting Rushton's arbitrary categorisation of races and regions, would again give a radically different picture. For males, Africans and Europeans each have capacities of 1397, while East Asians trail with 1371. For females, the European and East Asian estimates are very close (1216 and 1213), while Africans trail with 1141. Taken at face value these data would suggest a large 'race' × sex interaction. But there is no good reason to take any of these numbers seriously.

The Jurgens *et al.* monograph is of little value for the purposes to which Rushton has put it. Their data were not compiled with a theoretical purpose in mind. They were concerned with 'the ergonomic design of consumer goods on a world-wide basis', and they subdivided the world population into two different bodily types – 'northern people' and 'southern people' (p. v). This was done in order to provide 'for the manufacture of different (in this case two) sizes with adjustability' (p. 82). With such a rough practical purpose in mind, there was no need to be overly precise

in estimating regional medians. Jurgens *et al.* provide no information on how they amalgamated the data taken from the numerous studies within each region. Their tabled summaries, however, show that entries for all head measurements have been rounded to the nearest 5 mm. The rounding can have very large effects on estimated capacities. For example, median length and breadth for males in the West Africa region are tabled as 195 and 145 mm, respectively. The analogous medians for the Eastern Europe region are 190 and 155. These values provide (German formula) estimated capacities of 1339 cm^3 in West Africa and 1419 cm^3 in Eastern Europe. But imagine that the West African entries had been rounded down from 197.49 and 147.49, while the Eastern European entries had been rounded up from 187.5 and 152.5. The unrounded figures reverse the difference between regions, suggesting capacities of 1384 for West Africans and 1374 for Eastern Europeans.

The data entries tabled by Jurgens *et al.* can only be regarded as very rough approximations. We have examined the 165 of their 337 references which were most readily available to us. Many of their references are in difficult to obtain journals in Bulgaria, Poland, and Japan; others are from 'the so-called "grey" literature and unpublished data' (p. 15). Of the 165 references we examined, only 37 contained data on head measurements. However, Jurgens *et al.* indicate (p. 18) that 'procedures were developed for deducing unavailable values from those available'. From references they cite in support of this practice, it appears that since virtually all sources contained data on stature, Jurgens *et al.* often used an expected ratio between stature and head dimensions to deduce very approximate head dimensions.

The imprecisions involved can easily be appreciated by a detailed examination of their sources cited for the region 'Australia (European population)'. This region had the smallest number of references, and all six of those references were available to us. Only two of the references contain any head measurements. In each case the only head measurement is circumference – and in one case the data are in fact for Samoans resident in Hawaii! Another reference, without head measurements, gives anthropometric data for Caucasians, Japanese, Chinese, Filipinos, and Hawaiians – all resident in Hawaii, not Australia. Still another reference deals with Samoans resident in Samoa and in Hawaii. Three references do in fact provide anthropometric data for Australians and/or New Zealanders, but only one contains a head measurement (circumference). Five of the six references contain data on stature; the exception provides circumference data. Presumably Jurgens *et al.* used expected ratios between stature and head dimensions, and then amalgamated six studies of different racial groups resident somewhere in the Pacific to provide estimated median head dimensions for a region called 'Australia (European population)'. Rushton, in his analysis of 'racial' differences, treated the medians for this region as 'European or Caucasoid'. The misclassification of sources by Jurgens *et al.* ignored by Rushton, was not restricted to the Pacific. For example, a study of Rumanians was assigned to the region of South-eastern Africa, a study in Great Britain was assigned to Latin America, and a study of Australian aborigines was lumped together with studies in South-east Asia.

There are other problems with the Jurgens *et al.* medians. Since body size varies with age, Jurgens *et al.* report that their compilation was restricted to the age group 25–45 years. However, many of the references they cite contain data only for subjects outside that age range. For example, a source cited for Central Europe contains data only for the age group 60–89 years, and one cited for South-eastern Europe contains data only for ages 3–18 years. The procedures employed by Jurgens *et al.* were perhaps sufficient to satisfy their rough ergonomic and manufacturing purposes, but their many errors and imprecise estimation procedures make the data useless for any comparison of cranial capacities across 'racial' groups.

The most recent and extensive data on head sizes of American whites and blacks were gathered by the American army in the course of an anthropometric survey (Gordon *et al.*, 1989). The army technical report did not break the data down by race, but Rushton (1992) obtained such a breakdown, and the same breakdown has been made available to us. The race differences in a stratified random sample of 6,090 military personnel were analysed by Rushton. The data were derived from both officers and enlisted personnel, male and female. Within each rank × sex category, data were separated by Rushton into 'Negroid', 'Caucasoid', and 'Mongoloid'. We will use the terms black, white, and Asian American. Data were obtained for head length, breadth, and height, as well as for circumference. The availability of head height data enabled Rushton to estimate cranial capacities using equations (3) and (4), based on the three linear dimensions.

Lee and Pearson (1901, p. 212) had indicated that those equations might be applied to all races. Rushton (1992, p. 403) explicitly describes them as 'pan-racial' equations. In fact, Lee and Pearson had written (p. 260) that they *wanted* 'panracial' formulas, but were 'compelled to take the regression formulae which are least changed as we pass from race to race.' Pearson, far from regarding these formulas as 'pan-racial', did not view them as applicable both to the English and to 'negroes'. Estabrooks (1928, p. 254) had used the formulas to estimate cranial capacities of children in 'three broad racial groups, North European, Italian and Jew. North European simply meant that the parents originally came from North Europe or the British Islands. The Italian group comprised all children whose parents were Italian while the Jew group explains itself ... the writer has herein divided the North European group into pure blonds, mixed and pure brunettes ... He also only considers those Italians who are pure brunettes.' Estabrooks, clearly as concerned as Rushton with matters of 'race', quoted from a letter he had received from Professor Karl Pearson. Pearson, after pointing out that the formulas used by Estabrooks had been intended for adults, declared: 'I should be slow, however, to combine negro and Jewish children together with North Europeans, and doubt whether the same reconstruction formula would apply to both, the correlation, for say, English and negroes being so different.' Pearson doubted that his formulas could apply to both negroes and Jews, but no such doubts dissuaded Rushton from applying the formulas to 'Caucasoids', 'Negroids', and 'Mongoloids'.

Rushton in any event first submitted the unadjusted capacity estimates derived from the formulas to an analysis of variance. He found significant effects of rank (officers had larger capacities), of sex (males larger), and of race (Asian Americans > whites > blacks). There was also a significant race × sex interaction; white men had a larger capacity than Asian American men, but Asian American women had a larger capacity than white women. The apparent racial differences, however, are confounded with differences among groups on many relevant variables. Among males, 82% of 1590 whites were enlisted men, but 97% of 1381 blacks and 94% of 411 Asian Americans were enlisted. Among females, 74% of 1371 whites were enlisted women, but 93% of 1295 blacks and 88% of 132 Asian Americans were enlisted. Officers were significantly taller, significantly heavier, and significantly older than enlisted personnel. Further, 49% of white male officers, but only 13% of black and 5%

of Asian American male officers were pilots. Two percent of white women officers, and no black or Asian American women, were pilots. Those differences are relevant, since pilots had been selected according to different anthropometric criteria than other officers. Both whites and blacks were significantly taller and heavier than Asian Americans, but there were no marked black-white differences in height or weight. Asian Americans were significantly older than whites or blacks. For many variables, the distributions for the small officer and Asian American samples deviated significantly from normality.

Rushton attempted to control for some, but not all, of the confounded variables with a series of covariance analyses. He reported that adjusting for stature and weight, and then for race, rank, and sex, produced adjusted capacity means such that Asian Americans > whites > blacks, but that race × sex interactions were frequently significant. We have already indicated that it is not clear that a covariance analysis can adequately control for large group differences in body size. Since our interest is in white-black differences, and since white-black differences in body size were small and non-significant, our own analysis focuses on the unadjusted means of the four large sub-samples: white and black enlisted personnel, both male and female. The small sub-samples of older, larger body-sized officers, confounding race with pilot status, were not included in our analysis. The data for the two sexes, differing greatly in body size, were analysed separately. The small Asian American samples, with much smaller body sizes, and older than either whites or blacks, were not analysed by us.

Rushton's report provides data only for his estimates of cranial capacity, not for the three head dimensions on which those estimates had been based, nor for head circumference. We have looked at those separate variables, as well as at the capacities estimated with equations (3) and (4). Table 2 presents for each race × sex category mean data for the four head measures and for the estimated cranial capacities. For reference at a later point, the table also includes data for Asian Americans.

Males, not surprisingly, are significantly larger than females in every head dimension. Turning to the separate dimensions employed in the formulas, there is no white-black difference within either sex in head breadth; the means are identical to the nearest mm. But within each sex whites have a larger head height than blacks ($p < 0.001$ in each case). However, within each sex blacks have a larger head length than whites ($p < 0.01$ for males, $p < 0.0001$ for females). For those keeping score, the results are one win each for whites and blacks, plus one tie. However, the weights assigned to the dimensions by the arbitrary 'pan-racial' formulas result in a larger estimated capacity for white males than for blacks ($p < 0.0001$). For females whites also have a larger estimated capacity, but the difference falls far short of significance ($0.40 > p > 0.30$). The large sample sizes clearly mean that the race × sex interaction is significant. This is consistent with similar race × sex interactions noted in black and white children by Jensen and Johnson (1994) and by Rushton and Osborne (1995). The fact that the interaction occurs in adults discounts the supposition by those authors that the interaction observed in children was due to a more rapid maturation by blacks and by girls.

Table 2 Mean head measurements, US Army enlisted personnel

Group	Length (mm)	Breadth (mm)	Height (mm)	Circumference (mm)	Capacity cm^3
White males	197	151	132	567	1468
Black males	198	151	129	569	1449
Asian males	190	156	132	561	1464
White females	186	144	124	543	1263
Black females	188	144	122	549	1260
Asian females	181	150	126	543	1296

Note: Data derived from Gordon *et al.* (1989)

Finally, we consider the head dimension not entering the Lee and Pearson formulas (3) and (4), circumference. Within each sex, blacks have a significantly greater circumference than whites ($p < 0.002$ for males, < 0.0001 for females). If, following Jensen and Johnson (1994), we estimate capacities from the Lee and Pearson circumferential equations (1) and (2), blacks have a significantly larger cranial capacity.

The pattern of the army data for females is closely replicated in a United States Air Force survey conducted in 1968, and summarised by NASA (United States National Aeronautics and Space Administration, 1978, p. 5).

Head length, breadth, and circumference were obtained from 1216 enlisted white women and 131 enlisted black women. The absence of head height data makes it impossible to calculate cranial capacities with equations (3) and (4). But in agreement with Gordon *et al.* (1989), black women had greater head lengths (187 mm vs. 183, $p < 0.0001$) and a slight advantage for whites in head breadth was not significant (145 mm vs. 144, $p > 0.10$). Again, black women had significantly larger circumferences (558 mm vs. 547, $p < 0.0001$).

To sum up, the adult data (Gordon *et al.*, 1989; NASA, 1978) clearly indicate that American blacks have larger head circumferences than American whites, and that the difference is larger within females than males. The child data (Jensen & Johnson, 1994; Paterson, 1930; Rushton & Osborne, 1995) clearly indicate that black girls have larger circumferences than white girls. For boys, there is a suggestion of a race × age interaction. Jensen and Johnson found white boys to have a significantly larger circumference at ages 4 and 7 years; Paterson reported a white advantage at age 7 years, but a black advantage at ages 9–11 years; and the Rushton and Osborne data for ages 12–18 years suggest a non-significant advantage for blacks. The adult and child data consistently indicate, across ages, a race × sex interaction. The advantage of black females over whites is larger than any comparable sex difference among males.

For head breadth, neither adult study found any significant difference within either sex. In the one child study from which such data could be retrieved (Osborne, 1980) white boys, but not girls, had significantly greater breadths. However, the white boys were much larger in body size than the black boys. For head length, both adult studies found a black advantage, within each sex; the child study found no significant race difference. For head height, both adult studies found whites to be significantly larger, and this was true within each sex. There are no reliable head height data for children.

The most illuminating summary of these data is also the simplest: whites and blacks have differently shaped heads, and the shape difference varies between the sexes. Different estimates of

'cranial capacity' are the consequence of differently shaped heads. The Lee and Pearson 'panracial' equations (3) and (4) produce larger estimated capacities for whites as a consequence of the fact that the white advantage in head height is slightly larger than the black advantage in head length.

The shapes of white and black heads are in turn different from that of Asian American heads. This is illustrated by Gordon *et al.*'s (1989) data for Asian American soldiers, presented in Table 2. Within each sex, Asian American head breadth is larger, and head length smaller, than either white or black. Those two opposing effects are nearly offsetting in the 'panracial' equations, but a tendency for Asian Americans to have slightly greater head heights then produces a large estimated capacity for them. The black advantage in circumference plays a role only in equations (1) and (2), which produce larger estimated capacities for blacks than for whites or Asian Americans. The larger black circumference is especially marked among females.

It is not clear that the race × sex interaction in circumference measures is of fundamental biological significance. Murdoch and Sullivan (1923), attempting to relate head size to IQ in a white sample, used the average of head length and head breadth, rather than circumference, as their measure. They explained (p. 214): 'Head circumference is very difficult to take and is subject to gross errors of observation due to differences in technique and to differences in the amounts of hair on the subjects.' Todd (1923, p. 145) wrote that;

> Circumference alone...cannot be expected to give good results. Indeed all arc measurements, if applied to the head itself, are not comparable or reliable as anyone would testify who has tried to carry them out on one of our typical negro women.

Whether or not blacks and whites of each sex differ in the amount, texture, and styling of their hair – and how such differences might affect measurement of circumference and other head dimensions – has not been reported by contemporary craniologists.

The estimation of cranial capacity from external head dimensions, whatever its reliability, in no way distinguishes among the various contents of the skull – dura, ventricles, white matter, gray matter, etc. The implicit 'theory' relating race differences in cranial capacity to differences in IQ is that the skull is a case containing a certain volume of material, and that the sheer volume of material contained is positively related to intelligence. Bigger is assumed to be better. The justification for this view is the assertion that external measurements of the head, race aside, are in fact correlated with measured IQ. We turn now to a brief review of the literature purporting to demonstrate such a correlation.

Head size and 'intelligence'

The results of numerous studies between 1906 and 1994 relating various external head measurements to purported measures of intelligence have been tabulated by Rushton (1990), by Lynn (1993a), by Wickett, Vernon, and Lee (1994), and by Rushton and Ankney (1996). There is of course great overlap in the studies cited in each tabulation. The unweighted mean correlation for 15 samples tabulated by Rushton was 0.17. For 15 studies tabulated by Lynn the mean was 0.16, and for the 39 samples tabulated by Wickett *et al.* it was 0.18. Rushton and Ankney separated studies of children from those of adults, and reported a mean correlation of 0.21 for the former and 0.15 for the latter. Some, but not all, of the correlations were statistically significant. The reported values ranged between 0.02 (Reed & Jensen, 1993), and 0.39 (Schreider, 1968, as reported by Rushton & Ankney). However, that largest reported correlation can be dismissed. Though Rushton and Ankney maintained that Schreider had measured head 'perimeter', Schreider had in fact reported a correlation, based on 80 Otomi Indians, between an intelligence measure and the distance between the top of the head and the sternum.

Data reported in this literature sometimes pool the two sexes and sometimes do not. There is usually no attempt to correct for, or to report, differences among subjects in body size. Body size differences are associated with social class. The second largest reported correlation was by Weinberg *et al.* (1974), who found a correlation of .35 between head circumference and IQ in 8- and 9-year-old boys. When the authors attempted to partial out social class, the correlation dropped to 0.21 – but, as Weinberg *et al.* pointed out, the relation between IQ and their social class measure was not linear. Other individual studies, many dating from early in the century, suffer from a number of defects. For example, Murdoch and Sullivan (1923) reported a correlation of 0.22 between head 'diameter' (the mean of head length and breadth) and IQ in white Hawaiian school children. The children, in grades K to 12, had been given one of three different IQ tests, depending on their age. Because the three tests produced very different average 'IQs,' the authors subtracted 12 points from the IQ scores of younger children, and added 6 points to the scores of older children. The older children obviously had larger heads; if Murdoch and Sullivan over-corrected their IQ scores, their correlation between IQ and head size could be entirely artifactual.

The fact that no negative correlations have been published may be attributable to the 'file drawer' effect. It is not likely that a researcher finding a negative correlation of the order of –0.01 or –0.15 between head size and intelligence would submit it for publication; if (s)he did, it is not likely that a journal would publish it. In any event, even if we accept that a correlation between head size and IQ exists, it is obviously very modest in size. Even that modest correlation might be largely, if not entirely, attributable to the correlation of head size with body size, and to nutritional and social class effects on both body size and IQ.

It is of interest to examine those studies which correlated an intelligence measure with more than one head size dimension. The various tabulations contain five such studies, and their results are summarised in Table 3. The correlations are all small,

Table 3 Correlations of head measurements with IQ

Study	*N*	Circumference	Head length	Head breadth	Head height
Schreider (1968)	80	–	0.05	0.11	0.32
Schreider (1968)	158	–	0.02	0.23	0.21
Weinberg *et al.* (1974)	334	0.35	0.40	0.20	–
Susanne (1979)	2071	0.24	0.22	0.13	–
Henneberg *et al.* (1985)	302	–	0.13	0.09	0.09
Jensen (1994)	286	0.16	0.19	0.11	–

and the rank ordering of head dimensions in terms of their association with IQ is not consistent from study to study. But it is clear that circumference is at least as powerful a predictor of IQ as are head length, breadth, or height. Head circumference, a dimension on which American blacks exceed whites, has in fact the highest average correlation in the table. Further, Rushton and Ankney's tabulation of different studies included 20 correlations between 'perimeter' and intelligence, and nine correlations between 'capacity' and intelligence. We have calculated the average correlation for the circumference measure (0.19) and for the capacity measure (0.15). If head size is to explain race differences in measured IQ, we should if anything expect blacks to have higher IQs. They do not. The explanation for black-white differences in IQ must be sought elsewhere.

Conclusion

We have reviewed the recent literature purporting to demonstrate black-white differences in cranial capacity, as estimated by Lee and Pearson's (1901) regression formulas for external head measurements of living subjects. We questioned the applicability of the formulas to different races. We pointed to a number of calculational and other errors, which invalidate the conclusions of several of the studies. We concluded that black-white differences do exist for some head dimensions, and that the differing estimated cranial capacities produced by Lee and Pearson's antiquated formulas are a consequence of the differently shaped heads of blacks and whites.

We briefly reviewed a literature which reports a small but significant correlation, race aside, between head size and IQ. We suggested that at least some of the reported correlation could be attributable to uncontrolled body size differences, and to nutritional and social class effects on head size and IQ. From studies which reported separate correlations between IQ and different head dimensions, it appeared that head circumference, a dimension on which blacks exceed whites, was at least as powerful a predictor of IQ as any other dimension.

The differences in external head dimensions between whites and blacks are small, and inconsistent in direction. The reported correlation between head size and intelligence is itself small. These data thus could not possibly explain more than a tiny fraction of the black-white difference in measured IQ. We have to ask, why then has so much calculational labour, and so much journal space, been devoted to the resuscitation of Lee and Pearson's outmoded formulas? How can reputable journals have published racially oriented articles so replete with errors? The answer seems obvious. The well-spring of contemporary 'scientific' interest in estimating race differences in cranial capacity in no way differs from the considerations which animated Soemmering in 1875 to fill black and white crania with water, and which caused the Paris Anthropological Society in 1861 to debate about the American Negro's brain. Then, as now, science is called upon to 'explain' race differences in social and economic position.

Today, unfortunately, there appears to be no shortage of scientists, or of scientific journals, ready to answer the call.

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