Brain Size Matters: A Reply to Peters

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Abstract Peters (1993) claimed that published research on brain size and IQ is flawed because it did not meet his list of "minimum conditions" that (a) subjects should be matched for height, weight and age, (b) analyses should be conducted separately within sex, (c) subjects should not vary in prenatal and nutritional history, (d) people with IQs appreciably below the population mean of 100 should not be studied, and (e) brain size measures should be done "blind". However, these "conditions" have either been met or are unnecessary and/or inappropriate. We show, contrary to Peters' claims, that (a) brain size is related to mental abilities, (b) brain size varies by sex and race, and (c) mental abilities vary by sex and race. Finally, we suggest that brain size constraints on behavioural complexity may be best understood from an evolutionary perspective.

Résumé Peters (1993) a prétendu que la recherche publiée sur la corrélation entre la dimension du cerveau et le QI n'était pas valide car elle ne répondait pas aux exigences de sa liste de conditions minimales, à savoir (a) qu'il faudrait jumeler les sujets en fonction de leur taille, de leur poids et de leur âge; (b) que les analyses devraient se faire pour les gens d'un même sexe; (c) que les sujets devraient avoir des antécédents prénatals et de nutrition semblables; (d) qu'il faudrait exclure des résultats des tests les personnes dont le QI est substantiellement inférieur à la moyenne de 100 estimée pour la population générale; et, (e) que la mesure de la dimension du cerveau devrait se faire de manière objective. Toutefois, ces conditions ont été satisfaites ou sont inutiles et/ou inappropriées. Nous démontrons, contrairement aux avancés de Peters, que: (a) la dimension du cerveau a un rapport avec les facultés intellectuelles; (b) la dimension du cerveau varie selon la race et le sexe; et, (c) les facultés intellectuelles varient selon la race et le sexe. Enfin, nous suggérons que l'influence de la dimension du cerveau sur la complexité du comportement peut être mieux comprise d'un point de vue tenant compte de l'évolution.

In a reply to Lynn (1993) about brain size and IQ, Peters (1993) charged bias and questionable motives to dismiss relations first established over 100 years

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ago. Peters (1993) claimed that studies of brain size are confounded by systematic bias, including "racial bias", over and above normal measurement error. Peters (1993) also conjectured that uni-directional measurement errors may exist and so he dismissed Rushton's (1992) analyses showing race and sex differences in cranial capacity in 6,325 U.S. military personnel. Consequently, Peters claimed that such studies must be done "blind", i.e., the person doing the measurement should not know the race of the subject being measured.

Peters did not note, although it was made clear in Rushton's (1992) paper, that (1) Rushton neither made the measurements nor knew who did, and (2) measurements were made to determine proper helmet sizes not brain sizes (i.e., they were done "blind", as the measurers were unaware of the use that Rushton would make of their data). The East Asian/European/African differences that Rushton (1992) found in cranial capacity (cm^3) using external head measurements are similar to those found by Beals, Smith, and Dodd (1984) who estimated cm^3 from endocranial volume, and by Ho, Roessmann, Straumfjord, and Monroe (1980) who weighed brain mass (grams) at autopsy. Does Peters believe that Ho et al. "leaned" on their scales, when weighing brains of European-Americans, by just enough to produce the same difference caused by "extra snug" measurements supposedly made by those measuring heads of African-Americans? Regardless, it is implausible that the "racial bias" alleged by Peters would also produce findings that East Asians have relatively larger brains than do Europeans.

Allometric and nutritional factors

Peters (1993) misstates when and why it is appropriate to correct for variation in body size (e.g., height or weight) when analyzing human attributes. It is only appropriate to correct for body size if one wishes to determine whether two (or more) individuals or groups are *relatively* different in some attribute, when it is already known that they are *absolutely* different in that attribute *and/or* in body size. For example, men and women differ in both *absolute* brain size and *absolute* body size. Thus, it is appropriate to correct for body size to determine if men have relatively larger brains. But, it would be inappropriate to correct for body size to determine if men have *absolutely* higher IQs.

Consider this simple analogy: John Doe is 178 cm tall and can jump 1 m off the ground, whereas basketball star Michael Jordan is 208 cm tall and can jump 1.17 m off the ground. There are two questions that we can ask from this: (1) For his size, can Michael Jordan jump higher? (Answer is no – he's 17% taller and can jump 17% higher), and (2) Can Michael Jordan jump higher? (Answer is, obviously, yes).

Now, consider Peters' argument that to determine if larger brains produce (absolutely) higher IQs, one must correct for body size. This, as can be seen from the above, makes no sense. A higher IQ is a higher IQ (just as a higher jump is a higher jump) regardless of body size. On average, taller people have higher IQ's, not because they are taller, per se, but because, on average, they have larger brains. Correcting for body size reduces the question to a nullity, i.e., do tall people with their larger brains have *relatively* higher IQ's?

Peters erred similarly when he argued that age must be controlled when analyzing brain-size/IQ relations in adults. Both brain size (Ho et al., 1980) and IQ (Brody, 1992) decline after the age of 45 years. This likely is not coincidental but, regardless, if one corrects for age then the result would simply be that brains of similar size tend to produce similar IQ's.

Peters' erroneously stated that subjects in studies of brain-size/IQ relations should have similar early-life nutrition and be from the same social class. His rationale is that these factors can affect brain size. But, the question is "do people with smaller brains have lower IQ's?", not "why do they have smaller brains?". It might be interesting to know why John Doe is shorter than Michael Jordan but, regardless, he cannot jump as high.

Brain size and intelligence

As Lynn (1993) showed, the IQ/brain-size relation is ubiquitous. Studies, additional to those provided by Lynn (1993), show that the correlation ranges from 0.10 to 0.30 with a mean of about 0.20 (Wickett, Vernon, & Lee, 1994). The head-perimeter/IQ relation occurs in Orientals as well as whites and blacks and is apparent early in life. The National Collaborative Perinatal Project (Broman et al., 1987) found that head perimeter at birth, at 1 year, and at 4 years correlated with IQ at age 7 from $r = 0.13$ to 0.24 in 19,000 black and 17,000 white children. Jensen and Johnson (1994) used these data to show that head size at age 7 (although not at age 4) is correlated with IQ *within-families* (i.e., among same-sex full siblings, with age partialed out), thus indicating a *functional* relation between brain size and IQ.

Magnetic resonance imaging techniques that create a 3-dimensional model of the brain *in vivo* confirm the brain-size/IQ relation. Five studies found an average correlation greater than 0.40, an improvement over studies that used head perimeter as a measure (Willerman et al., 1991; Andreasen et al., 1993; Raz et al., 1993; Egan et al., 1994; Wickett et al., 1994). Peters critiqued the two studies then available, but only confused the issue. First, he claimed that Willerman et al.'s (1991) low IQ group, because it averaged only 90.5, was an improper "control". It was, however, not intended to be a control. Importantly, Willerman et al. showed that those with below average IQ had, on average, smaller brains. Second, Peters (1993) almost conceded the brain-size/IQ relation in his footnote citation to Andreasen et al. (1993). However, even there he suspected bias, i.e., "self-selection of subjects." But, this could only bias such results if people with large-brains/high-IQ and small-brains/low-IQ volunteered, whereas those with "large-brains/low-IQ" and "small-brains/high-IQ" did not. We are unaware of evidence to support such an implausibility. Regardless, beside studies by Willerman et al. (1991) and Andreasen et al. (1993) cited by Peters (1993), the brain-size/IQ relation established using magnetic resonance imaging was corroborated by Raz et al. (1993), Egan et al. (1994), and Wickett et al. (1994).

The null hypothesis of no relation between brain size and IQ is false. In anticipation of this, Peters (1993) argued that even if brain-size/IQ correlations are valid, they account for only a small percentage of variation. But, it is predictable that correlations between IQ and overall brain size will be modest. First, much of the brain is not involved in producing what we call intelligence; thus, variation in size/mass of that tissue will reduce the correlation. Second, IQ is an imperfect measure of intelligence and thus, variation in IQ scores is an imperfect measure of variation in intelligence.

Sex differences

Peters (1993) correctly noted the absolute male/female difference in brain size. He was, however, incorrect that comparisons of brain size across sex cannot be made because there are (supposedly) no appropriate scalars of body size. Ankney (1992) reexamined Ho et al.'s (1980) autopsy data on 1,261 Americans aged 25 to 80 after excluding obviously damaged brains. Using allometric techniques that are standard in comparative biology, Ankney (1992) found that at any given surface area or height, brains of European-American men are heavier than those of European-American women and brains of African-American men are heavier than those of African-American women. For example, among 168 cm (5'7") tall European-Americans (the approximate overall mean height for men and women combined), brain mass of men averages about 100 grams heavier than that of women.

Ankney's (1992) results were confirmed in Rushton's (1992) study of a stratified random sample of U.S. Army personnel. After adjusting for effects of age, stature, weight, military rank and race, cranial capacity of men averaged 1,442 cm^3 and women 1,332 cm^3. This difference was found in all of the many analyses that were done to control for various possible body size effects (see Rushton, 1992). Moreover, the difference was replicated across samples of Asian-Americans, European-Americans and African-Americans, as well as in officers and enlisted personnel.

Peters (1993) correctly noted the paradox that women have proportionately smaller brains than do men, but *apparently* have the same IQ scores. Thus, Ankney (1992) proposed that the sex difference in brain size relates to those intellectual abilities at which men excel. Briefly, according to Kimura (1992), women excel in verbal ability, perceptual speed, and motor coordination within personal space; men do better on various spatial tests and on tests of mathematical reasoning. Ankney hypothesized that it may require more brain tissue to process spatial information. Just as increasing word processing power in a computer may require extra capacity, increasing 3-dimensional processing, as in graphics, requires a major jump in capacity. In support of Ankney's hypothesis, although Lynn (1994) found that men average 4 points higher than do women on standard IQ tests, Ankney (1995) showed that nearly all of this difference derived from men's higher scores on spatial and mathematical reasoning subtests.

Race differences

Rushton (1995) reviewed 100 years of scientific literature and found that across a triangulation of procedures, brains of East-Asians and their descendants average about 17 cm^3 (1 in^3) larger than those of Europeans and their descendents whose brains average about 80 cm^3 (5 in^3) larger than those of Africans and their descendents. Although critics can pick outliers to show counter-examples and suggest opposite trends (as could critics of a statement that men are, on average, taller than women) the aggregated data are clear (see Rushton, 1995, for full discussion of alleged counter examples).

Consider the following statistically significant comparisons. Using brain mass at autopsy, Ho et al. (1980) summarized data for 1,261 adults (see above) and reported a sex-combined difference between 811 European-Americans with a mean of 1,323 g (SD = 146) and 450 African-Americans with a mean of 1,223 g (SD = 144). Using endocranial volume, Beals et al. (1984, page 307, Table 5) analyzed 20,000 crania and found sex-combined brain cases differed by continental area. Excluding Caucasoid areas of Asia (e.g., India) and Africa (e.g., Egypt), 19 East Asian populations averaged 1,415 cm^3 (SD = 51), 10 European groups averaged 1,362 cm^3 (SD = 35) and 9 African groups averaged 1,268 cm^3 (SD = 85). Using external head measurements, Rushton (1992) found, in a stratified random sample of 6,325 U.S. Army personnel, measured in 1988 to determine head size for fitting helmets, Asian-Americans, European-Americans, and African-Americans averaged 1,416, 1,380, and 1,359 cm^3, respectively (see also, Rushton, 1994).

Globally, racial differences in brain size parallel those found in measured intelligence. Europeans in North America, Europe and Australasia have mean IQs of around 100. For East Asians, measured in North America and in Pacific Rim countries, means range from 101 to 111. Africans living south of the Sahara, African-Americans and African-Caribbeans (including those living in Britain), have mean IQs of from 70 to 90 (Lynn, 1991). Elementary speed of information processing in 9- to 12-year-olds, in which children decide which of several lights stands out from others, show that racial differences in mental ability are pervasive. All children can perform the tasks in less than 1 s, but more intelligent children, as measured by traditional IQ tests, perform the tasks faster than do less intelligent children. Japanese and Hong Kong children have faster decision times (controlling for movement time) than do British and Irish children who have faster decision time than South African Black and African-American children (Jensen, 1993; Jensen & Whang, 1993; Lynn, 1991).

Evolutionary considerations

Metabolically, the human brain is an expensive organ. Representing only 2% of body mass, the brain uses about 5% of basal metabolic rate in rats, cats, and dogs, about 10% in rhesus monkeys and other primates, and about 20% in humans. Thus, from an adaptationist perspective, unless large brains substantially contributed to evolutionary fitness (defined as increased survival of genes through successive generations), they would not have evolved.

Paradoxically, Peters (1993) cited Haug (1987) to refute "speculations about the significance of differences in brain size across individuals, sex, or race", even though Haug (1987, p.135) reported a correlation of $r = 0.479$ ($n = 81$, $p < .001$) between number of cortical neurons and brain size including both men and women in the sample. Haug's analysis showed that a person with a brain size of 1,400 cm^3 has, on average, 600 million fewer cortical neurons than an individual with a brain size of 1,500 cm^3. The difference between the low end of normal (1,000 cm^3) and the high end (1,700 cm^3) equates to 4.200 billion neurons (a difference of 27% more neurons for a 41% increase in brain size).

Haug noted that most female data points lay above the regression line (i.e., women average more neurons for a given brain size than do men). This suggests that women's brains are differently organized than are men's, and so causes and results of race differences in brain size may be different from those of sex differences. Kolakowski and Malina (1974) hypothesized that differing roles of men and women during human evolution produced a sexual dichotomy in abilities. Men roamed from the home base to hunt, which would select for targeting ability and navigational skills; women were relatively sedentary. Ankney (1992, 1995) expanded on this hypothesis to argue that selection for such abilities also selected for relatively larger brains in men and that it may require more brain tissue to process spatial information.

Rushton (1995) provided an evolutionary hypothesis for why East Asians have the largest brains. The currently accepted view of human origins posits a beginning in Africa some 200,000 years ago, an African/non-African split about 110,000 years ago, and a European/East Asian split about 40,000 years ago (Stringer & Andrews, 1988). Evolutionary selection pressures were different in the hot savanna where Africans evolved than in the cold arctic where East Asians evolved. According to Rushton (1995), the further north the populations migrated, out of Africa, the more they encountered cognitively demanding problems of gathering and storing food, gaining shelter, making clothes, and raising children during prolonged winters. As the original African populations evolved into Europeans and East Asians, they did so in the direction of larger brains, greater intelligence, slower rates of maturation, and other traits that differentiate these populations.

Conclusion

The evidence is overwhelming that there are racial and sexual differences in brain size, that there are racial differences in general IQ, that there are sexual differences in verbal versus performance IQ, and that differences in mental abilities are related to differences in brain size. Peters cannot simply deny this evidence. Thus, important research questions include (1) what is responsible for the group differences, i.e., are they genetically and/or environmentally caused?, (2) does the brain size/IQ correlation indicate "cause and effect"?, and (3) is there bidirectional causality such that the greater learning ability of high IQ children feeds back to produce even larger brain size?

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