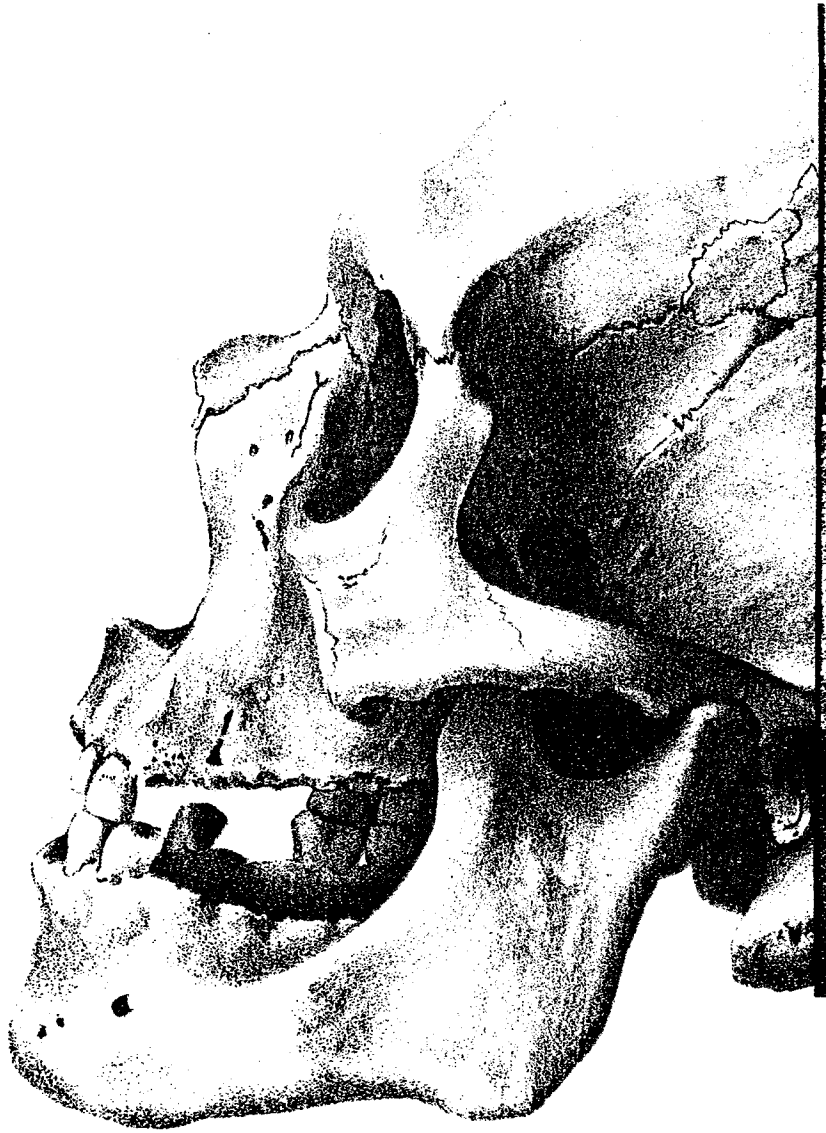

THE Mismeasure of Man

BY STEPHEN JAY GOULD

...nature, but by our institutions, great is

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THREE

Measuring Heads

Paul Broca and the Heyday of Craniology

No rational man, cognisant of the facts, believes that the average negro is the equal, still less the superior, of the average white man. And, if this be true, it is simply incredible that, when all his disabilities are removed, and our prognathous relative has a fair field and no favor, as well as no oppressor, he will be able to compete successfully with his bigger-brained and smaller-jawed rival, in a contest which is to be carried on by thoughts and not by bites. —T. H. HUXLEY

The allure of numbers

Introduction

Evolutionary theory swept away the creationist rug that had supported the intense debate between monogenists and polygenists, but it satisfied both sides by presenting an even better rationale for their shared racism. The monogenists continued to construct linear hierarchies of races according to mental and moral worth; the polygenists now admitted a common ancestry in the prehistoric mists, but affirmed that races had been separate long enough to evolve major inherited differences in talent and intelligence. As historian of anthropology George Stocking writes (1973, p. lxx): "The resulting intellectual tensions were resolved after 1859 by a comprehensive evolutionism which was at once monogenist and racist, which affirmed human unity even as it relegated the dark-skinned savage to a status very near the ape."

The second half of the nineteenth century was not only the era of evolution in anthropology. Another trend, equally irresistible,

swept through the human sciences—the allure of numbers, the faith that rigorous measurement could guarantee irrefutable precision, and might mark the transition between subjective speculation and a true science as worthy as Newtonian physics. Evolution and quantification formed an unholy alliance; in a sense, their union forged the first powerful theory of "scientific" racism—if we define "science" as many do who misunderstand it most profoundly: as any claim apparently backed by copious numbers. Anthropologists had presented numbers before Darwin, but the crudity of Morton's analysis (Chapter 2) belies any claim to rigor. By the end of Darwin's century, standardized procedures and a developing body of statistical knowledge had generated a deluge of more truthworthy numerical data.

This chapter is the story of numbers once regarded as surpassing all others in importance—the data of craniometry, or measurement of the skull and its contents. The leaders of craniometry were not conscious political ideologues. They regarded themselves as servants of their numbers, apostles of objectivity. And they confirmed all the common prejudices of comfortable white males—that blacks, women, and poor people occupy their subordinate roles by the harsh dictates of nature.

Science is rooted in creative interpretation. Numbers suggest, constrain, and refute; they do not, by themselves, specify the content of scientific theories. Theories are built upon the interpretation of numbers, and interpreters are often trapped by their own rhetoric. They believe in their own objectivity, and fail to discern the prejudice that leads them to one interpretation among many consistent with their numbers. Paul Broca is now distant enough. We can stand back and show that he used numbers not to generate new theories but to illustrate a priori conclusions. Shall we believe that science is different today simply because we share the cultural context of most practicing scientists and mistake its influence for objective truth? Broca was an exemplary scientist; no one has ever surpassed him in meticulous care and accuracy of measurement. By what right, other than our own biases, can we identify his prejudice and hold that science now operates independently of culture and class?

Francis Galton—apostle of quantification

No man expressed his era's fascination with numbers so well as Darwin's celebrated cousin, Francis Galton (1822–1911). Independently wealthy, Galton had the rare freedom to devote his considerable energy and intelligence to his favorite subject of measurement. Galton, a pioneer of modern statistics, believed that, with sufficient labor and ingenuity, anything might be measured, and that measurement is the primary criterion of a scientific study. He even proposed and began to carry out a statistical inquiry into the efficacy of prayer! Galton coined the term "eugenics" in 1883 and advocated the regulation of marriage and family size according to hereditary endowment of parents.

Galton backed his faith in measurement with all the ingenuity of his idiosyncratic methods. He sought, for example, to construct a "beauty map" of the British Isles in the following manner (1909, pp. 315–316):

> Whenever I have occasion to classify the persons I meet into three classes, "good, medium, bad," I use a needle mounted as a pricker, wherewith to prick holes, unseen, in a piece of paper, torn rudely into a cross with a long leg. I use its upper end for "good," the cross arm for "medium," the lower end for "bad." The prick holes keep distinct, and are easily read off at leisure. The object, place, and date are written on the paper. I used this plan for my beauty data, classifying the girls I passed in streets or elsewhere as attractive, indifferent, or repellent. Of course this was a purely individual estimate, but it was consistent, judging from the conformity of different attempts in the same population. I found London to rank highest for beauty; Aberdeen lowest.

With good humor, he suggested the following method for quantifying boredom (1909, p. 278):

> Many mental processes admit of being roughly measured. For instance, the degree to which people are bored, by counting the number of their fidgets. I not infrequently tried this method at the meetings of the Royal Geographical Society, for even there dull memoirs are occasionally read. . . . The use of a watch attracts attention, so I reckon time by the number of my breathings, of which there are 15 in a minute. They are not counted mentally, but are punctuated by pressing with 15 fingers successively. The counting is reserved for the fidgets. These observations should be confined to persons of middle age. Children are rarely still, while elderly philosophers will sometimes remain rigid for minutes altogether.

Quantification was Galton's god, and a strong belief in the inheritance of nearly everything he could measure stood at the right hand. Galton believed that even the most socially embedded behaviors had strong innate components: "As many members of our House of Lords marry the daughters of millionaires," he wrote (1909, pp. 314–315), "it is quite conceivable that our Senate may in time become characterized by a more than common share of shrewd business capacity, possibly also by a lower standard of commercial probity than at present." Constantly seeking new and ingenious ways to measure the relative worth of peoples, he proposed to rate blacks and whites by studying the history of encounters between black chiefs and white travelers (1884, pp. 338–339):

> The latter, no doubt, bring with them the knowledge current in civilized lands, but that is an advantage of less importance than we are apt to suppose. A native chief has as good an education in the art of ruling men, as can be desired; he is continually exercised in personal government, and usually maintains his place by the ascendancy of his character shown every day over his subjects and rivals. A traveller in wild countries also fills, to a certain degree, the position of a commander, and has to confront native chiefs at every inhabited place. The result is familiar enough—the white traveller almost invariably holds his own in their presence. It is seldom that we hear of a white traveller meeting with a black chief whom he feels to be the better man.

Galton's major work on the inheritance of intelligence (*Hereditary Genius,* 1869) included anthropometry among its criteria, but his interest in measuring skulls and bodies peaked later when he established a laboratory at the International Exposition of 1884. There, for threepence, people moved through his assembly line of tests and measures, and received his assessment at the end. After the Exposition, he maintained the lab for six years at a London museum. The laboratory became famous and attracted many notables, including Gladstone:

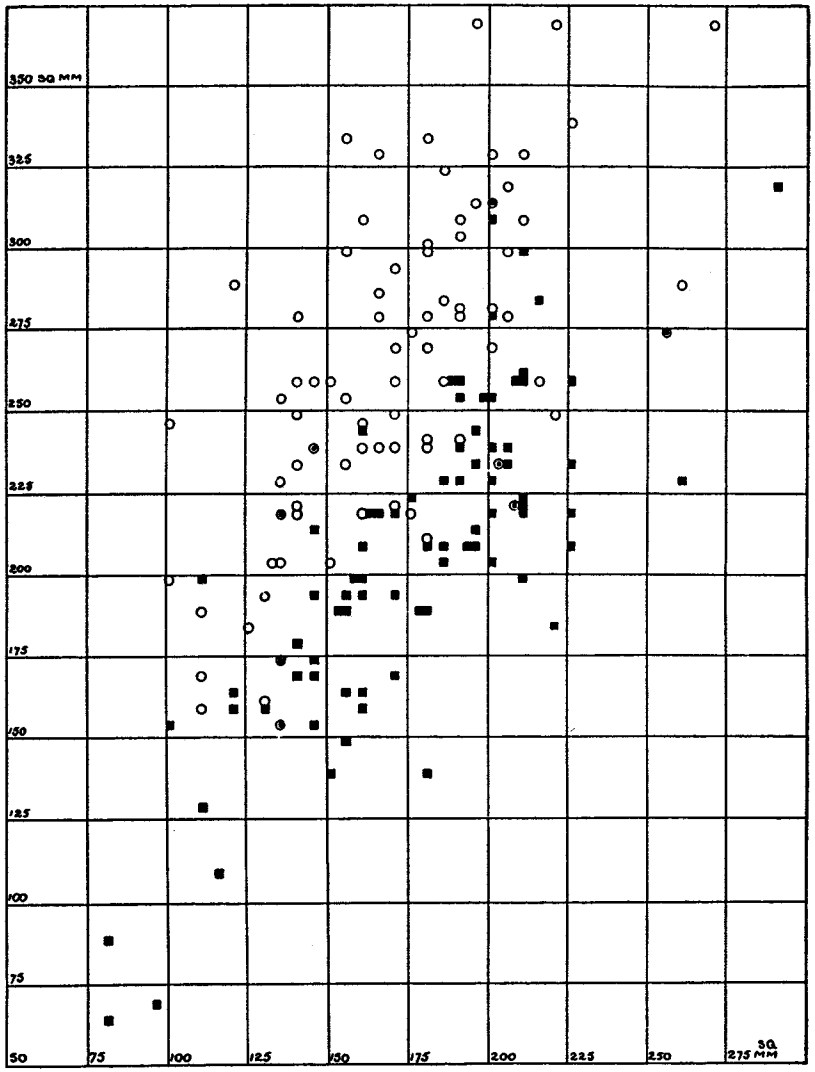
> Mr. Gladstone was amusingly insistent about the size of his head, saying that hatters often told him that he had an Aberdeenshire head—"a fact which you may be sure I do not forget to tell my Scotch constituents." It was a beautifully shaped head, though rather low, but after all it was not so very large in circumference (1909, pp. 249–250).

Lest this be mistaken for the harmless musings of some dotty Victorian eccentric, I point out that Sir Francis was taken quite seriously as a leading intellect of his time. The American hereditarian Lewis Terman, the man most responsible for instituting IQ tests in America, retrospectively calculated Galton's IQ at above 200, but accorded only 135 to Darwin and a mere 100–110 to Copernicus (see pp. 183–188 on this ludicrous incident in the history of mental testing). Darwin, who approached hereditarian arguments with strong suspicion, wrote after reading *Hereditary Genius:* "You have made a convert of an opponent in one sense, for I have always maintained that, excepting fools, men did not differ much in intellect, only in zeal and hard work" (in Galton, 1909, p. 290). Galton responded: "The rejoinder that might be made to his remark about hard work, is that character, including the aptitude for work, is heritable like every other faculty."

A curtain-raiser with a moral: Numbers do not guarantee truth

In 1906, a Virginia physician, Robert Bennett Bean, published a long, technical article comparing the brains of American blacks and whites. With a kind of neurological green thumb, he found meaningful differences wherever he looked—meaningful, that is, in his favored sense of expressing black inferiority in hard numbers.

Bean took special pride in his data on the corpus callosum, a structure within the brain that contains fibers connecting the right and left hemispheres. Following a cardinal tenet of craniometry, that higher mental functions reside in the front of the brain and sensorimotor capacities toward the rear, Bean reasoned that he might rank races by the relative sizes of parts within the corpus callosum. So he measured the length of the genu, the front part of the corpus callosum, and compared it with the length of the splenium, the back part. He plotted genu vs. splenium (Fig. 3.1) and obtained, for a respectably large sample, virtually complete separation between black and white brains. Whites have a relatively large genu, hence more brain up front in the seat of intelligence. All the more remarkable, Bean exclaimed (1906, p. 390) because the genu contains fibers both for olfaction and for intelligence! Bean continued: We all know that blacks have a keener sense of smell than whites; hence we might have expected larger genus in blacks if intelligence did not differ substantially between races. Yet black genus are smaller despite their olfactory predominance; hence, blacks must really suffer from a paucity of intelligence.



3•1 Bean's plot of the genu on the y-axis vs. the splenium on the x-axis. White circles are, unsurprisingly, for white brains; black squares for black brains. Whites seem to have a larger genu, hence more up front, and presumably more intelligence.

Moreover, Bean did not neglect to push the corresponding conclusion for sexes. Within each race, women have relatively smaller genus than men.

Bean then continued his discourse on the relatively greater size of frontal vs. parietal and occipital (side and back) parts of the brain in whites. In the relative size of their frontal areas, he proclaimed, blacks are intermediate between "man [*sic*] and the ourang-outang" (1906, p. 380).

Throughout this long monograph, one common measure is conspicuous by its absence: Bean says nothing about the size of the brain itself, the favored criterion of classical craniometry. The reason for this neglect lies buried in an addendum: black and white brains did not differ in overall size. Bean temporized: "So many factors enter into brain weight that it is questionable whether discussion of the subject is profitable here." Still, he found a way out. His brains came from unclaimed bodies given to medical schools. We all know that blacks have less respect for their dead than whites. Only the lowest classes of whites—prostitutes and the depraved—would be found among abandoned bodies, "while among Negroes it is known that even the better classes neglect their dead." Thus, even an absence of measured difference might indicate white superiority, for the data "do perhaps show that the low class Caucasian has a larger brain than a better class Negro" (1906, p. 409).

Bean's general conclusion, expressed in a summary paragraph before the troublesome addendum, proclaimed a common prejudice as the conclusion of science:

> The Negro is primarily affectionate, immensely emotional, then sensual and under stimulation passionate. There is love of ostentation, and capacity for melodious articulation; there is undeveloped artistic power and taste—Negroes make good artisans, handicraftsmen—and there is instability of character incident to lack of self-control, especially in connection with the sexual relation; and there is lack of orientation, or recognition of position and condition of self and environment, evidenced by a peculiar bumptiousness, so called, that is particularly noticeable. One would naturally expect some such character for the Negro, because the whole posterior part of the brain is large, and the whole anterior portion is small.

Bean did not confine his opinions to technical journals. He published two articles in popular magazines during 1906, and attracted

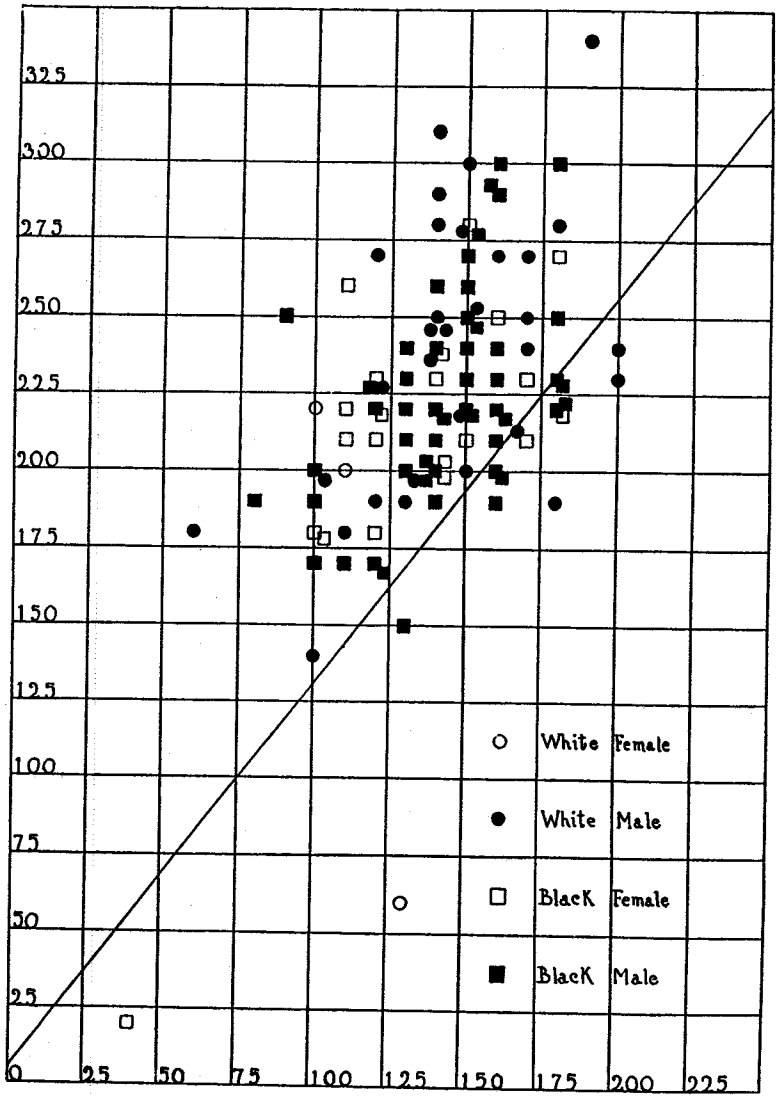
sufficient attention to become the subject of an editorial in *American Medicine* for April 1907 (cited in Chase, 1977, p. 179). Bean had provided, the editorial proclaimed, "the anatomical basis for the complete failure of the negro schools to impart the higher studies—the brain cannot comprehend them any more than a horse can understand the rule of three. . . . Leaders in all political parties now acknowledge the error of human equality. . . . It may be practicable to rectify the error and remove a menace to our prosperity—a large electorate without brains."

But Franklin P. Mall, Bean's mentor at Johns Hopkins, became suspicious: Bean's data were too good. He repeated Bean's work, but with an important difference in procedure—he made sure that he did not know which brains were from blacks and which from whites until *after* he had measured them (Mall, 1909). For a sample of 106 brains, using Bean's method of measurement, he found no difference between whites and blacks in the relative sizes of genu and splenium (Fig. 3.2). This sample included 18 brains from Bean's original sample, 10 from whites, 8 from blacks. Bean's measure of the genu was larger than Moll's for 7 whites, but for only a single black. Bean's measure of the splenium was larger than Moll's for 7 of the 8 blacks.

I use this small tale of zealotry as a curtain-raiser because it illustrates so well the major contentions of this chapter and book:

1. Scientific racists and sexists often confine their label of inferiority to a single disadvantaged group; but race, sex, and class go together, and each acts as a surrogate for the others. Individual studies may be limited in scope, but the general philosophy of biological determinism pervades—hierarchies of advantage and disadvantage follow the dictates of nature; stratification reflects biology. Bean studied races, but he extended his most important conclusion to women, and also invoked differences of social class to argue that equality of size between black and white brains really reflects the inferiority of blacks.

2. Prior prejudice, not copious numerical documentation, dictates conclusions. We can scarcely doubt that Bean's statement about black bumptiousness reflected a prior belief that he set out to objectify, not an induction from data about fronts and backs of brains. And the special pleading that yielded black inferiority from equality of brain size is ludicrous outside a shared context of a priori belief in the inferiority of blacks.



3•2 Moll's plot of genu vs. splenium. Moll measured the brains without knowing whether they came from whites or blacks. He found no difference between the races. The line represents Bean's separation between whites and blacks.

3. Numbers and graphs do not gain authority from increasing precision of measurement, sample size, or complexity in manipulation. Basic experimental designs may be flawed and not subject to correction by extended repetition. Prior commitment to one among many potential conclusions often guarantees a serious flaw in design.

4. Craniometry was not just a plaything of academicians, a subject confined to technical journals. Conclusions flooded the popular press. Once entrenched, they often embarked on a life of their own, endlessly copied from secondary source to secondary source, refractory to disproof because no one examined the fragility of primary documentation. In this case, Mall nipped a dogma in the bud, but not before a leading journal had recommended that blacks be barred from voting as a consequence of their innate stupidity.

But I also note an important difference between Bean and the great European craniometricians. Bean committed either conscious fraud or extraordinary self-delusion. He was a poor scientist following an absurd experimental design. The great craniometricians, on the other hand, were fine scientists by the criteria of their time. Their numbers, unlike Bean's, were generally sound. Their prejudices played a more subtle role in specifying interpretations and in suggesting what numbers might be gathered in the first place. Their work was more refractory to exposure, but equally invalid for the same reason: prejudices led through data in a circle back to the same prejudices—an unbeatable system that gained authority because it seemed to arise from meticulous measurement.

Bean's story has been told several times (Myrdal, 1944; Haller, 1971; Chase, 1977), if not with all its details. But Bean was a marginal figure on a temporary and provincial stage. I have found no modern analysis of the main drama, the data of Paul Broca and his school.

Masters of craniometry: Paul Broca and his school

The great circle route

In 1861 a fierce debate extended over several meetings of a young association still experiencing its birth pangs. Paul Broca

(1824–1880), professor of clinical surgery in the faculty of medicine, had founded the Anthropological Society of Paris in 1859. At a meeting of the society two years later, Louis Pierre Gratiolet read a paper that challenged Broca's most precious belief: Gratiolet dared to argue that the size of a brain bore no relationship to its degree of intelligence.

Broca rose in his own defense, arguing that "the study of the brains of human races would lose most of its interest and utility" if variation in size counted for nothing (1861, p. 141). Why had anthropologists spent so much time measuring skulls, unless their results could delineate human groups and assess their relative worth?

> Among the questions heretofore discussed within the Anthropological Society, none is equal in interest and importance to the question before us now. . . . The great importance of craniology has struck anthropologists with such force that many among us have neglected the other parts of our science in order to devote ourselves almost exclusively to the study of skulls. . . . In such data, we hoped to find some information relevant to the intellectual value of the various human races (1861, p. 139).

Broca then unleashed his data and poor Gratiolet was routed. His final contribution to the debate must rank among the most oblique, yet abject concession speeches ever offered by a scientist. He did not abjure his errors; he argued instead that no one had appreciated the subtlety of his position. (Gratiolet, by the way, was a royalist, not an egalitarian. He merely sought other measures to affirm the inferiority of blacks and women—earlier closure of the skull sutures, for example.)

Broca concluded triumphantly:

> In general, the brain is larger in mature adults than in the elderly, in men than in women, in eminent men than in men of mediocre talent, in superior races than in inferior races (1861, p. 304). . . . Other things equal, there is a remarkable relationship between the development of intelligence and the volume of the brain (p. 188).

Five years later, in an encyclopedia article on anthropology, Broca expressed himself more forcefully:

> A prognathous [forward-jutting] face, more or less black color of the skin, woolly hair and intellectual and social inferiority are often associated,

while more or less white skin, straight hair and an orthognathous [straight] face are the ordinary equipment of the highest groups in the human series (1866, p. 280). . . . A group with black skin, woolly hair and a prognathous face has never been able to raise itself spontaneously to civilization (pp. 295–296).

These are harsh words, and Broca himself regretted that nature had fashioned such a system (1866, p. 296). But what could he do? Facts are facts. "There is no faith, however respectable, no interest, however legitimate, which must not accommodate itself to the progress of human knowledge and bend before truth" (in Count, 1950, p. 72). Paul Topinard, Broca's leading disciple and successor, took as his motto (1882, p. 748): *"J'ai horreur des systèmes et surtout des systèmes a priori"* (I abhor systems, especially a priori systems).

Broca singled out the few egalitarian scientists of his century for particularly harsh treatment because they had debased their calling by allowing an ethical hope or political dream to cloud their judgment and distort objective truth. "The intervention of political and social considerations has not been less injurious to anthropology than the religious element" (1855, in Count, 1950, p. 73). The great German anatomist Friedrich Tiedemann, for example, had argued that blacks and whites did not differ in cranial capacity. Broca nailed Tiedemann for the same error I uncovered in Morton's work (see pp. 50–69). When Morton used a subjective and imprecise method of reckoning, he calculated systematically lower capacities for blacks than when he measured the same skulls with a precise technique. Tiedemann, using an even more imprecise method, calculated a black average 45 cc above the mean value recorded by other scientists. Yet his measures for white skulls were no larger than those reported by colleagues. (For all his delight in exposing Tiedemann, Broca apparently never checked Morton's figures, though Morton was his hero and model. Broca once published a one-hundred-page paper analyzing Morton's techniques in the most minute detail—Broca, 1873b.)

Why had Tiedemann gone astray? "Unhappily," Broca wrote (1873b, p. 12), "he was dominated by a preconceived idea. He set out to prove that the cranial capacity of all human races is the same." But "it is an axiom of all observational sciences that facts must precede theories" (1868, p. 4). Broca believed, sincerely I assume, that facts were his only constraint and that his success in affirming traditional rankings arose from the precision of his measures and his care in establishing repeatable procedures.

Indeed, one cannot read Broca without gaining enormous respect for his care in generating data. I believe his numbers and doubt that any better have ever been obtained. Broca made an exhaustive study of all previous methods used to determine cranial capacity. He decided that lead shot, as advocated by "le célèbre Morton" (1861, p. 183), gave the best results, but he spent months refining the technique, taking into account such factors as the form and height of the cylinder used to receive the shot after it is poured from the skull, the speed of pouring shot into the skull, and the mode of shaking and tapping the skull to pack the shot and to determine whether or not more will fit in (Broca, 1873b). Broca finally developed an objective method for measuring cranial capacity. In most of his work, however, he preferred to weigh the brain directly after autopsies performed by his own hands.

I spent a month reading all of Broca's major work, concentrating on his statistical procedures. I found a definite pattern in his methods. He traversed the gap between fact and conclusion by what may be the usual route—predominantly in reverse. Conclusions came first and Broca's conclusions were the shared assumptions of most successful white males during his time—themselves on top by the good fortune of nature, and women, blacks, and poor people below. His facts were reliable (unlike Morton's), but they were gathered selectively and then manipulated unconsciously in the service of prior conclusions. By this route, the conclusions achieved not only the blessing of science, but the prestige of numbers. Broca and his school used facts as illustrations, not as constraining documents. They began with conclusions, peered through their facts, and came back in a circle to the same conclusions. Their example repays a closer study, for unlike Morton (who manipulated data, however unconsciously), they reflected their prejudices by another, and probably more common, route: advocacy masquerading as objectivity.

Selecting characters

When the "Hottentot Venus" died in Paris, Georges Cuvier, the greatest scientist and, as Broca would later discover to his delight,

the largest brain of France, remembered this African woman as he had seen her in the flesh.

> She had a way of pouting her lips exactly like what we have observed in the orang-utan. Her movements had something abrupt and fantastical about them, reminding one of those of the ape. Her lips were monstrously large [those of apes are thin and small as Cuvier apparently forgot]. Her ear was like that of many apes, being small, the tragus weak, and the external border almost obliterated behind. These are animal characters. I have never seen a human head more like an ape than that of this woman (in Topinard, 1878, pp. 493–494).

The human body can be measured in a thousand ways. Any investigator, convinced beforehand of a group's inferiority, can select a small set of measures to illustrate its greater affinity with apes. (This procedure, of course, would work equally well for white males, though no one made the attempt. White people, for example, have thin lips—a property shared with chimpanzees—while most black Africans have thicker, consequently more "human," lips.)

Broca's cardinal bias lay in his assumption that human races could be ranked in a linear scale of mental worth. In enumerating the aims of ethnology, Broca included: "to determine the relative position of races in the human series" (in Topinard, 1878, p. 660). It did not occur to him that human variation might be ramified and random, rather than linear and hierarchical. And since he knew the order beforehand, anthropometry became a search for characters that would display the correct ranking, not a numerical exercise in raw empiricism.

Thus Broca began his search for "meaningful" characters—those that would display the established ranks. In 1862, for example, he tried the ratio of radius (lower arm bone) to humerus (upper arm bone), reasoning that a higher ratio marks a longer forearm—a character of apes. All began well: blacks yielded a ratio of .794, whites .739. But then Broca ran into trouble. An Eskimo skeleton yielded .703, an Australian aborigine .709, while the Hottentot Venus, Cuvier's near ape (her skeleton had been preserved in Paris), measured a mere .703. Broca now had two choices. He could either admit that, on this criterion, whites ranked lower than several dark-skinned groups, or he could abandon the criterion. Since he knew (1862a, p. 10) that Hottentots, Eskimos, and Australian aborigines ranked below most African blacks, he chose the second course: "After this, it seems difficult to me to continue to say that elongation of the forearm is a character of degradation or inferiority, because, on this account, the European occupies a place between Negroes on the one hand, and Hottentots, Australians, and eskimos on the other" (1862, p. 11).

Later, he almost abandoned his cardinal criterion of brain size because inferior yellow people scored so well:

> A table on which races were arranged by order of their cranial capacities would not represent the degrees of their superiority or inferiority, because size represents only one element of the problem [of ranking races]. On such a table, Eskimos, Lapps, Malays, Tartars and several other peoples of the Mongolian type would surpass the most civilized people of Europe. A lowly race may therefore have a big brain (1873a, p. 38).

But Broca felt that he could salvage much of value from his crude measure of overall brain size. It may fail at the upper end because some inferior groups have big brains, but it works at the lower end because small brains belong exclusively to people of low intelligence. Broca continued:

> But this does not destroy the value of small brain size as a mark of inferiority. The table shows that West African blacks have a cranial capacity about 100 cc less than that of European races. To this figure, we may add the following: Caffirs, Nubians, Tasmanians, Hottentots, Australians. These examples are sufficient to prove that if the volume of the brain does not play a decisive role in the intellectual ranking of races, it nevertheless has a very real importance (1873a, p. 38).

An unbeatable argument. Deny it at one end where conclusions are uncongenial; affirm it by the same criterion at the other. Broca did not fudge numbers; he merely selected among them or interpreted his way around them to favored conclusions.

In choosing among measures, Broca did not just drift passively in the sway of a preconceived idea. He advocated selection among characters as a stated goal with explicit criteria. Topinard, his chief disciple, distinguished between "empirical" characters "having no apparent design," and "rational" characters "related to some physiological opinion" (1878, p. 221). How then to determine which characters are "rational"? Topinard answered: "Other characteristics are looked upon, whether rightly or wrongly, as dominant.

They have an affinity in negroes to those which they exhibit in apes, and establish the transition between these and Europeans" (1878, p. 221). Broca had also considered this issue in the midst of his debate with Gratiolet, and had reached the same conclusion (1861, p. 176):

> We surmount the problem easily by choosing,for our comparison of brains, races whose intellectual inequalities are completely clear. Thus, the superiority of Europeans compared with African Negroes, American Indians, Hottentots, Australians and the Negroes of Oceania, is sufficiently certain to serve as a point of departure for the comparison of brains.

Particularly outrageous examples abound in the selection of individuals to represent groups in illustrations. Thirty years ago, when I was a child, the Hall of Man in the American Museum of Natural History still displayed the characters of human races by linear arrays running from apes to whites. Standard anatomical illustrations, until this generation, depicted a chimp, a Negro, and a white, part by part in that order—even though variation among whites and blacks is always large enough to generate a different order with other individuals: chimp, white, black. In 1903, for example, the American anatomist E. A. Spitzka published a long treatise on brain size and form in "men of eminence." He printed the following figure (Fig. 3.3) with a comment: "The jump from a Cuvier or a Thackeray to a Zulu or a Bushman is not greater than from the latter to the gorilla or the orang" (1903, p. 604). But he also published a similar figure (Fig. 3.4) illustrating variation in brain size among eminent whites apparently never realizing that he had destroyed his own argument. As F. P. Mall, the man who exposed Bean, wrote of these figures (1909, p. 24): "Comparing [them], it appears that Gambetta's brain resembles the gorilla's more than it does that of Gauss."

Averting anomalies

Inevitably, since Broca amassed so much disparate and honest data, he generated numerous anomalies and apparent exceptions to his guiding generality—that size of brain records intelligence and that comfortable white males have larger brains than women, poor people, and lower races. In noting how he worked around each apparent exception, we obtain our clearest insight into Broca's

methods of argument and inference. We also understand why data could never overthrow his assumptions.

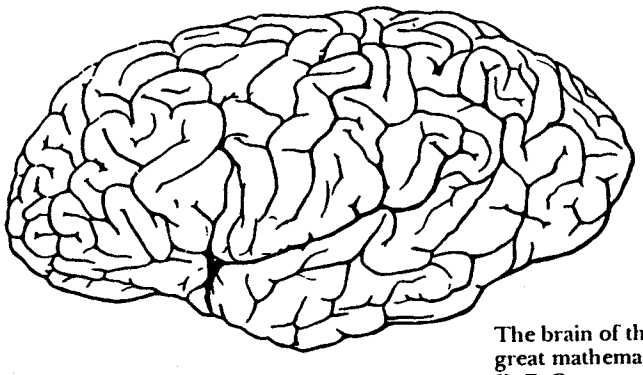
BIG-BRAINED GERMANS

Gratiolet, in his last desperate attempt, pulled out all the stops. He dared to claim that, on average, German brains are 100 grams heavier than French brains. Clearly, Gratiolet argued, brain size has nothing to do with intelligence! Broca responded disdainfully: "Monsieur Gratiolet has almost appealed to our patriotic sentiments. But it will be easy for me to show him that he can grant some value to the size of the brain without ceasing, for that, to be a good Frenchman" (1861, pp. 441–442).

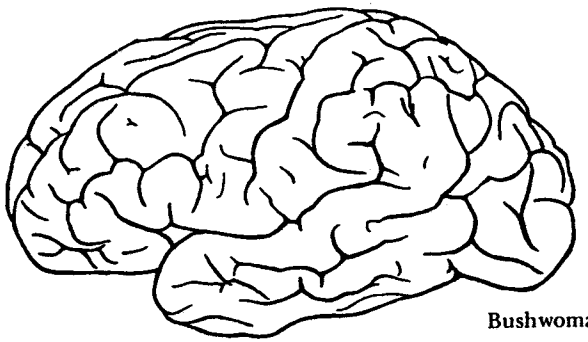
Broca then worked his way systematically through the data. First of all, Gratiolet's figure of 100 grams came from unsupported claims of the German scientist E. Huschke. When Broca collated all the actual data he could find, the difference in size between German and French brains fell from 100 to 48 grams. Broca then applied a series of corrections for nonintellectual factors that also affect brain size. He argued, quite correctly, that brain size increases with body size, decreases with age, and decreases during long periods of poor health (thus explaining why executed criminals often have larger brains than honest folk who die of degenerative diseases in hospitals). Broca noted a mean French age of fifty-six and a half years in his sample, while the Germans averaged only fifty-one. He estimated that this difference would account for 16 grams of the disparity between French and Germans, cutting the German advantage to 32 grams. He then removed from the German sample all individuals who had died by violence or execution. The mean brain weight of twenty Germans, dead from natural causes, now stood at 1,320 grams, already *below* the French average of 1,333 grams. And Broca had not even yet corrected for the larger average body size of Germans. *Vive la France.*

Broca's colleague de Jouvencel, speaking on his behalf against the unfortunate Gratiolet, argued that greater German brawn accounted for all the apparent difference in brain and then some. Of the average German, he wrote (1861, p. 466):

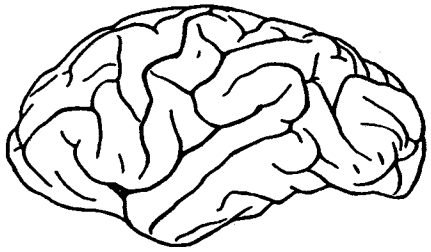
> He ingests a quantity of solid food and drink far greater than that which satisfies us. This, joined with his consumption of beer, which is pervasive even in areas where wine is made, makes the German much more



The brain of the great mathematician K. F. Gauss

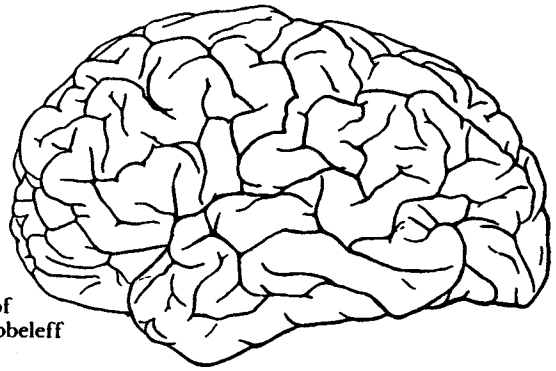


Bushwoman

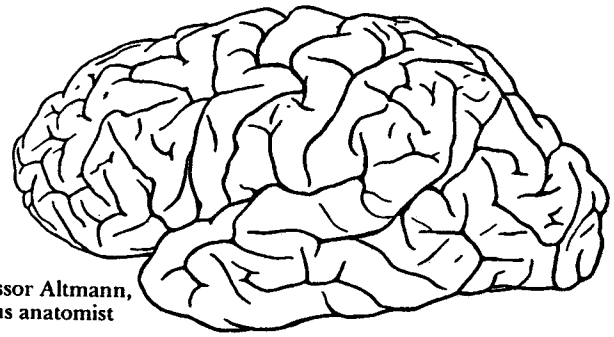


Gorilla

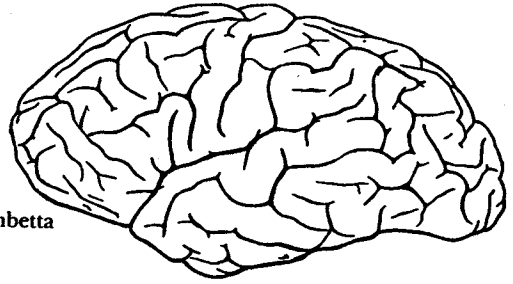
3•3 Spitzka's chain of being according to brain size.



The brain of General Skobeleff



Professor Altmann, famous anatomist



Gambetta

3•4 Spitzka's depiction of variation in brain size among white men of eminence.

fleshy [*charnu*] than the Frenchman—so much so that their relation of brain size to total mass, far from being superior to ours, appears to me, on the contrary, to be inferior.

I do not challenge Broca's use of corrections but I do note his skill in wielding them when his own position was threatened. Bear this in mind when I discuss how deftly he avoided them when they might have challenged a congenial conclusion—the small brains of women.

SMALL-BRAINED MEN OF EMINENCE

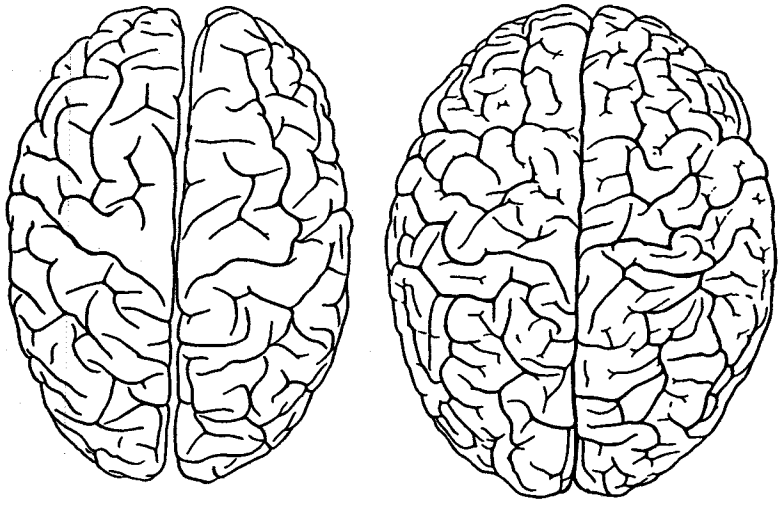
The American anatomist E. A. Spitzka urged men of eminence to donate their brains to science after their death. "To me the thought of an autopsy is certainly less repugnant than I imagine the process of cadaveric decomposition in the grave to be" (1907, p. 235). The dissection of dead colleagues became something of a cottage industry among nineteenth-century craniometricians. Brains exerted their customary fascination, and lists were proudly touted, accompanied by the usual invidious comparisons. (The leading American anthropologists J. W. Powell and W J McGee even made a wager over who carried the larger brain. As Ko-Ko told Nanki-Poo about the fireworks that would follow his execution, "You won't see them, but they'll be there all the same.")

Some men of genius did very well indeed. Against a European average of 1,300 to 1,400 grams, the great Cuvier stood out with his topheavy, 1,830 grams. Cuvier headed the charts until Turgenev finally broke the 2,000 gram barrier in 1883. (Other potential occupants of this stratosphere, Cromwell and Swift, lay in limbo for insufficiency of record.)

The other end was a bit more confusing and embarrassing. Walt Whitman managed to hear America singing with only 1,282 grams. As a crowning indignity, Franz Josef Gall, one of the two founders of phrenology—the original "science" of judging various mental capacities by the size of localized brain areas—weighed in at a meager 1,198 grams. (His colleague J. K. Spurzheim yielded a quite respectable 1,559 grams.) And, though Broca didn't know it, his own brain weighed only 1,424 grams, a bit above average to be sure, but nothing to crow about. Anatole France extended the range of famous authors to more than 1,000 grams when, in 1924, he opted for the other end of Turgenev's fame and clocked in at a mere 1,017 grams.

The small brains were troublesome, but Broca, undaunted, managed to account for all of them. Their possessors either died very old, were very short and slightly built, or had suffered poor preservation. Broca's reaction to a study by his German colleague Rudolf Wagner was typical. Wagner had obtained a real prize in 1855, the brain of the great mathematician Karl Friedrich Gauss. It weighed a modestly overaverage 1,492 grams, but was more richly convoluted than any brain previously dissected (Fig. 3.5). Encouraged, Wagner went on to weigh the brains of all dead and willing professors at Göttingen, in an attempt to plot the distribution of brain size among men of eminence. By the time Broca was battling with Gratiolet in 1861, Wagner had four more measurements. None posed any challenge to Cuvier, and two were distinctly puzzling—Hermann, the professor of philosophy at 1,368 grams, and Hausmann, the professor of mineralogy, at 1,226 grams. Broca corrected Hermann's brain for his age and raised it

3•5 The brain of the great mathematician K. F. Gauss (right) proved to be something of an embarrassment since, at 1,492 grams, it was only slightly larger than average. But other criteria came to the rescue. Here, E. A. Spitzka demonstrates that Gauss's brain is much more richly convoluted than that of a Papuan (left).



by 16 grams to 1.19 percent above average—"not much for a professor of linguistics," Broca admitted, "but still something" (1861, p. 167). No correction could raise Hausmann to the mean of ordinary folks, but considering his venerable seventy-seven years, Broca speculated that his brain may have undergone more than the usual amount of senile degeneration: "The degree of decadence that old age can impose upon a brain is very variable and cannot be calculated."

But Broca was still bothered. He could get around the low values, but he couldn't raise them to unusual weights. Consequently, to clinch an unbeatable conclusion, he suggested with a touch of irony that Wagner's post-Gaussian subjects may not have been so eminent after all:

> It is not very probable that 5 men of genius should have died within five years at the University of Göttingen. . . . A professorial robe is not necessarily a certificate of genius; there may be, even at Göttingen, some chairs occupied by not very remarkable men (1861, pp. 165–166).

At this point, Broca desisted: "The subject is delicate," he wrote (1861, p. 169), "and I must not insist upon it any longer."

LARGE-BRAINED CRIMINALS

The large size of many criminal brains was a constant source of bother to craniometricians and criminal anthropologists. Broca tended to dismiss it with his claim that sudden death by execution precluded the diminution that long bouts of disease produced in many honest men. In addition, death by hanging tended to engorge the brain and lead to spuriously high weights.

In the year of Broca's death, T. Bischoff published his study on the brains of 119 assassins, murderers, and thieves. Their average exceeded the mean of honest men by 11 grams, while 14 of them topped 1,500 grams, and 5 exceeded 1,600 grams. By contrast, only three men of genius could boast more than 1,600 grams, while the assassin Le Pelley, at 1,809 grams, must have given pause to the shade of Cuvier. The largest female brain ever weighed (1,565 grams) belonged to a woman who had killed her husband.

Broca's successor Paul Topinard puzzled over the data and finally decided that too much of a good thing is bad for some people. Truly inspired criminality may require as much upstairs as

professorial virtuosity; who shall decide between Moriarty and Holmes? Topinard concluded: "It seems established that a certain proportion of criminals are pushed to depart from present social rules by an exuberance of cerebral activity and, consequently, by the fact of a large or heavy brain" (1888, p. 15).

FLAWS IN A PATTERN OF INCREASE THROUGH TIME

Of all Broca's studies, with the exception of his work on differences between men and women, none won more respect or attention than his supposed demonstration of steady increase in brain size as European civilization advanced from medieval to modern times (Broca, 1862b).

This study merits close analysis because it probably represents the best case of hope dictating conclusion that I have ever encountered. Broca viewed himself as a liberal in the sense that he did not condemn groups to permanent inferiority based on their current status. Women's brains had degenerated through time thanks to a socially enforced underusage; they might increase again under different social conditions. Primitive races had not been sufficiently challenged, while European brains grew steadily with the march of civilization.

Broca obtained large samples from each of three Parisian cemeteries, from the twelfth, the eighteenth, and the nineteenth centuries. Their average cranial capacities were, respectively, 1,426, 1,409, and 1,462 cc—not exactly the stuff for a firm conclusion of steady increase through time. (I have not been able to find Broca's raw data for statistical testing, but with a 3.5 percent mean difference between smallest and largest sample, it is likely that no statistically significant differences exist at all among the three samples.)

But how did these limited data—only three sites with no information on ranges of variation at a given time and no clear pattern through time—lead Broca to his hopeful conclusion? Broca himself admitted an initial disappointment: he had expected to find intermediate values in the eighteenth-century site (1862b, p. 106). Social class, he argued, must hold the answer, for successful groups within a culture owe at least part of their status to superior wits. The twelfth-century sample came from a churchyard and must represent gentry. A common grave provided the eighteenth-century skulls. But the nineteenth-century sample was a mixture,

ninety skulls from individual graves with a mean of 1484 cc, and thirty-five from a common grave with an average of 1403 cc. Broca claimed that if differences in social class do not explain why calculated values fail to meet expectations, then the data are unintelligible. Intelligible, to Broca, meant steadily increasing through time—the proposition that the data were meant to prove, not rest upon. Again, Broca travels in a circle:

> Without this [difference in social class], we would have to believe that the cranial capacity of Parisians has really diminished during centuries following the 12th. Now during this period . . . intellectual and social progress has been considerable, and even if we are not yet certain that the development of civilization makes the brain grow as a consequence, no one, without doubt, would want to consider this cause as capable of making the brain decrease in size (1862b, p. 106).

But Broca's division of the nineteenth-century sample by social class also brought trouble as well as relief—for he now had two samples from common graves and the earlier one had a larger mean capacity, 1,409 for the eighteenth century vs. 1,403 for the nineteenth. But Broca was not to be defeated; he argued that the eighteenth-century common grave included a better class of people. In these prerevolutionary times, a man had to be really rich or noble to rest in a churchyard. The dregs of the poor measured 1,403 in the nineteenth century; the dregs leavened by good stock yielded about the same value one hundred years before.

Each solution brought Broca new trouble. Now that he was committed to a partition by social class within cemeteries, he had to admit that an additional seventeen skulls from the morgue's grave at the nineteenth-century site yielded a higher value than skulls of middle- and upper-class people from individual graves—1,517 vs. 1,484 cc. How could unclaimed bodies, abandoned to the state, surpass the cream of society? Broca reasoned in a chain of surpassingly weak inference: morgues stood on river borders; they probably housed a large number of drowned people; many drowned are suicides; many suicides are insane; many insane people, like criminals, have surprisingly large brains. With a bit of imagination, nothing can be truly anomalous.

Front and back

> Tell me about this new young surgeon, Mr. Lydgate. I am told he is wonderfully clever; he certainly looks it—a fine brow indeed.
>
> —GEORGE ELIOT, Middlemarch (1872)

Size of the whole, however useful and decisive in general terms, did not begin to exhaust the content of craniometry. Ever since the heyday of phrenology, specific parts of the brain and skull had been assigned definite status, thus providing a set of subsidiary criteria for the ranking of groups. (Broca, in his other career as a medical man, made his most important discovery in this area. In 1861 he developed the concept of cortical localization of function when he discovered that an aphasic patient had a lesion in the left inferior frontal gyrus, now called Broca's convolution.)

Most of these subsidiary criteria can be reduced to a single formula: front is better. Broca and his colleagues believed that higher mental functions were localized in anterior regions of the cortex, and that posterior areas busied themselves with the more mundane, though crucial, roles of involuntary movement, sensation, and emotion. Superior people should have more in front, less behind. We have already seen how Bean followed this assumption in generating his spurious data on front and back parts of the corpus callosum in whites and blacks.

Broca often used the distinction of front and back, particularly to extract himself from uncomfortable situations imposed by his data. He accepted Gratiolet's classification of human groups into *"races frontales"* (whites with anterior and frontal lobes most highly developed), *"races pariétales"* (Mongolians with parietal or mid lobes most prominent), and *"races occipitales"* (blacks with most in the back). He often unleashed the double whammy against inferior groups—small size and posterior prominence: "Negroes, and especially Hottentots, have a simpler brain than ours, and the relative poverty of their convolutions can be found primarily on their frontal lobes" (1873a, p. 32). As more direct evidence, he argued that Tahitians artificially deformed the frontal areas of certain male children in order to make the back portions bulge. These men became courageous warriors, but could never match white heroes for style: "Frontal deformation produced blind passions, ferocious instincts, and animal courage, all of which I would willingly call

occipital courage. We must not confound it with true courage, frontal courage, which we may call Caucasian courage" (1861, pp. 202–203).

Broca also went beyond size to assess the quality of frontal vs. occipital regions in various races. Here, and not only to placate his adversary, he accepted Gratiolet's favorite argument that the sutures between skull bones close earlier in inferior races, thus trapping the brain within a rigid vault and limiting the effectiveness of further education. Not only do white sutures close later; they close in a different order—guess how? In blacks and other inferior people, the front sutures close first, the back sutures later; in whites, the front sutures close last. Extensive modern studies of cranial closure show no difference of timing or pattern among races (Todd and Lyon, 1924 and 1925).

Broca used this argument to extricate himself from a serious problem. He had described a sample of skulls from the earliest populations of *Homo sapiens* (Cro-Magnon type) and found that they exceeded modern Frenchmen in cranial capacity. Fortunately, however, their anterior sutures closed first and these progenitors must have been inferior after all: "These are signs of inferiority. We find them in all races in which the material life draws all cerebral activity to it. As intellectual life develops among a people, the anterior sutures become more complicated and stay open for a longer time" (1873a, p. 19).

The argument of front and back,* so flexible and far-ranging, served as a powerful tool for rationalizing prejudice in the face of apparently contradictory fact. Consider the following two examples.

THE CRANIAL INDEX

Beyond brain size itself, the two most hoary and misused measures of craniometry were surely the facial angle (jutting forward of face and jaws—the less the better), and the cranial index. The cranial index never had much going for it beyond ease of measurement. It was calculated as the ratio of maximum width to maximum

*Broca did not confine his arguments on the relative worth of brain parts to the distinction between front and back. Virtually any measured difference between peoples could be given a value in terms of prior conviction about relative worth. Broca once claimed, for example (1861, p. 187), that blacks probably had larger cranial nerves than whites, hence a larger nonintellectual portion of the brain.

length of the skull. Relatively long skulls (ratio of .75 or less) were called dólichocephalic; relatively short skulls (over .8), brachycephalic. Anders Retzius, the Swedish scientist who popularized the cranial index, constructed a theory of civilization upon it. He believed that Stone Age peoples of Europe were brachycephalic, and that progressive Bronze Age elements (Indo-European, or Aryan dolichocephalics) later invaded and replaced the original and more primitive inhabitants. Some original brachycephalic stocks survive among such benighted people as Basques, Finns, and Lapps.

Broca disproved this popular tale conclusively by discovering dolichocephalics both among Stone Age skulls and within modern remnants of "primitive" stocks. Indeed, Broca had good reason to be suspicious of attempts by Nordic and Teutonic scientists to enshrine dolichocephaly as a mark of higher capability. Most Frenchmen, including Broca himself (Manouvrier, 1899), were brachycephalic. In a passage that recalls his dismissal of Tiedemann's claims for equality between black and white brains, Broca labeled Retzius's doctrine as self-serving gratification rather than empirical truth. Did he ever consider the possibility that he might fall prey to similar motivations?

> Since the work of Mr. Retzius, scientists have generally held, without sufficient study, that dolichocephaly is a mark of superiority. Perhaps so; but we must also not forget that the characters of dolichocephaly and brachycephaly were studied first in Sweden, then in England, the United States and Germany—and that in all these countries, particularly in Sweden, the dolichocephalic type clearly predominates. It is a natural tendency of men, even among those most free of prejudice, to attach an idea of superiority to the dominant characteristics of their race (1861, p. 513).

Obviously, Broca declined to equate brachycephaly with inherent stupidity. Still, the prestige of dolichocephaly was so great that Broca felt more than a little uncomfortable when clearly inferior people turned up longheaded—uncomfortable enough to invent one of his most striking, unbeatable arguments. The cranial index had run into a stunning difficulty: not only were African blacks and Australian aborigines dolichocephalic, but they turned out to be the world's most longheaded peoples. Adding insult to this injury, the fossil Cro-Magnon skulls were not only larger than those of modern Frenchmen; they were more dolichocephalic as well.

Dolichocephaly, Broca reasoned, could be attained in several ways. The longheadedness that served as a mark of Teutonic genius obviously arose by frontal elongation. Dolichocephalics among people known to be inferior must have evolved by lengthening the back—occipital dolichocephaly in Broca's terms. With one sweep, Broca encompassed both the superior cranial capacity and the dolichocephaly of his Cro-Magnon fossils: "It is by the greater development of their posterior cranium that their general cranial capacity is rendered greater than ours" (1873a, p. 41). As for blacks, they had acquired both a posterior elongation and a diminution in frontal width, thus giving them both a smaller brain in general and a longheadedness (not to be confused with the Teutonic style) exceeded by no human group. As to the brachycephaly of Frenchmen, it is no failure of frontal elongation (as the Teutonic supremacists claimed), but an addition of width to a skull already admirable.

THE CASE OF THE FORAMEN MAGNUM

The foramen magnum is the hole in the base of our skull. The spinal cord passes through it and the vertebral column articulates to the bone around its edge (the occipital condyle). In the embryology of all mammals, the foramen magnum begins under the skull, but migrates back to a position behind the skull at birth. In humans, the foramen magnum migrates only slightly and remains under the skull in adults. The foramen magnum of adult great apes occupies an intermediate position, not so far forward as in humans, not so far back as in other mammals. The functional significance of these orientations is clear. An upright animal like *Homo sapiens* must have its skull mounted *on top* of its vertebral column in order to look forward when standing erect; fourfooted animals mount their vertebral column *behind* their skull and look forward in their usual posture.

These differences provided an irresistible source for invidious comparison. Inferior peoples should have a more posterior foramen magnum, as in apes and lower mammals. In 1862 Broca entered an existing squabble on this issue. Relative egalitarians like James Cowles Pritchard had been arguing that the foramen magnum lies exactly in the center of the skull in both whites and blacks. Racists like J. Virey had discovered graded variation, the higher

the race, the more forward the foramen magnum. Neither side, Broca noted, had much in the way of data. With characteristic objectivity, he set out to resolve this vexatious, if minor, issue.

Broca amassed a sample of sixty whites and thirty-five blacks and measured the length of their skulls both before and behind the anterior border of the foramen magnum. Both races had the same amount of skull behind—100.385 mm for whites, 100.857 mm for blacks (note precision to third decimal place). But whites had much less in front (90.736 vs. 100.304 mm) and their foramen magnum therefore lay in a more anterior position (see Table 3.1). Broca concluded: "In orang-utans, the posterior projection [the part of the skull behind the foramen magnum] is shorter. It is therefore incontestable . . . that the conformation of the Negro, in this respect as in many others, tends to approach that of the monkey" (1862c, p. 16).

But Broca then began to worry. The standard argument about the foramen magnum referred only to its relative position on the cranium itself, not to the face projecting in front of the cranium. Yet Broca had included the face in his anterior measure. Now everyone knows, he wrote, that blacks have longer faces than whites. This is an apelike sign of inferiority in its own right, but it should not be confused with the relative position of the foramen magnum within the cranium. Thus Broca set out to subtract the facial influence from his measures. He found that blacks did, indeed, have longer faces—white faces accounted for only 12.385 mm of their anterior measure, black faces for 27.676 mm (see Table 3.1). Subtracting facial length, Broca obtained the following figures for anterior cranium: 78.351 for whites, 72.628 for blacks. In other words, based on the cranium alone, the foramen magnum

Table 3 • 1 Broca's measurements on the relative position of the foramen magnum

	WHITES	BLACKS	DIFFERENCE IN FAVOR OF BLACKS
ANTERIOR	90.736	100.304	+ 9.568
Facial	12.385	27.676	+15.291
Cranial	78.351	72.628	− 5.723
POSTERIOR	100.385	100.857	+ 0.472

of blacks lay *farther forward* (the ratio of front to back, calculated from Broca's data, is .781 for whites, and .720 for blacks). Clearly, by criteria explicitly accepted before the study, blacks are superior to whites. Or so it must be, unless the criteria suddenly shift, as they did forthwith.

The venerable argument of front and back appeared to rescue Broca and the threatened people he represented. The more forward position of the foramen magnum in blacks does not record their superiority after all; it only reflects their lack of anterior brain power. Relative to whites, blacks have lost a great deal of brain in front. But they have added some brain behind, thus reducing the front/back ratio of the foramen magnum and providing a spurious appearance of black advantage. But they have not added to these inferior back regions as much as they lost in the anterior realm. Thus blacks have smaller and more poorly proportioned brains than whites:

> The anterior cranial projection of whites . . . surpasses that of Negroes by 4.9 percent. . . . Thus, while the foramen magnum of Negroes is further back with respect to their incisors [Broca's most forward point in his anterior measure that included the face], it is, on the contrary, further forward with respect to the anterior edge of their brain. To change the cranium of a white into that of a Negro, we would have not only to move the jaws forward, but also to reduce the front of the cranium—that is, to make the anterior brain atrophy and to give, as insufficient compensation, part of the material we extracted to the posterior cranium. In other words, in Negroes, the facial and occipital regions are developed to the detriment of the frontal region (1862c, p. 18).

This was a small incident in Broca's career, but I can imagine no better illustration of his method—shifting criteria to work through good data toward desired conclusions. Heads I'm superior; tails, you're inferior.

And old arguments never seem to die. Walter Freeman, dean of American lobotomists (he performed or supervised thirty-five hundred lesions of frontal portions of the brain before his retirement in 1970), admitted late in his career (cited in Chorover, 1979):

> What the investigator misses most in the more highly intelligent individuals is their ability to introspect, to speculate, to philosophize, especially in regard to onesself. . . . On the whole, psychosurgery reduces creativity, sometimes to the vanishing point.

Freeman then added that "women respond better than men, Negroes better than whites." In other words, people who didn't have as much up front in the first place, don't miss it as badly.

Women's brains

Of all his comparisons between groups, Broca collected most information on the brains of women vs. men—presumably because it was more accessible, not because he held any special animus toward women. "Inferior" groups are interchangeable in the general theory of biological determinism. They are continually juxtaposed, and one is made to serve as a surrogate for all—for the general proposition holds that society follows nature, and that social rank reflects innate worth. Thus, E. Huschke, a German anthropologist, wrote in 1854: "The Negro brain possesses a spinal cord of the type found in children and women and, beyond this, approaches the type of brain found in higher apes" (in Mall, 1909, pp. 1–2). The celebrated German anatomist Carl Vogt wrote in 1864:

> By its rounded apex and less developed posterior lobe the Negro brain resembles that of our children, and by the protuberance of the parietal lobe, that of our females. . . . The grown-up Negro partakes, as regards his intellectual faculties, of the nature of the child, the female, and the senile white. . . . Some tribes have founded states, possessing a peculiar organization; but, as to the rest, we may boldly assert that the whole race has, neither in the past nor in the present, performed anything tending to the progress of humanity or worthy of preservation (1864, pp. 183–192).

G. Hervé, a colleague of Broca, wrote in 1881: "Men of the black races have a brain scarcely heavier than that of white women" (1881, p. 692). I do not regard as empty rhetoric a claim that the battles of one group are for all of us.

Broca centered his argument about the biological status of modern women upon two sets of data: the larger brains of men in modern societies and a supposed widening through time of the disparity in size between male and female brains. He based his most extensive study upon autopsies he performed in four Parisian hospitals. For 292 male brains, he calculated a mean weight of 1,325 grams; 140 female brains averaged 1,144 grams for a difference of 181 grams, or 14 percent of the male weight. Broca understood, of course, that part of this difference must be attributed to the larger

size of males. He had used such a correction to rescue Frenchmen from a claim of German superiority (p. 89). In that case, he knew how to make the correction in exquisite detail. But now he made no attempt to measure the effect of size alone, and actually stated that he didn't need to do so. Size, after all, cannot account for the entire difference because we know that women are not as intelligent as men.

> We might ask if the small size of the female brain depends exclusively upon the small size of her body. Tiedemann has proposed this explanation. But we must not forget that women are, on the average, a little less intelligent than men, a difference which we should not exaggerate but which is, nonetheless, real. We are therefore permitted to suppose that the relatively small size of the female brain depends in part upon her physical inferiority and in part upon her intellectual inferiority (1861, p. 153).

To record the supposed widening of the gap through time, Broca measured the cranial capacities of prehistoric skulls from L'Homme Mort cave. Here he found a difference of only 99.5 cc between males and females, while modern populations range from 129.5 to 220.7 cc. Topinard, Broca's chief disciple, explained the increasing discrepancy through time as a result of differing evolutionary pressures upon dominant men and passive women:

> The man who fights for two or more in the struggle for existence, who has all the responsibility and the cares of tomorrow, who is constantly active in combatting the environment and human rivals, needs more brain than the woman whom he must protect and nourish, than the sedentary woman, lacking any interior occupations, whose role is to raise children, love, and be passive (1888, p. 22).

In 1879 Gustave Le Bon, chief misogynist of Broca's school, used these data to publish what must be the most vicious attack upon women in modern scientific literature (it will take some doing to beat Aristotle). Le Bon was no marginal hate-monger. He was a founder of social psychology and wrote a study of crowd behavior still cited and respected today (*La psychologie des foules,* 1895). His writings also had a strong influence upon Mussolini. Le Bon concluded:

> In the most intelligent races, as among the Parisians, there are a large number of women whose brains are closer in size to those of gorillas than to the most developed male brains. This inferiority is so obvious that no one can contest it for a moment; only its degree is worth discussion. All psychologists who have studied the intelligence of women, as well as poets and novelists, recognize today that they represent the most inferior forms of human evolution and that they are closer to children and savages than to an adult, civilized man. They excel in fickleness, inconstancy, absence of thought and logic, and incapacity to reason. Without doubt there exist some distinguished women, very superior to the average man, but they are as exceptional as the birth of any monstrosity, as, for example, of a gorilla with two heads; consequently, we may neglect them entirely (1879, pp. 60–61).

Nor did Le Bon shrink from the social implications of his views. He was horrified by the proposal of some American reformers to grant women higher education on the same basis as men:

> A desire to give them the same education, and, as a consequence, to propose the same goals for them, is a dangerous chimera. . . . The day when, misunderstanding the inferior occupations which nature has given her, women leave the home and take part in our battles; on this day a social revolution will begin, and everything that maintains the sacred ties of the family will disappear (1879, p. 62).

Sound familiar?*

I have reexamined Broca's data, the basis for all this derivative pronouncement, and I find the numbers sound but Broca's interpretation, to say the least, ill founded. The claim for increasing difference through time is easily dismissed. Broca based this contention on the sample from L'Homme Mort alone. It consists of seven male, and six female, skulls. Never has so much been coaxed from so little!

In 1888 Topinard published Broca's more extensive data on Parisian hospitals. Since Broca recorded height and age as well as brain size, we may use modern statistical procedures to remove their effect. Brain weight decreases with age, and Broca's women were, on average, considerably older than his men at death. Brain weight increases with height, and his average man was almost half a foot taller than his average woman. I used multiple regression, a technique that permits simultaneous assessment of the influence of

*Ten years later, America's leading evolutionary biologist, E. D. Cope, dreaded the result if "a spirit of revolt become general among women." "Should the nation have an attack of this kind," he wrote (1890, p. 2071), "like a disease, it would leave its traces in many after-generations." He detected the beginnings of such anarchy in pressures exerted by women "to prevent men from drinking wine and smoking tobacco in moderation," and in the carriage of misguided men who supported female suffrage: "Some of these men are effeminate and long-haired."

height and age upon brain size. In an analysis of the data for women, I found that, at average male height and age, a woman's brain would weigh 1,212 grams.* Correction for height and age reduces the 181 gram difference by more than a third to 113 grams.

It is difficult to assess this remaining difference because Broca's data contain no information about other factors known to influence brain size in a major way. Cause of death has an important effect, as degenerative disease often entails a substantial diminution of brain size. Eugene Schreider (1966), also working with Broca's data, found that men killed in accidents had brains weighing, on average, 60 grams more than men dying of infectious diseases. The best modern data that I can find (from American hospitals) records a full 100 gram difference between death by degenerative heart disease and by accident or violence. Since so many of Broca's subjects were elderly women, we may assume that lengthy degenerative disease was more common among them than among the men.

More importantly, modern students of brain size have still not agreed on a proper measure to eliminate the powerful effect of body size (Jerison, 1973; Gould, 1975). Height is partly adequate, but men and women of the same height do not share the same body build. Weight is even worse than height, because most of its variation reflects nutrition rather than intrinsic size—and fat vs. skinny exerts little influence upon the brain. Léonce Manouvrier took up this subject in the 1880s and argued that muscular mass and force should be used. He tried to measure this elusive property in various ways and found a marked difference in favor of men, even in men and women of the same height. When he corrected for what he called "sexual mass," women came out slightly ahead in brain size.

Thus, the corrected 113 gram difference is surely too large; the true figure is probably close to zero and may as well favor women as men. One hundred thirteen grams, by the way, is exactly the average difference between a five-foot four-inch and a six-foot-four-inch male in Broca's data†—and we would not want to ascribe

*I calculate, where y is brain size in grams, x_1 age in years, and x_2 body height in cm: $y = 764.5 - 2.55x_1 + 3.47x_2$

†For his largest sample of males, and using the favored power function for bivariate analysis of brain allometry, I calculate, where y is brain weight in grams and x is body height in cm: $y = 121.6x^{0.47}$

greater intelligence to tall men. In short, Broca's data do not permit any confident claim that men have bigger brains than women.

Maria Montessori did not confine her activities to educational reform for young children. She lectured on anthropology for several years at the University of Rome and wrote an influential book entitled *Pedagogical Anthropology* (English edition, 1913). She was, to say the least, no egalitarian. She supported most of Broca's work and the theory of innate criminality proposed by her compatriot Cesare Lombroso (next chapter). She measured the circumference of children's heads in her schools and inferred that the best prospects had bigger brains. But she had no use for Broca's conclusions about women. She discussed Manouvrier's work at length and made much of his tentative claim that women have slightly larger brains when proper corrections are made. Women, she concluded, are intellectually superior to men, but men have prevailed heretofore by dint of physical force. Since technology has abolished force as an instrument of power, the era of women may soon be upon us: "In such an epoch there will really be superior human beings, there will really be men strong in morality and in sentiment. Perhaps in this way the reign of woman is approaching, when the enigma of her anthropological superiority will be deciphered. Woman was always the custodian of human sentiment, morality and honor" (1913, p. 259).

Montessori's argument represents one possible antidote to "scientific" claims for the constitutional inferiority of certain groups. One may affirm the validity of biological distinctions, but argue that the data have been misinterpreted by prejudiced men with a stake in the outcome, and that disadvantaged groups are truly superior. In recent years, Elaine Morgan has followed this strategy in her *Descent of Woman,* a speculative reconstruction of human prehistory from the woman's point of view—and as farcical as more famous tall tales by and for men.

I dedicate this book to a different position. Montessori and Morgan follow Broca's method to reach a more congenial conclusion. I would rather label the whole enterprise of setting a biological value upon groups for what it is: irrelevant, intellectually unsound, and highly injurious.

Postscript

Craniometric arguments lost much of their luster in our century, as determinists switched their allegiance to intelligence testing—a more "direct" path to the same invalid goal of ranking groups by mental worth—and as scientists exposed the prejudiced nonsense that dominated most literature on form and size of the head. The American anthropologist Franz Boas, for example, made short work of the fabled cranial index by showing that it varied widely both among adults of a single group and within the life of an individual (Boas, 1899). Moreover, he found significant differences in cranial index between immigrant parents and their American-born children. The immutable obtuseness of the brachycephalic southern European might veer toward the dolichocephalic Nordic norm in a single generation of altered environment (Boas, 1911).

Yet the supposed intellectual advantage of bigger heads refuses to disappear entirely as an argument for assessing human worth. We still encounter it occasionally at all levels of determinist contention.

1. Variation within the general population: Arthur Jensen (1979, pp. 361–362) supports the value of IQ as a measure of innate intelligence by claiming that the correlation between brain size and IQ is about 0.30. He doesn't doubt that the correlation is meaningful and that "there has been a direct causal effect, through natural selection in the course of human evolution, between intelligence and brain size." Undaunted by the low value of the correlation, he proclaims that it would be even higher if so much of the brain were not "devoted to noncognitive functions."

On the same page, Jensen cites an average correlation of 0.25 between IQ and physical stature. Although this value is effectively the same as the IQ vs. brain size correlation, Jensen switches ground and holds that "this correlation almost certainly involves no causal or functional relationship between stature and intelligence." Both height and intelligence, he argues, are perceived as desirable traits, and people lucky enough to possess more than the average of both are drawn to each other. But is it not more likely that height vs. brain size represents the primary causal correlation for the obvious reason that tall people tend to have large body parts? Brain size would then be an imperfect measure of height,

and IQ might correlate with it (at the low value of 0.3) for the primarily environmental reason that poverty and poor nutrition can lead both to reduced stature and poor IQ scores.

2. Variation among social classes and occupational groups: In a book dedicated to putting educators in touch with latest advances in the brain sciences, H. T. Epstein (in Chall and Mirsky, 1978) states (pp. 349–350):

> First we shall ask if there is any indication of a linkage of any kind between brain and intelligence. It is generally stated that there is no such linkage. . . . But the one set of data I have found seems to show clearly that there is a substantial connection. Hooton studied the head circumferences of white Bostonians as part of his massive study of criminals. The following table shows that the ordering of people according to head size yields an entirely plausible ordering according to vocational status. It is not at all clear how the impression has been spread that there is no such correlation.

Epstein's chart, reproduced as he presents it in Table 3.2, seems to support the notion that people in more prestigious jobs have larger heads. But a bit of probing and checking in original sources exposes the chart as a shoddy bit of finagling (not by Epstein who, I suspect, copied it from another secondary source that I have not been able to identify).

i) Epstein's reported standard deviations are so low, and therefore imply such a small range of variation within each occupational class, that the differences in mean head size must be significant

Table 3 • 2 Mean and standard deviation of head circumference for people of varied vocational statuses

VOCATIONAL STATUS	N	MEAN (IN MM)	S.D.
Professional	25	569.9	1.9
Semiprofessional	61	566.5	1.5
Clerical	107	566.2	1.1
Trades	194	565.7	0.8
Public service	25	564.1	2.5
Skilled trades	351	562.9	0.6
Personal services	262	562.7	0.7
Laborers	647	560.7	0.3

Source: Ernest A. Hooton, *The American Criminal*, vol. 1 (Cambridge, Mass.: Harvard University Press, 1939), Table VIII-17.

even though they are so small. But a glance at Hooton's original table (1939, Table VIII-17) reveals that the wrong column (standard errors of the mean) has been copied and called standard deviation. The true standard deviations, given in another column of Hooton's table, run from 14.4 to 18.6—large enough to render most mean differences between occupational groups statistically insignificant.

ii) The chart arranges occupational groups by mean head size, but does not include Hooton's ranked assessments of vocational status based upon years of education (1939, p. 150). In fact, since the column is labeled "vocational status," we are led to assume that the jobs have been listed in their proper order of prestige and that a perfect correlation therefore exists between status and head size. But the professions are arranged only by head size. Several professions do not fit the pattern; personal services and skilled trades (Hooton's status 5 and 6) rank just above the bottom in head size but at the middle in prestige.

iii) As a much worse, and entirely inexcusable omission, my consultation of Hooton's original chart shows that data for three trades have been expunged without comment in Table 3.2. Guess why? All three rank at or near the bottom of Hooton's list of status—factory workers at rank 7 (of 11), transportation employees at rank 8, and "extractive" trades (farming and mining) at the lowest rank 11. All three have mean head circumferences (564.7, 564.9, and 564.7, respectively) *above* the grand average for all professions (563.9)!

I do not know the source of this disgracefully fudged chart. Jensen (1979, p. 361) reproduces it in Epstein's version with the three trades omitted. But he correctly labels the standard error (though he also omits the standard deviation) and properly denotes the professions as "occupational category" rather than "vocational status." Yet Jensen's version includes the same minor numerical error as Epstein's (standard error of 0.3 for laborers, miscopied as the correct value from the omitted line of "extractive" workers placed just above laborers in Hooton's chart). Since I doubt that the same insignificant error would have been made twice independently, and since Jensen's book and Epstein's article appeared at virtually the same time, I assume that both took the information from an unidentified secondary source (neither cite anyone but Hooton).

iv) Since Epstein and Jensen make so much of Hooton's data, they might have consulted his own opinion about it. Hooton was no do-gooding environmentalist liberal. He was a strong eugenicist and biological determinist who ended his study of American criminals with these chilling words: "The elimination of crime can be effected only by the extirpation of the physically, mentally, and morally unfit, or by their complete segregation in a socially aseptic environment" (1939, p. 309). Yet Hooton himself thought that his chart of head sizes and professions had proved nothing (1939, p. 154). He noted that only one vocational group, laborers, departed significantly from the average of all groups. And he stated explicitly that his sample for the only profession with noticeably larger than average heads—the professionals—was "wholly inadequate" (p. 153) as a result of its small size.

v) The primary environmental hypothesis for correlations of head size with social class holds that they are artifacts of a causal correlation between body size and status. Large bodies tend to carry large heads, and proper nutrition and freedom from poverty fosters better growth in childhood. Hooton's data provide tentative support for both parts of this argument, though Epstein doesn't mention these data on stature at all. Hooton provides information on both height and weight (both inadequate measures of stature—see p. 106). Most significant deviations from the grand average support the environmental hypothesis. For weight, two groups departed significantly: professionals (status 1) heavier than average, and laborers (status 10) lighter than average. For height, three groups were deficient and none significantly taller than average: laborers (status 10), personal service (status 5), and clerical (status 2—and contrary to the environmentalist hypothesis). I also computed correlation coefficients for head circumference vs. stature from Hooton's data. I found no correlation for total height, but significant correlations for both sitting height (0.605) and weight (0.741).

3. Variation among races: In its eighteenth edition of 1964, the *Encyclopaedia Britannica* was still listing "a small brain in relation to their size" along with woolly hair as characteristic of black people.

In 1970 the South African anthropologist P. V. Tobias wrote a courageous article exposing the myth that group differences in brain size bear any relationship to intelligence—indeed, he argued, group differences in brain size, independent of body size and other

biasing factors, have never been demonstrated at all.

This conclusion may strike readers as strange, especially since it comes from a famous scientist well acquainted with the reams of published data on brain size. After all, what can be simpler than weighing a brain?—Take it out, and put it on the scale. Not so. Tobias lists fourteen important biasing factors. One set refers to problems of measurement itself: at what level is the brain severed from the spinal cord; are the meninges removed or not (meninges are the brain's covering membranes, and the dura mater, or thick outer covering, weighs 50 to 60 grams); how much time elapsed after death; was the brain preserved in any fluid before weighing and, if so, for how long; at what temperature was the brain preserved after death. Most literature does not specify these factors adequately, and studies made by different scientists usually cannot be compared. Even when we can be sure that the same object has been measured in the same way under the same conditions, a second set of biases intervenes—influences upon brain size with no direct tie to the desired properties of intelligence or racial affiliation: sex, body size, age, nutrition, nonnutritional environment, occupation, and cause of death. Thus, despite thousands of published pages, and tens of thousands of subjects, Tobias concludes that we do not know—as if it mattered at all—whether blacks, on the average, have larger or smaller brains than whites. Yet the larger size of white brains was an unquestioned "fact" among white scientists until quite recently.

Many investigators have devoted an extraordinary amount of attention to the subject of group differences in human brain size. They have gotten nowhere, not because there are no answers, but because the answers are so difficult to get and because the a priori convictions are so clear and controlling. In the heat of Broca's debate with Gratiolet, one of Broca's defenders, admittedly as a nasty debating point, made a remark that admirably epitomizes the motivations implicit in the entire craniometric tradition: "I have noticed for a long time," stated de Jouvencel (1861, p. 465), "that, in general, those who deny the intellectual importance of the brain's volume have small heads." Self-interest, for whatever reason, has been the wellspring of opinion on this heady issue from the start.