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Gray Matter and Sexes: A Gray Area Scientifically

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Correction Appended

When Lawrence H. Summers, the president of Harvard, suggested this month that one factor in women's lagging progress in science and mathematics might be innate differences between the sexes, he slapped a bit of brimstone into a debate that has simmered for decades. And though his comments elicited so many fierce reactions that he quickly apologized, many were left to wonder: Did he have a point?

Has science found compelling evidence of inherent sex disparities in the relevant skills, or perhaps in the drive to succeed at all costs, that could help account for the persistent paucity of women in science generally, and at the upper tiers of the profession in particular?

Researchers who have explored the subject of sex differences from every conceivable angle and organ say that yes, there are a host of discrepancies between men and women - in their average scores on tests of quantitative skills, in their attitudes toward math and science, in the architecture of their brains, in the way they metabolize medications, including those that affect the brain.

Yet despite the desire for tidy and definitive answers to complex questions, researchers warn that the mere finding of a difference in form does not mean a difference in function or output inevitably follows.

"We can't get anywhere denying that there are neurological and hormonal differences between males and females, because there clearly are," said Virginia Valian, a psychology professor at Hunter College who wrote the 1998 book "Why So Slow? The Advancement of Women." "The trouble we have as scientists is in assessing their significance to real-life performance."

For example, neuroscientists have shown that women's brains are about 10 percent smaller than men's, on average, even after accounting for women's comparatively smaller body size.

But throughout history, people have cited anatomical distinctions in support of

overarching hypotheses that turn out merely to reflect the societal and cultural prejudices of the time.

A century ago, the French scientist Gustav Le Bon pointed to the smaller brains of women - closer in size to gorillas', he said - and said that explained the "fickleness, inconstancy, absence of thought and logic, and incapacity to reason" in women.

Overall size aside, some evidence suggests that female brains are relatively more endowed with gray matter - the prized neurons thought to do the bulk of the brain's thinking - while men's brains are packed with more white matter, the tissue between neurons.

To further complicate the portrait of cerebral diversity, new brain imaging studies from the University of California, Irvine, suggest that men and women with equal I.Q. scores use different proportions of their gray and white matter when solving problems like those on intelligence tests.

Men, they said, appear to devote 6.5 times as much of their gray matter to intelligence-related tasks as do women, while women rely far more heavily on white matter to pull them through a ponder.

What such discrepancies may or may not mean is anyone's conjecture.

"It is cognition that counts, not the physical matter that does the cognition," argued Nancy Kanwisher, a professor of neuroscience at the Massachusetts Institute of Technology.

When they do study sheer cognitive prowess, many researchers have been impressed with how similarly young boys and girls master new tasks.

"We adults may think very different things about boys and girls, and treat them accordingly, but when we measure their capacities, they're remarkably alike," said Elizabeth Spelke, a professor of psychology at Harvard. She and her colleagues study basic spatial, quantitative and numerical abilities in children ranging from 5 months through 7 years.

"In that age span, you see a considerable number of the pieces of our mature capacities for spatial and numerical reasoning coming together," Dr. Spelke said. "But while we always test for gender differences in our studies, we never find them."

In adolescence, though, some differences in aptitude begin to emerge, especially when it comes to performance on standardized tests like the SAT. While average verbal scores are very similar, boys have outscored girls on the math half of the dreaded exam by about 30 to 35 points for the past three decades or so.

Nor is the masculine edge in math unique to the United States. In an international

standardized test administered in 2003 by the international research group Organization for Economic Cooperation and Development to 250,000 15-year-olds in 41 countries, boys did moderately better on the math portion in just over half the nations. For nearly all the other countries, there were no significant sex differences.

But average scores varied wildly from place to place and from one subcategory of math to the next. Japanese girls, for example, were on par with Japanese boys on every math section save that of "uncertainty," which measures probabilistic skills, and Japanese girls scored higher over all than did the boys of many other nations, including the United States.

In Iceland, girls broke the mold completely and outshone Icelandic boys by a significant margin on all parts of the test, as they habitually do on their national math exams. "We have no idea why this should be so," said Almar Midvik Halldorsson, project manager for the Educational Testing Institute in Iceland.

Interestingly, in Iceland and everywhere else, girls participating in the survey expressed far more negative attitudes toward math.

The modest size and regional variability of the sex differences in math scores, as well as an attitudinal handicap that girls apparently pack into their No. 2 pencil case, convince many researchers that neither sex has a monopoly on basic math ability, and that culture rather than chromosomes explains findings like the gap in math SAT scores.

Yet Dr. Summers, who said he intended his remarks to be provocative, and other scientists have observed that while average math skillfulness may be remarkably analogous between the sexes, men tend to display comparatively greater range in aptitude. Males are much likelier than females to be found on the tail ends of the bell curve, among the superhigh scorers and the very bottom performers.

Among college-bound seniors who took the math SAT's in 2001, for example, nearly twice as many boys as girls scored over 700, and the ratio skews ever more male the closer one gets to the top tally of 800. Boys are also likelier than girls to get nearly all the answers wrong.

For Dr. Summers and others, the overwhelmingly male tails of the bell curve may be telling. Such results, taken together with assorted other neuro-curiosities like the comparatively greater number of boys with learning disorders, autism and attention deficit disorder, suggest to them that the male brain is a delicate object, inherently prone to extremes, both of incompetence and of genius.

But few researchers who have analyzed the data believe that men's greater representation among the high-tail scores can explain more than a small fraction of the sex disparities in career success among scientists.

For one thing, said Kimberlee A. Shauman, a sociologist at the University of California,

Davis, getting a high score on a math aptitude test turns out to be a poor predictor of who opts for a scientific career, but it is an especially poor gauge for girls. Catherine Weinberger, an economist at the University of California, Santa Barbara, has found that top-scoring girls are only about 60 percent as likely as top-scoring boys to pursue science or engineering careers, for reasons that remain unclear.

Moreover, men seem perfectly capable of becoming scientists without a math board score of 790. Surveying a representative population of working scientists and engineers, Dr. Weinberger has discovered that the women were likelier than the men to have very high test scores. "Women are more cautious about entering these professions unless they have very high scores to begin with," she said.

And this remains true even though a given score on standardized math tests is less significant for women than for men. Dr. Valian, of Hunter, observes that among women and men taking the same advanced math courses in college, women with somewhat lower SAT scores often do better than men with higher scores. "The SAT's turn out to underpredict female and overpredict male performance," she said. Again, the reasons remain mysterious.

Dr. Summers also proposed that perhaps women did not go into science because they found it too abstract and cold-blooded, offering as anecdotal evidence the fact that his young daughter, when given toy trucks, had treated them as dolls, naming them "Daddy truck" and "baby truck."

But critics dryly observed that men had a longstanding tradition of naming their vehicles, and babying them as though they were humans.

Yu Xie, a sociologist at the University of Michigan and a co-author with Dr. Shauman of "Women in Science: Career Processes and Outcomes" (2003), said he wished there was less emphasis on biological explanations for success or failure, and more on effort and hard work.

Among Asians, he said, people rarely talk about having a gift or a knack or a gene for math or anything else. If a student comes home with a poor grade in math, he said, the parents push the child to work harder.

"There is good survey data showing that this disbelief in innate ability, and the conviction that math achievement can be improved through practice," Dr. Xie said, "is a tremendous cultural asset in Asian society and among Asian-Americans."

In many formerly male-dominated fields like medicine and law, women have already reached parity, at least at the entry levels. At the undergraduate level, women outnumber men in some sciences like biology.

Thus, many argue that it is unnecessary to invoke "innate differences" to explain the gap that persists in fields like physics, engineering, mathematics and chemistry. Might

scientists just be slower in letting go of baseless sexism?

C. Megan Urry, a professor of physics and astronomy at Yale who led the American delegation to an international conference on women in physics in 2002, said there was clear evidence that societal and cultural factors still hindered women in science.

Dr. Urry cited a 1983 study in which 360 people - half men, half women - rated mathematics papers on a five-point scale. On average, the men rated them a full point higher when the author was "John T. McKay" than when the author was "Joan T. McKay." There was a similar, but smaller disparity in the scores the women gave.

Dr. Spelke, of Harvard, said, "It's hard for me to get excited about small differences in biology when the evidence shows that women in science are still discriminated against every stage of the way."

A recent experiment showed that when Princeton students were asked to evaluate two highly qualified candidates for an engineering job - one with more education, the other with more work experience - they picked the more educated candidate 75 percent of the time. But when the candidates were designated as male or female, and the educated candidate bore a female name, suddenly she was preferred only 48 percent of the time.

The debate is sure to go on.

Sandra F. Witelson, a professor of psychiatry and behavioral neurosciences at McMaster University in Hamilton, Ontario, said biology might yet be found to play some role in women's careers in the sciences.

"People have to have an open mind," Dr. Witelson said.

Correction: January 29, 2005, Saturday:

A front-page article on Monday about claims that brain differences between men and women may affect their success in math and science careers referred incorrectly to a 1983 study finding that when college students were shown identical academic papers, they tended give higher ratings to those they were told were by a man. The papers judged in the study were about politics, education and the psychology of women, not mathematics.