

Research & Books

<http://chronicle.com/free/v51/i26/26a00102.htm>

From the issue dated March 4, 2005

WOMEN AND SCIENCE: THE DEBATE GOES ON

Primed for Numbers

Are boys born better at math? Experts try to divide the influences of nature and nurture

By RICH MONASTERSKY

The country's stock of No. 2 pencils dipped on January 22, as 380,000 high-school students across the country opened up their SAT tests and proceeded to indent lasting grooves in their fingers.

"For all positive integers w and y , where $w > y$, let the operation be defined by $w y = 2^{w+y} / 2^{w-y}$. For how many positive integers w is $w 1$ equal to 4?"

Questions like that no doubt caused some test takers, in between palpitations, to wonder whether they were any good at math. Girls, especially, might have found their thoughts wandering to the news that just a week earlier, Lawrence H. Summers, president of Harvard University, had said that "intrinsic" differences in aptitude between the sexes might be an important reason that men dominate the science-and-engineering work force.

The remarks sparked widespread protests, and Mr. Summers quickly apologized. But a growing body of research suggests that there is some truth in his comments: That something in the brains of boys may predispose them to perform better on certain standardized tests of mathematical abilities. Hormones in women -- and in men -- apparently alter how well they can do particular cognitive tasks. And there may be biological differences that lead mathematically gifted men toward careers in science and engineering while pointing mathematically gifted women in other directions.

Some academics just don't want to hear such conclusions, says Steven Pinker, a professor of psychology at Harvard who wrote about innate traits in *The Blank Slate: The Modern Denial of Human Nature* (Penguin Putnam, 2002). "Human nature in the eyes of many academics is morally tainted," he says, "and that gets in the way of figuring out what makes us tick."

At the same time, however, researchers who study gender differences say Mr. Summers's emphasis on innate aptitude simply doesn't add up. Whatever biological factors do exist, they pale next to the pervasive social forces that push young women away from advanced math courses, and later, from careers in mathematics and in related disciplines like physics and engineering. Women make up only 26 percent of the work force with doctorates in science or engineering. In doctorate-granting mathematics departments, women hold just 8 percent of the tenured faculty positions.

"There may be some innate differences, but we're so far from hitting that barrier that it's silly to talk about it," says Jacquelynne S. Eccles, a professor of psychology at the University of Michigan at Ann Arbor who has followed several groups of students over two decades, tracking how they chose high-

school courses, college majors, and then careers.

Alice Silverberg, a professor of mathematics and computer science at the University of California at Irvine who graduated *summa cum laude* in mathematics from Harvard, says in an e-mail message: "I no longer ask why there are so few women in mathematics; I ask why there are so many. I can think of few male mathematicians who would have stayed in the field if they had faced the prejudice and discrimination female mathematicians deal with."

If any good comes of the current controversy, observers say, it will pressure math and science educators to make those disciplines more attractive to young women in high school and college. It will also point to new ways of instructing both girls and boys, with the aim of improving American students' mediocre math performance compared with those in many other countries.

Born Different

Humans have been doing complex mathematics for only a few thousand years, far too short a time to have evolved any specialized brain regions devoted to, say, understanding cosines or calculus. So the brain has taken advantage of more-basic abilities and put them to use in tallying bowling scores or doing linear algebra. Over the past decade, researchers have started to map how various components in the brain -- language centers, spatial sectors, memory units -- work in concert to create our mathematical abilities.

Cognitive research is also showing that boys and girls perform differently on some types of mathematical tests. Although the two sexes score the same on broad measures of mathematical ability, girls demonstrate an advantage in arithmetic, while boys score better in spatial tests that involve mentally rotating three-dimensional objects.

On their own, those findings say little about innate gender differences. By the time kids can take tests, they have already spent years immersed in the sea of cultural stimuli that can influence their performance. So some researchers have gone back to the beginning.

In one study, scientists at Cambridge University, in England, measured how long 1-day-old infants looked at different objects. They found that boys tended to gaze at three-dimensional mobiles longer than girls did, while girls looked at human faces longer than boys did. In tests of 1-year-old babies, boys liked to watch videos of cars with moving wiper blades more than videos of faces, while girls preferred the opposite.

To Simon Baron-Cohen, a professor of psychopathology and director of the autism research center at Cambridge, such data point to clear biological differences in the sexes. In general, boys are born with an interest in figuring out how systems work, while girls naturally focus more on understanding the mental state of others, he says. A fair percentage of each sex shows an equal interest in people and systems, and some small fraction of males and females display the reverse pattern. But broadly speaking, boys tend to exhibit preferences that coincide, later in life, with careers in mathematics, science, and engineering.

The Cambridge team has extended its work by measuring fetal testosterone levels and examining how they correlate with children's behavior after birth. Some boys and girls produce more testosterone in the womb than others. And children of either sex who are exposed to higher levels of testosterone are less likely to establish eye contact with their mothers. They also develop language later and have smaller vocabularies at 2 years of age.

"These studies are telling us that some of these factors are established prenatally, possibly genetically," says Mr. Baron-Cohen, who also cautions that genes are not the entire story.

Other studies establish a clear link between hormones and mathematical abilities, says David C. Geary, a professor of psychology at the University of Missouri at Columbia and author of *Male, Female: The Evolution of Human Sex Differences* (American Psychological Association, 1998). "In transsexuals, when you suppress male hormones, their spatial abilities go down," he says. "When you give male hormones to women, their spatial abilities go up."

A similar effect happens with female hormones, like estradiol and progesterone. During menstruation, when those substances are less concentrated in the bloodstream, women perform better on tests of spatial ability than they do closer to ovulation, Mr. Geary says. (Verbal abilities follow the opposite pattern during the menstrual cycle.)

The three-dimensional advantage helps males not only on spatial tests but also more broadly, in word problems and other types of math questions, he says.

Some evidence for that comes from studies by M. Beth Casey, a professor of applied developmental and educational psychology at Boston College. In one experiment, she and her colleagues looked at students' performance on the Third International Mathematics and Science Study, which compares eighth graders around the world. Ms. Casey pulled out questions on the test that boys tended to answer better than girls did, like: "A straight line on a graph passes through the points (3,2) and (4,4). Which of these points also lies on the line? A. (1,1) B. (2,4) C. (5,6) D. (6,3) E. (6,5)." (The answer is C.)

Ms. Casey wanted to explore the reasons that more boys than girls answered such questions correctly. So she measured students' self-confidence about math and how well they could use spatial and mechanical reasoning. While confidence levels did play a role in determining how students performed on the international test questions, she found, spatial skills were three times as important as confidence in predicting who would do well on those questions.

The Teaching Gap

Those results point out a problem in the way students learn math in the United States, she says: "In school, we don't teach spatial math thinking. We teach logical deductive reasoning."

Boys have a natural advantage, Ms. Casey says, because early in life they tend to play more often than girls do in ways that develop spatial abilities. "Boys are attracted to those kinds of spatial activities where they're running cars along the ground or block building," she says. So when the time comes to solve math problems, they can draw on their spatial abilities as well as the more verbally based algorithms that they learned in school. Girls, on the other hand, with less experience developing spatial skills, have to rely more on the learned algorithms to solve math problems.

With support from the National Science Foundation, Ms. Casey has taken those theories into the classroom by designing a curriculum to enhance spatial-problem-solving skills in young children. Information about the curriculum is available on the Web (<http://www2.bc.edu/~caseyb/oview.html>). In preliminary tests, both boys and girls benefited from the new type of instruction, but girls showed more of an improvement than did boys, she says.

Those findings match other experimental data showing that gender differences, whatever the source, are not immutable. In some cases, Mr. Geary says, boys perform better than girls on word problems, but "if

you provide girls with the basic diagramming skills, then some of the gap disappears in the solving of multistep word problems."

Other research points to the role that behavior -- or misbehavior -- may play in helping boys learn math. In one study, Martha Carr, a professor of educational psychology at the University of Georgia, looked at first graders who were learning to add and subtract using "manipulatives," like counting with their fingers or with beads. Midway through the year, she noticed that most boys were abandoning the manipulatives and were doing the problems in their heads by recalling the answers from memory. Most girls, meanwhile, continued to use the manipulatives.

At first glance, such a result might suggest that boys have a natural advantage in arithmetic. But the difference had nothing to do with ability, Ms. Carr says. "Basically," she explains, "a lot of the boys were guessing."

The boys had stopped using the manipulatives because it took too much time, and the boys were vying to answer first. "There's this competitive one-upmanship, and that supports the move toward retrieval," she says. By the end of the year, boys and girls were doing the problems equally well, but boys could answer the problems from memory, while girls were still using the technique they had been taught.

In general, girls tend to follow instructions better than boys do, which made the girls less likely to change strategies on their own, says Ms. Carr. So it was the boys' competitive nature -- whether learned or innate -- that caused them to make leaps in learning.

The Problem With Multiple Talents

In a similar way, other factors unrelated to mathematical ability apparently play important roles in determining whether girls will pursue math in school or in careers. One clear demonstration comes from studies of gifted students who scored at least 390 on the math portion of the SAT test when they were 13 years old, which put them at the top 1 percent of their age class.

Those students are part of a cohort of more than 100,000 teenagers who have participated in a talent search run by the Johns Hopkins University since the early 1970s. Camilla Persson Benbow and David Lubinski, both professors at Vanderbilt University, have tracked some of those talent-search students for 20 years to see what factors influenced their choices in education and careers.

The researchers found that, in general, mathematically gifted females had broader abilities than did mathematically talented males. Girls tended to show more balance between their math and verbal SAT scores, while boys had more of a tilt, scoring higher on the math section and lower on the verbal.

That "quantitative tilt" turned out to be an important factor, the researchers said. Students with exceptional math abilities were less likely to major in math or science if they also had high verbal skills.

Indeed, among those mathematically talented students, 64 percent of the boys said their favorite high-school class was in math or science, while only 39 percent of the girls said so. When it came time to choose majors and careers, the mathematically gifted young women followed their broader abilities and interests into the life sciences and humanities at much higher rates than did the mathematically gifted boys.

Susan C. Athey is a case in point. She was a standout in math at an early age and qualified for the Johns Hopkins program. But she also had exceptional verbal abilities. "That made it less obvious that math

was where I needed to be focusing. It makes the career choice harder," she says. Although she started studying computer science in college, she switched to economics because she saw it as more relevant to society. She is now a professor of economics at Stanford University.

For Mr. Lubinski and Ms. Persson Benbow, the data from their studies suggest that efforts to gain gender parity in all academic disciplines may be wrongheaded. "If the United States is to remain true to the ideals that all students be given access to opportunities for developing their potential and that people be allowed to choose their life paths freely, this might require questioning whether males and females should be equally represented across the full educational-vocational spectrum," they concluded in a paper published in the journal *Psychological Science* in 2001.

"There are some extremists out there who say that there ought to be as many female electrical engineers as males," says Julian C. Stanley, a professor emeritus of psychology at Johns Hopkins who started the Study of Mathematically Precocious Youth there in 1971. "That doesn't make any sense to me," he argues, given the different interests that women and men consistently express.

In studies of the students who went through the talent search, he says, "women are more oriented toward social services and aesthetics, while boys are much more oriented toward theoretical concerns, factual concerns, economics, and power."

That may explain why mathematically gifted women tend to go into medicine, psychology, and biology rather than physics or electrical engineering, Mr. Stanley says. "The question is, Do we want to work hard on a woman who would rather be a doctor than a physicist and make a physicist out of her?"

A Red Herring

Other researchers deride the very idea of such a question. "This kind of logic assumes that these differences in interest are coming straight out of the genes, that they're not affected by the environment," says Elizabeth S. Spelke, a professor of psychology at Harvard who studies how children develop math skills. "If we know anything about the social forces that affect both genders, it's that people of either gender, if they look toward a field that is populated almost entirely by the opposite gender, they're not going to be drawn to it."

Then there is the reality of discrimination, both in its overt form and in the subtler, perhaps unconscious ways that it seeps into our culture.

At the university level, those biases often creep into the closed rooms where committees make hiring decisions, according to Ms. Silverberg of UC Irvine. "In my 20-plus years as a mathematician, I've seen a variety of excuses used to justify not choosing a woman, which I've never seen used against a man," she says in an e-mail message.

"Academics (even female ones) often view women as part of their personal lives, not their professional lives," she says. "Men in academia often relate to their female colleagues the way they relate to their wives, mothers, ex-wives, and daughters, rather than the way they relate to their male colleagues. As a result, women often are not taken seriously or treated professionally."

Making matters worse, women are more susceptible to cultural influences because they are raised to focus on relationships, says Martha Putallaz, a professor of psychology at Duke University who runs the Duke Talent Identification Program, which tests 80,000 middle-school students each year and invites the gifted ones to participate in advanced academic programs. "We socialize females to be very good

monitors of interactions and interpersonal feelings," she says, while males are taught to focus on achievement.

Data from Mr. Stanley's program, at Johns Hopkins, shows just how strong the cultural factors are in determining math achievement. In the early 1980s, he and Ms. Persson Benbow reported a whopping disparity in the numbers of mathematically gifted boys and girls who scored 700 on the math section of the SAT at the age of 13, a distinction achieved by one in 10,000 students. A quarter-century ago, there were 13 boys for every girl at that level. Now the ratio is only 2.8 to 1, a precipitous drop that has not been reported in the news media. "It's gone way down as women have had an opportunity to take their math earlier," says Mr. Stanley.

Despite that remarkable shift, women are still vastly underrepresented in physics, engineering, computer science, and other math-heavy disciplines. Ms. Eccles thinks she knows why. The Michigan researcher has tracked 3,000 students from elementary school through their postcollege years. Unlike those in the talent-search studies, the students in Ms. Eccles's sample included people of all different abilities.

When she examined why students elected to take advanced math and physics courses in high school, she found that they did not base their selections on the obvious factors, such as what courses they liked. Instead, utility mattered most. "How important was the course to their long-term goals?" she says. "Already in high school, they've made decisions about what they want to do later."

And mathematically talented girls took themselves out of the physics-engineering pipeline for much the same reasons that Mr. Stanley enumerated. "The females are more likely than the males to say they want a job where they can help other people," Ms. Eccles says. "Males are more likely to say they want a job where they can be their own boss and make lots of money." As a result, many young women with high math skills in her study ended up studying biology instead of physics or engineering.

But unlike Mr. Stanley, Ms. Eccles sees room to change the interest gap, by educating students better about career choices. "You have to change their views of these professions," she says. "Engineers do help people. Physical scientists do help people. We've got to get a lot more information to high-school kids about what the physical sciences are like."

Another way to draw in women would be to change the way some disciplines are taught. "Females want to be good at lots of things. They want to try lots of things. They want to follow their interests," she says. But typical engineering programs don't allow students to choose many elective courses, so they tend to repel students with broad interests. Some engineering schools are experimenting by making their programs more relevant to students' interests and more diverse in terms of coursework. Those kinds of changes will attract more students of both sexes, says Ms. Eccles.

Such a goal will find no dissenters, even among those who see evidence for innate gender differences. Although Mr. Geary, of Missouri, wrote a book about male-female differences, he says that "the gap between boys and girls is relatively trivial compared to the gap between U.S. adolescents and adolescents in numerous other countries who are receiving a much more solid education in mathematics and science."

Still, he maintains that it is important to study potential sexual differences, in part to multiply the mathematical talent in America. "It could be when we better understand where exactly the differences are," he says, "we can provide additional interventions for girls and boys."

<http://chronicle.com>

Section: Research & Publishing
Volume 51, Issue 26, Page A1

[Copyright](#) © 2005 by [The Chronicle of Higher Education](#)

[Subscribe](#) | [About The Chronicle](#) | [Contact us](#) | [Terms of use](#) | [Privacy policy](#) | [Help](#)