WHO SAYS A WOMAN CAN'T BE EINSTEIN?

Yes, men's and women's brains are different. But new research upends the old myths about who's good at what. A tour of the ever changing brain

By Amanda Ripley

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THERE WAS SOMETHING SELF-DESTRUCTIVE ABOUT Harvard University President Larry Summers' speech on gender disparities in January. In his first sentence, he said his goal was "provocation" (rarely a wise strategy at a diversity conference). He called for "rigorous and careful" thinking to explain the gender gap among top-tier tenured science professors. But he described his pet theory with something less than prudence. The most likely explanations, he said, are that 1) women are just not so interested as men in making the sacrifices required by high-powered jobs, 2) men may have more "intrinsic aptitude" for high-level science and 3) women may be victims of old-fashioned discrimination. "In my own view, their importance probably ranks in exactly the order that I just described," he announced.

Cue the hysteria. The comments about aptitude in particular lingered, like food poisoning, long after the conference ended. For weeks, pundits and professors spouted outrage and praise, all of which added up to very little. Then came the tedious analysis of faculty-lounge politics at Harvard, as if anyone outside Cambridge really cared.

The rest of us were left with a nagging question: What is the latest science on the differences between men's and women's aptitudes, anyway? Is it true, even a little bit, that men are better equipped for scientific genius? Or is it ridiculous--even pernicious--to ask such a question in the year 2005?

It's always perilous to use science to resolve festering public debates. Everyone sees something differentlike 100 people finding shapes in clouds. By the time they make up their minds, the clouds have drifted beyond the horizon. But scientists who have spent their lives studying sex differences in the brain (some of whom defend Summers and some of whom dismiss him as an ignoramus) generally concede that he was not entirely wrong. Thanks to new brain-imaging technology, we know there are indeed real differences between the male and the female brain, more differences than we would have imagined a decade ago. "The brain is a sex organ," says Sandra Witelson, a neuroscientist who became famous in the 1990s for her study of Albert Einstein's brain. "In the last dozen years, there has been an exponential increase in the number of studies that have found differences in the brain. It's very exciting."

But that's just the beginning of the conversation. It turns out that many of those differences don't seem to change our behavior. Others do--in ways we might not expect. Some of the most dramatic differences are not just in our brains but also in our eyes, noses and ears--which feed information to our brains. Still, almost none of those differences are static. The brain is constantly changing in response to hormones, encouragement, practice, diet and drugs. Brain patterns fluctuate within the same person, in fact, depending on age and time of day. So while Summers was also right that more men than women make up the extreme high--and low--scorers in science and math tests, it's absurd to conclude that the difference is primarily because of biology--or environment. The two interact from the time of conception, which only makes life more interesting.

Any simplistic theory is "doomed to fail," says Yu Xie, a sociology professor at the University of Michigan. Xie's research on women in the sciences was cited by Summers in his statement, and Xie has spent every day since trying to explain the intricacy of human behavior to reporters. "I don't exclude biology as an explanation," he says. "But I know biological factors would not play a role unless they interacted with social conditions."

Unless one appreciates that complexity, it would be all too easy to look at the latest research on the brain and conclude, say, that men may not in fact make the best university presidents. For example, studies show that men are slightly more likely to say things without realizing how their actions will affect others. And as men age, they tend to lose more tissue from a part of the brain located just behind the forehead that concerns itself with consequences and self-control. Generally speaking, the brain of a female is more interlinked and--if one assumes that a basic requirement of the post is to avoid dividing the faculty into two sweaty mobs--may be better suited for the kind of cautious diplomacy required of a high-profile university leader. Of course, to borrow a line from Summers, "I would prefer to believe otherwise."

Now that scientists are finally starting to map the brain with some accuracy, the challenge is figuring out what to do with that knowledge. The possibilities for applying it to the classroom, workplace and doctor's office are tantalizing. "If something is genetic, it means it must be biological. If we can figure out the biology, then we should be able to tweak the biology," says Richard Haier, a psychology professor who studies intelligence at the University of California at Irvine. Maybe Summers' failure was not one of sensitivity but one of imagination.

LESSON 1: FUNCTION OVER FORM

SCIENTISTS HAVE BEEN LOOKING FOR SEX differences in the brain since they have been looking at the brain. Many bold decrees have been issued. In the 19th century, the corpus callosum, a bundle of nerve fibers that connects the two hemispheres of the brain, was considered key to intellectual development. Accordingly, it was said to have a greater surface area in men. Then, in the 1980s, we were told that no, it is larger in women--and that explains why the emotional right side of women's brains is more in touch with the analytical left side. Aha. That theory has since been discredited, and scientists remain at odds over who has the biggest and what it might mean. Stay tuned for more breaking news.

But most studies agree that men's brains are about 10% bigger than women's brains overall. Even when the comparison is adjusted for the fact that men are, on average, 8% taller than women, men's brains are still slightly bigger. But size does not predict intellectual performance, as was once thought. Men and women perform similarly on IQ tests. And most scientists still cannot tell male and female brains apart just by looking at them.

Recently, scientists have begun to move away from the obsession with size. Thanks to new brain-imaging technology, researchers can get a good look at the living brain as it functions and grows. Earlier studies relied on autopsies or X rays--and no one wanted to expose children or women, who might be pregnant, to regular doses of radiation.

The deeper you probe, the more interesting the differences. Women appear to have more connections between the two brain hemispheres. In certain regions, their brain is more densely packed with neurons. And women tend to use more parts of their brain to accomplish certain tasks. That might explain why they often recover better from a stroke, since the healthy parts of their mind compensate for the injured regions. Men do their thinking in more focused regions of the brain, whether they are solving a math problem, reading a book or feeling a wave of anger or sadness.

Indeed, men and women seem to handle emotions quite differently. While both sexes use a part of the brain called the amygdala, which is located deep within the organ, women seem to have stronger connections between the amygdala and regions of the brain that handle language and other higher-level

functions. That may explain why women are, on average, more likely to talk about their emotions and men tend to compartmentalize their worries and carry on. Or, of course, it may not.

"Men and women have different brain architectures, and we don't know what they mean," says Haier. By administering IQ tests to a group of college students and then analyzing scans of their brain structure, Haier's team recently discovered that the parts of the brain that are related to intelligence are different in men and women. "That is in some ways a major observation, because one of the assumptions of psychology has been that all human brains pretty much work the same way," he says. Now that we know they don't, we can try to understand why some brains react differently to, say, Alzheimer's, many medications and even teaching techniques, Haier says.

Even more interesting than the brain's adult anatomy might be the journey it takes to get there. For 13 years, psychiatrist Jay Giedd has been compiling one of the world's largest libraries of brain growth. Every Tuesday evening, from 5 o'clock until midnight, a string of children files into the National Institutes of Health outside Washington to have their brains scanned. Giedd and his team ease the kids through the MRI procedure, and then he gives them a brain tour of their pictures--gently pointing out the spinal cord and the corpus callosum, before offering them a copy to take to show-and-tell.

Most of the kids are all business. Rowena Avery, 6, of Sparks, Nev., arrived last week with a stuffed animal named Sidewalk and stoically disappeared into the machine while her mom, dad and little sister watched. In preparation, she had practiced at home by lying very still in the bathtub. Her picture came out crystal clear. "The youngest ones are the best at lying still. It's kind of surprising," Giedd says. "It must be because they are used to hiding in kitchen cabinets and things like that."

Among the girls in Giedd's study, brain size peaks around age 111/2. For the boys, the peak comes three years later. "For kids, that's a long time," Giedd says. His research shows that most parts of the brain mature faster in girls. But in a 1999 study of 508 boys and girls, Virginia Tech researcher Harriet Hanlon found that some areas mature faster in boys. Specifically, some of the regions involved in mechanical reasoning, visual targeting and spatial reasoning appeared to mature four to eight years earlier in boys. The parts that handle verbal fluency, handwriting and recognizing familiar faces matured several years earlier in girls.

Monkeys are among our most trusted substitutes in brain research. This week a study in the journal Behavioral Neuroscience shows that stage of life is also important in male and female rhesus monkeys. In a sort of shell game, young male monkeys proved better at finding food after they saw it hidden on a tray-suggesting better spatial memory. But they peaked early. By old age, male and female monkeys performed equally well, according to the study, which was led by AgnÃ[°]s Lacreuse at the Yerkes National Primate Research Center. All of which suggests that certain aptitudes may not be that different between males and females. It just depends on when you test them. (We'll have more to say about those monkeys in just a bit.)

LESSON 2: THE SEGREGATION OF THE SENSES

SO HOW DO WE EXPLAIN WHY, IN STUDY after study, boys and men are still on average better at rotating 3-D objects in their minds? As for girls and women, how do we explain why they tend to have better verbal skills and social sensitivities?

The most surprising differences may be outside the brain. "If you have a man and a woman looking at the same landscape, they see totally different things," asserts Leonard Sax, a physician and psychologist whose book Why Gender Matters came out last month. "Women can see colors and textures that men

cannot see. They hear things men cannot hear, and they smell things men cannot smell." Since the eyes, ears and nose are portals to the brain, they directly affect brain development from birth on.

In rats, for example, we know that the male retina has more cells designed to detect motion. In females, the retina has more cells built to gather information on color and texture. If the same is true in humans, as Sax suspects, that may explain why, in an experiment in England four years ago, newborn boys were much more likely than girls to stare at a mobile turning above their cribs. It may also help explain why boys prefer to play with moving toys like trucks while girls favor richly textured dolls and tend to draw with a wider range of colors, Sax says.

Likewise, women's ears are more sensitive to some noises. Baby girls hear certain ranges of sound better. And the divergence gets even bigger in adults. As for smell, a study published in the journal Nature Neuroscience in 2002 showed that women of childbearing age were many times more sensitive than men to several smells upon repeated exposure. (Another study has found that heterosexual women have the most sensitive smell and homosexual men have the least.)

Rest assured, Sax says: none of that means women are, overall, better than men at perception. It just means the species is internally diverse, making it more likely to survive. "The female will remember the color and texture of a particular plant and be able to warn people if it's poisonous. A man looking at the same thing will be more alert to what is moving in the periphery," he says. "Which is better? You need both."

LESSON 3: NEVER UNDERESTIMATE THE BRAIN

UNTIL RECENTLY, THERE HAVE BEEN TWO groups of people: those who argue sex differences are innate and should be embraced and those who insist that they are learned and should be eliminated by changing the environment. Sax is one of the few in the middle--convinced that boys and girls are innately different and that we must change the environment so differences don't become limitations.

At a restaurant near his practice in Montgomery County, Md., Sax spreads out dozens of papers and meticulously makes his case. He is a fanatic, but a smart, patient one. In the early 1990s, he says, he grew alarmed by the "parade" of parents coming into his office wondering whether their sons had attention-deficit/hyperactivity disorder. Sax evaluated them and found that, indeed, the boys were not paying attention in school. But the more he studied brain differences, the more he became convinced that the problem was with the schools. Sometimes the solution was simple: some of the boys didn't hear as well as the girls and so needed to be moved into the front row. Other times, the solution was more complex.

Eventually, Sax concluded that very young boys and girls would be better off in separate classrooms altogether. "[Previously], as far as I was concerned, single-sex education was an old-fashioned leftover. I thought of boys wearing suits and talking with British accents," he says. But coed schools do more harm than good, he decided, when they teach boys and girls as if their brains mature at the same time. "If you ask a child to do something not developmentally appropriate for him, he will, No. 1, fail. No. 2, he will develop an aversion to the subject," he says. "By age 12, you will have girls who don't like science and boys who don't like reading." And they won't ever go back, he says. "The reason women are underrepresented in computer science and engineering is not because they can't do it. It's because of the way they're taught."

So far, studies about girls' and boys' achievements in same-sex grammar schools are inconclusive. But if it turns out that targeting sex differences through education is helpful, there are certainly many ways to carry it out. Says Giedd: "The ability for change is phenomenal. That's what the brain does best." A small but charming 2004 study published in Nature found that people who learned how to juggle increased the

gray matter in their brains in certain locations. When they stopped juggling, the new gray matter vanished. A similar structural change appears to occur in people who learn a second language. Remember that new research on spatial memory in rhesus monkeys? The young females dramatically improved their performance through simple training, wiping out the gender gap altogether.

In a recent experiment with humans at Temple University, women showed substantial progress in spatial reasoning after spending a couple of hours a week for 10 weeks playing Tetris, of all things. The males improved with weeks of practice too, says Nora Newcombe, a Temple psychologist who specializes in spatial cognition, and so the gender gap remained. But the improvement for both sexes was "massively greater" than the gender difference. "This means that if the males didn't train, the females would outstrip them," she says.

Of course, we already manipulate the brain through drugs--many of which, doctors now realize, have dramatically different effects on different brains. Drugs for improving intelligence are in the works, says Haier, in the quest to find medication for Alzheimer's. "We're going to get a lot better at manipulating genetic biology. We may even be better at manipulating genetic biology than manipulating the environment."

Until then, one solution to overcoming biological tendencies is to consciously override them, to say to yourself, "O.K., I may have a hard time with this task, but I'm going to will myself to conquer it." Some experiments show that baby girls, when faced with failure, tend to give up and cry relatively quickly, while baby boys get angry and persist, says Witelson at Ontario's Michael G. DeGroote School of Medicine at McMaster University. "What we don't know is whether that pattern persists into adulthood," she says. But in her experience in academia, she says she knows of at least a couple of brilliant women who never realized their potential in science because they stopped trying when they didn't get grants or encountered some other obstacle. "It's much better," she says, "for people to understand what the differences are, act on their advantages and be prepared for their disadvantages."

LESSON 4: EXPECTATIONS MATTER

WE HAVE A TENDENCY TO MAKE TOO MUCH of test-score differences between the sexes (which are actually very small compared with the differences between, say, poor and affluent students). And regardless of what happens in school, personality and discipline can better predict success when it comes to highly competitive jobs.

One thing we know about the brain is that it is vulnerable to the power of suggestion. There is plenty of evidence that when young women are motivated and encouraged, they excel at science. For most of the 1800s, for example, physics, astronomy, chemistry and botany were considered gender-appropriate subjects for middle-and upper-class American girls. By the 1890s, girls outnumbered boys in public high school science courses across the country, according to The Science Education of American Girls, a 2003 book by Kim Tolley. Records from top schools in Boston show that girls outperformed boys in physics in the mid-19th century. Latin and Greek, meanwhile, were considered the province of gentlemen--until the 20th century, when lucrative opportunities began to open up in the sciences.

Today, in Iceland and Sweden, girls consistently outperform boys in math and physics (see box). In Sweden the gap is widest in the remote regions in the north. That may be because women want to move to the big cities farther south, where they would need to compete in high-tech economies, while men are focused on local hunting, fishing and forestry opportunities, says Niels Egelund, a professor of educational psychology at the Danish University of Education. The phenomenon even has a name, the Jokkmokk effect, a reference to an isolated town in Swedish Lapland. Back in the States, the achievement gap in the sciences is closing, albeit slowly. Female professors have been catching up with male professors in their publishing output. Today half of chemistry and almost 60% of biology bachelor of science degrees go to females. Patience is required.

Next, Summers may want to take up the male question. In all seriousness. Why do so many more boys than girls have learning disorders, autism, attention-deficit problems and schizophrenia? Why are young men now less likely to go to college than women are? And what to make of a 2003 survey that found eighth-grade girls outperforming boys in algebra in 22 countries, with boys outscoring girls in only three nations? If we're not careful, the next Einstein could find herself working as a high-powered lawyer who does wonders with estate-tax calculations instead of discovering what the universe is made of. --With reporting by Nadia Mustafa and Deirdre van Dyk/ New York and Ulla Plon/Lulea