The New York Times

The Male Condition

By SIMON BARON-COHEN
Published: August 8, 2005
Cambridge, England

TWO big scientific debates have attracted a lot of attention over the past year. One concerns the causes of autism, while the other addresses differences in scientific aptitude between the sexes. At the risk of adding fuel to both fires, I submit that these two lines of inquiry have a great deal in common. By studying the differences between male and female brains, we can generate significant insights into the mystery of autism.

So was Lawrence Summers, the president of Harvard, right when he remarked that women were innately less suited than men to be top-level scientists? Judging from current research, he was and he wasn't. It's true that scientists have documented psychological and physiological differences between male and female brains. But Mr. Summers was wrong to imply that these differences render any individual woman less capable than any individual man of becoming a top-level scientist.

In fact, the differences that show up in brain research reflect averages, meaning that they emerge only when you study groups of males and females and compare the two groups' averages on particular psychological tests or physiological measures. The evidence to date tells us nothing about individuals - which means that if you are a woman, there is no evidence to suggest that you could not become a Nobel laureate in your chosen area of scientific inquiry. A good scientist is a good scientist regardless of sex.

Nonetheless, with brain scanning, we can discern physiological differences between the average male and the average female brain. For example, the average man's cerebrum (the area in the front of the brain concerned with higher thinking) is 9 percent larger than the average woman's. Similar, though less distinct, overgrowth is found in all the lobes of the male brain. On average, men also have a larger amygdala (an almond shaped structure in the center of the brain involved in processing fear and emotion), and more nerve cells. Quite how these differences in size affect function, if at all, is not yet known.

In women, meanwhile, the connective tissue that allows communication between the two hemispheres of the brain tends to be thicker, perhaps facilitating interchange. This may explain why one study from Yale found that when performing language tasks, women are likely to activate both hemispheres, whereas males (on average) activate only the left hemisphere.

Psychological tests also reveal patterns of sex difference. On average, males finish faster and score higher than females on a test that requires the taker to visualize an object's appearance after it is rotated in three dimensions. The same is true for map-reading tests, and for embedded-figures tests, which ask subjects to find a component shape hidden within a larger design. Males are over-represented in the top percentiles on college-level math tests and tend to score higher on mechanics tests than females do. Females, on the other hand, average higher scores than males on tests of emotion recognition, social sensitivity and language ability.

Many of these sex differences are seen in adults, which might lead to the conclusion that all they reflect are differences in socialization and experience. But some differences are also seen extremely early in development, which may suggest that biology also plays a role. For example, girls tend to talk earlier than boys, and in the second year of life their vocabularies grow at a faster rate. One-year-old girls also make more eye contact than boys of their age.

In my work I have summarized these differences by saying that males on average have a stronger drive to systemize, and females to empathize. Systemizing involves identifying the laws that govern how a system works. Once you know the laws, you can control the system or predict its behavior. Empathizing, on the other hand, involves recognizing what another person may be feeling or thinking, and responding to those feelings with an appropriate emotion of one's own.

Our research team in Cambridge administered questionnaires on which men and women could report their level of interest in these two aspects of the world - one involving systems, the other involving other people's feelings. Three types of people were revealed through our study: one for whom empathy is stronger than systemizing (Type E brains); another for whom systemizing is stronger than empathy (Type S brains); and a third for whom empathy and systemizing are

equally strong (Type B brains). As one might predict, more women (44 percent) have Type E brains than men (17 percent), while more men have Type S brains (54 percent) than women (17 percent).

What of Mr. Summers's other claim, that such sex differences are innate? We know that culture plays a role in the divergence of the sexes, but so does biology. For example, on the first day of life, male and female newborns pay attention to different things. On average, at 24 hours old, more male infants will look at a mechanical mobile suspended above them, whereas more female infants will look at a human face.

It has also been found that the amount of prenatal testosterone, which is produced by the fetus and measurable in the amniotic fluid in which the baby is bathed in the womb, predicts how sociable a child will be. The higher the level of prenatal testosterone, the less eye contact the child will make as a toddler, and the slower the child will develop language. That is connected to the role of fetal testosterone in influencing brain development.

Males obviously produce far more prenatal testosterone than females do, but levels vary considerably even across members of the same sex. In fact, it may not be your sex per se that determines what kind of brain you have, but your prenatal hormone levels. From there it's a short leap to the intriguing idea that a male can have a typically female brain (if his testosterone levels are low), while a female can have a typically male brain (if her testosterone levels are high). That notion fits with the evidence that girls born with congenital adrenal hyperplasia, who for genetic reasons produce too much testosterone, are more likely to exhibit "tomboy" behavior than girls with more ordinary hormone levels.

What does all this have to do with autism? According to what I have called the "extreme male brain" theory of autism, people with autism simply match an extreme of the male profile, with a particularly intense drive to systemize and an unusually low drive to empathize. When adults with Asperger's syndrome (a subgroup on the autistic spectrum) took the same questionnaires we gave to non-autistic adults, they exhibited extreme Type S brains. Psychological tests reveal a similar pattern.

And this analysis makes sense. It helps explain the social disability in autism, because empathy difficulties make it harder to make and maintain relationships with others. It also explains the "islets of ability" that people with autism display in subjects like math or music or drawing - all skills that benefit from systemizing.

People with autism often develop obsessions, which may be nothing other than very intense systemizing at work. The child might become obsessed with electrical switches (an electrical system), or train timetables (a temporal system), or spinning objects (a physical system), or the names of deep-sea fish (a natural, taxonomic system). The child with severe autism, who may have additional learning difficulties and little language ability, might express his obsessions by bouncing constantly on a trampoline or spinning around and around, because motion is highly lawful and predictable. Some children with severe autism line objects up for hours on end. What used to be dismissed by clinicians as "purposeless, repetitive behavior" may actually be a sign of a mind that is highly tuned to systemize.

One needs to be extremely careful in advancing a cause for autism, because this field is rife with theories that have collapsed under empirical scrutiny. Nonetheless, my hypothesis is that autism is the genetic result of "assortative mating" between parents who are both strong systemizers. Assortative mating is the term we use when like is attracted to like, and there are four significant reasons to believe it is happening here.

FIRST, both mothers and fathers of children with autism complete the embedded figures test faster than men and women in the general population.

Second, both mothers and fathers of children with autism are more likely to have fathers who are talented systemizers (engineers, for example).

Third, when we look at brain activity with magnetic resonance imaging, males and females on average show different patterns while performing empathizing or systemizing tasks. But both mothers and fathers of children with autism show strong male patterns of brain activity.

Fourth, both mothers and fathers of children with autism score above average on a questionnaire that measures how many autistic traits an individual has. These results suggest a genetic cause of autism, with both parents contributing genes that ultimately relate to a similar kind of mind: one with an affinity for thinking systematically.

In order to fully test this theory, we still need to do a lot of work. The specific genes involved must be identified. It is a theory that may be controversial and perhaps unpopular among those who believe that the cause of autism is largely or totally environmental. But controversy is not a reason not to test it - systematically, as we might say.