

Gender and the brain

New evidence shows how hormones wire the minds of men and women to see the world differently

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Scientists are still a long way from figuring out what women and men really want, but they are getting a lot closer to understanding what makes their brains so different.

That women and men think differently has little to do with whether they are handed dolls or trucks to play with as infants. After all, when infant monkeys are given a choice of human toys, females prefer dolls and males go after cars and trucks.

The differences, researchers are beginning to discover, appear to have a lot more to do with how powerful hormones wire the female and male brain during early development and later in life.

Among the newest findings: A previously unknown hormone appears to launch puberty's sexual and mental transformation; growth hormone is made in the brain's memory center at rates up to twice as high in females as in males; and the brain's hot button for emotions, the amygdala, is wired to different parts of the brain in women and men.

Scientists hope the findings may help explain such mysteries as why females are often more verbal, more socially empathetic, more nurturing and more susceptible to depression, while males tend to be more aggressive, more outdoorsy, more focused on things than people and more vulnerable to alcohol and drug addiction.

"Males and females look different, we act different, so of course our brains are different," said Rutgers University psychologist Tracey Shors, who is studying the effects of growth hormone on the brain. "Sex hormones along with stress and growth hormones change the brain's anatomy, and in that way you change behavior, your ability to think and learn."

Sex differences begin with the X and Y sex chromosomes a person is born with. But scientists now believe that whether the brain and nervous system are wired as female or male depends a lot on the early influence of estrogen, the so-called female hormone, or testosterone, the male hormone.

The brain's sexual identity is first established when those hormones are briefly released before and shortly after birth, which may influence a child's preference for dolls or trucks.

"There's a peak of testosterone in males at birth that's very important for future sexual behavior," said Dr. Sophie Messenger of Paradigm Therapeutics in Cambridge, England. "If you block that, the male rats behave like females for the rest of their life."

The sex hormones then lie dormant until they get turned on again in puberty to make the body ready for reproduction.

That is where a recently discovered hormone called kisspeptin comes in. Created in the brain, it unleashes a cascade of hormones that race down to the gonads--ovaries in females and testes in males.

There they stimulate the production of estrogen or testosterone, starting the physical transformations of puberty. Messenger proved in animals that blocking kisspeptin prevented those

changes from happening.

But there is another target for this activity: the brain. The hormonal downrush kicked off by kisspeptin comes full circle when estrogen and testosterone travel back to the brain, imprinting neural circuits with female and male characteristics, Messenger said.

Animal studies show that genetic females will behave like males if their estrogen is blocked and replaced by testosterone. Genetic males, in turn, act like females if their testosterone is knocked out.

Until kisspeptin was discovered, scientists had generally accepted the idea that sex differences were centered in the hypothalamus, a small organ on the underside of the brain. It was thought that the hypothalamus originated the flow of hormones that start puberty, determine male and female physical characteristics and orchestrate mating behavior.

"The bias of mainstream neuroscience for the last 25 years has been, 'OK, sure there's some sex differences way down deep in the brain in this little structure called the hypothalamus, but otherwise the brains of men and women were pretty much the same,'" said Larry Cahill, a neurobiologist at the University of California, Irvine.

"That was wrong, as wrong as could be," said Cahill, who is using imaging technology to show how male and female brains are wired for emotions. "Sex matters a lot in how the brain works and we neuroscientists have to change our tune."

One example lies in the amygdala, the organ that interprets the emotional content of an experience, affecting what people remember.

Located deep in the brain on both sides, the amygdala amplifies memories that are pleasant or frightening. It tells the hippocampus, where memories are put together to be stored, which memories need to be most tightly locked in place. It will never let you forget what you were doing when you won the lottery or where you were on Sept. 11.

Cahill and his colleagues found that the amygdala works differently in men and women, which may help explain why women are more likely to develop mood disorders such as depression and men are more prone to alcoholism and drug abuse.

In one experiment, Cahill showed that when men and women watched the same emotional movie, the right side of the amygdala was more active in men, and the left amygdala was more active in women. "They're using very different brain processes to create enhanced memories," he said.

The right amygdala is more in tune to the outside environment, communicating with the visual cortex, which controls vision, and the striatum, which coordinates motor actions. These processes are thought to be key to spatial orientation--knowing how to negotiate your surroundings, as in hunting.

The left amygdala is concentrated more on the inner environment of the body, connecting with the insular cortex, which produces emotionally relevant content from sensory experiences, and the hypothalamus' regulation of the body's metabolic and autonomic activities. Scientists speculate that this is important for the female capacity for nurturing.

A second study by Cahill involved the beta blocker propranolol, a drug used to treat high blood pressure that also has been found to greatly reduce the activity of the amygdala. Because it subdues emotional arousal propranolol is being studied as a way to reduce the impact of post-traumatic stress disorder.

In Cahill's experiment, normal subjects were given propranolol before seeing an emotionally disturbing movie about a boy run over by a car. Cahill found that women on the drug were able to remember the central idea of the story, such as that the boy was with his mother, but fewer of the details. Men, on the other hand, remembered more details, like the soccer ball the boy was holding, but less of the essence of the story.

"The drug impaired memory for the details of the emotional story in women but not men, and it impaired memory for the gist of the story in men but not women," Cahill said.

One possible explanation for why women tend to be less aggressive than men is that they may be better able to filter out overly arousing feelings. The front part of the brain, which controls emotions, is bigger in women than in men when compared with the size of the amygdala, where experiences get their emotional charge.

That difference may be why women are less prone than men to fly off the handle, Cahill said.

Scientists also have made new discoveries about growth hormone, whose chief job was thought to be to build the body. But researchers have found the hormone is produced not only in the pituitary gland but also in the brain, in the hippocampus.

That suggests the hormone plays a previously unsuspected role in learning and emotions.

Said Shors: "Sex hormones, like estrogen, have a tremendous effect on the growth and architecture of the brain."

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