

## Boys and Girls Transcript

For a long time, talking about the brain's sexual dimorphism- the brain differences between males and females- was off-limits for scientists in liberal institutions. Suggesting that women's brains might function differently from the male brain was often interpreted as a threat to women's rights and the feminist movement, who fought to prove that the sexes were equal in all ways. Equally intelligent, equally rational, equally emotional, and equally capable of participating in the workforce. It was a patriarchal society, not biology, that made men and women think and act differently.

Politically, it might seem like a good idea to deny any difference between the sexes, but biologically, it's a flat out lie. If you've spent any time wandering around on planet Earth, you know it's a lie- men and women don't act or feel the same way in a lot of subtle but profound ways. Thankfully, scientists in the 21st century are gaining social license to study and discuss the brain differences between the sexes and what they mean for our physical, mental, and emotional health. At long last, we are going to explore those differences today. What does it mean to be a male as opposed to a female, from a neurological perspective? How do sexuality and reproduction affect the way we think and feel? How different are we, really?

Before we start, I'd like to preface this episode with two quick points. First, this episode focuses on facts about cisgender, heterosexual men and women. While some of the findings may be applicable to people of different identities and sexualities, I cannot promise that any one finding will hold true for gay or transgender people. But not to worry- episode 6, A Rainbow Brain, goes into great detail about the homosexual and transgender brain. Second, I want to highlight the fact that all of the information presented in this episode is based on averages and trends, as is true of all Brainstorms episodes. Nothing in this episode defines individuals- it defines trends among groups. For example, we could say that men tend to be taller than women. This is a fact, but that doesn't mean all men are taller than all women. The same holds for neuroscientific findings- there is typically more variation within each sex than between sexes. If you find that any of these facts are inaccurate about you, personally, don't think that you're somehow built wrong, or that the science is messed up. And now, with that taken care of, on to the science.

Let's start this episode with cognition- our mental faculties that describe intelligence, learning, and memory. It's kind of the proverbial elephant in the room when we talk about sex differences, so I'd like to address it first. Let's start by dispelling a myth about cognition- that brain size determines intelligence. The male brain, across the lifespan, is about 10 percent larger than the female brain. Nonetheless, both sexes have identical average IQs. In fact, girls outperform boys in measures of GPA and reading scores in 75 tested nations, though this probably says more about effort and culture than intelligence. Size-wise, saying that brain size correlates with

intelligence is like claiming that eye size is correlated with better vision- perhaps true if you're comparing a beetle eye to an elephant eye, but within the human species, eye size is irrelevant. What matters to vision is the acuity of the cornea, retina, lens, and the optic nerve. In much the same way, the brain's functioning isn't dependent on size from person to person- brain power and efficiency is dependent upon the quantity and quality of our neural connections. That is, the more useful connections you have in the brain, and the more efficient those connections are when they fire, the better. Intelligence also varies by skill- just because you're quick at mathematical reasoning doesn't mean you have impeccable verbal skills, and vice versa. It's basically useless to quantify intelligence as a single quantity, but as a quantity that varies across cognitive domains. This turns out to be the key to understanding the differences in male and female cognition.

In general, women tend to be better at verbal reasoning and perceptual speed, and men tend to perform better on tasks of spatial and mathematical reasoning. Women also tend to show greater accuracy and more acute motor skills, with men having a stronger working memory. Some of these trends can be seen early in the childhood years and all the way through adulthood. For example, 20-month-old girl babies have roughly double the vocabulary of their male counterparts. This discrepancy eventually evens out, but women do speak *faster* throughout the lifetime- an estimated 250 words spoken per minute versus 125 for men. This sort of verbal trend is even true of rhesus monkeys: while females use sixteen vocal tones to communicate, the males only ever employ three to six tones in their lifetime. In terms of mathematical and spatial reasoning, men tend to be better at mentally manipulating 3D objects, and tend to have a better sense of direction. These differences are actually visible in the structure of the male and female brains. According to research at the University of Iowa, men tend to have a more insulated parietal lobe, which deals with spatial reasoning. Some studies have found that the female straight gyrus, a critical region dedicated to social cognition, tends to be larger in adult women, though this trend is strangely reversed in children. Additionally, women, on average, have more connection between the two sides, or hemispheres, of the brain, while men have stronger connections from the back of the brain to the front in each respective lobe. This makes men more apt for spatial and logistical reasoning, while women tend towards better intuitive and analytical reasoning and integration.

Again, these are only trends, but their biological underpinnings are fascinating. Many studies have found that the sex hormones, androgens and estrogens, affect cognitive performance on specific tasks that vary between the sexes. Back in 1988, two Canadian psychologists realized that women performed differently on cognitive tasks depending on their menstrual phase. Women in their experiments performed better on tasks of verbal reasoning, such as word games and puzzles, just before ovulation, when estrogen levels are highest. In contrast, the women performed better on tasks of spatial reasoning, such as manipulating shapes, just after ovulation,

when their estrogen levels are lowest. In essence, the women actually excelled more at male-dominant tasks when estrogen levels were lowest, and performed best in female-dominant tasks when estrogen was highest. To be clear, this finding is significant, but it doesn't mean women drastically fluctuate in intelligence over the menstrual cycle. Rather, it shows that sex hormones *do* affect our cognitive functions. Some studies have confirmed that this concept applies to men and testosterone as well, but since results are so mixed, it's very unclear as to whether this trend really exists in the male brain.

So why are men better at spatial and mathematical reasoning, while women tend to excel more at social and verbal reasoning tasks? A first theory is that the difference could be built into our DNA, thanks to evolutionary pressures for each sex. In a research paper from David Skuse from the Institute of Child Health in London, Skuse presents studies that have shown that male rats also show greater spatial reasoning than females, and that this trait falls on the X or Y chromosome, the chromosomes that differentiate the sexes. Women have two X chromosomes, while men have one X and one Y. If spatial ability is related to our genes, then we may be able to find an evolutionary reason for the difference. While we can't be sure if any one hypothesis is true, one of the best guesses is that early human males had to venture farther from their social group's home to hunt and find food, and needed a better sense of direction and spatial awareness to succeed in their travels. Females, on the other hand, were more likely to stay at home and rear children, possibly explaining why females have greater verbal and social cognition skills- they interacted more with children and other females, and bonded the social group. While evolutionary theories are exciting, another possible answer to the question of cognition differences comes from our culture, and the way we typically raise our children. The brain is built by genes, but also by experience, and our interactions with others and the environment do change the very structure of the brain. Knowing this researchers caution that the structure differences in male and female brains could have something to do with the way we raise boys and girls. Our culture persists in assigning math and science careers as masculine career trajectories, while the humanities, social work, and teaching are more associated with a feminine career path.

For the record, many women do exceed the average mathematical and spatial abilities of men, and many men exceed the average verbal and social cognition of women. Plus, studies have found that by high school, math aptitude disappears between the sexes. So, while the very narrow domains of spatial reasoning and verbal reasoning may persist to adulthood, the effects are small and have no real bearing on the career and academic potential of men and women. Our brains may be built a bit differently to deal with directions and word games, but otherwise, our mental capacities are essentially the same. The deficiency of women in STEM fields is purely a cultural phenomenon, which you can read more about in my suggestions in the show notes.

While cognition in men and women does not differ to a large extent, there is one striking difference in learning between boys and girls: the prevalence of learning disorders, such as ADHD, autism, and dyslexia. Boys have more than twice the rate of ADHD as girls, about 4 times the rate of autism, and are typically recorded as having higher rates of dyslexia, though the difference is disputed among researchers. Why is there such a discrepancy between the sexes in terms of cognitive disorders? There are several reasons why these disorders may be more prevalent in boys. According to Jay Giedd, a neuroscientist at the National Institute of Mental Health, girls have a larger basal ganglia than boys, on average. The basal ganglia, which promotes the habit-building that we talked about in episode 5, also supplements the activity of the prefrontal cortex. If a person has a smaller-than-average basal ganglia, they may be more prone to learning disorders that deal with attention and rational thought. So, if boys have a smaller basal ganglia on average, it makes sense that more boys will have abnormally small basal ganglia and more subsequent learning disorders.

Another explanation specific to ADHD is the trajectory of cognitive development in boys and girls. As you might have experienced, girls tend to be more mature than their male peers, and this isn't just my own female bias. By and large, females develop earlier than males, both in terms of biological puberty and in the brain. ADHD, or attention-deficit hyperactive disorder, is characterized by distractibility, hyper behavior, and difficulty paying attention and following rules. Many boys get an ADHD diagnosis as children not because they are permanently disordered, but because they're a bit delayed in terms of brain maturation compared to their peers. In fact, the majority of people with ADHD grow out of the diagnosis by the late adolescent years. Finally, there is the question of autism, which is still a bit of a puzzle for researchers. Why do boys have 4 times the rate of autism across cultures and the lifespan? One possible explanation is genetic: in 2009, researchers at UCLA discovered a gene variant that is prevalent in autistic boys, which affects the excitability of neurons in response to stimuli. This gene variant is much more common in boys, though the reason is still unknown. Another explanation, also genetic, found that girls with autism showed far more genetic variations than boys with the disorder. Possibly, girls require *more* variations to cross the diagnostic threshold than boys, though again, the reasons are terribly complicated and difficult to deduce. Regardless, genes seem to play the principal role in this discrepancy.

Next up, I'd like to talk about emotions. More so than cognition, emotions and instinctual responses seem to differ in important ways between the sexes. One of the most pressing differences relates to negative emotions- stress, fear, anxiety, and sadness. I've mentioned before that girls are twice as likely to suffer from anxiety and depression as boys during the adolescent years, but didn't provide a neurological causation. It turns out that men and women *do* process negative images differently, according to research at the University of Montreal. Two regions of the brain, the amygdala and the dorsomedial prefrontal cortex, the dmPFC, work together when

something negative happens. The amygdala fires up a threat response, while the dmPFC helps us to rationalize and reason with the amygdala's response. Essentially, we see that men have stronger connections between these two regions on average, making them more capable of rationality in the face of negative emotion. The higher a man's testosterone level, the stronger the connection between the dmPFC and the amygdala. Also related to mental health and the sexes is the stress response, and how it fires in boys and girls. A study at the University of Pittsburgh investigated hormone and cortisol levels in children and teenagers to see how boys and girls diverged in the stress response during puberty. In boys, testosterone levels make the stress and worry systems— the hippocampus and amygdala— less sensitive. Estrogen, on the other hand, makes these systems more alert and sensitive, especially to social conflict. No wonder girls experience so much more anxiety- while boys are becoming numbed to worry, girls are becoming finely tuned to hear it. Additionally, The teenage boys in the study showed a stress response when their authority was challenged, while the girls showed a stress response when in conflict with their peers. This is exactly the kind of trend we saw in episode 2, with boys seeking social dominance and girls seeking belonging.

Just to be clear, this doesn't mean that women are all emotional wrecks and that men are all paragons of poised emotional responses. This difference, while it causes women to suffer from more mood disorders, does mean that women tend to be more empathetic and capable of expressing their emotions compared to men. Mostly, this information is important because it sheds light on why men and women often get confused at the emotional response of the other. Men may criticize women for overreacting or being too emotional, while women may find a man's emotional response to be cold and calculated, lacking in proper sympathy. Both sexes *are* capable of sympathy, empathy, love, and caring, but often we come to these emotions in different ways and at different paces.

Of course, no discussion of emotions and gender is complete without a nice dose of explaining and myth-busting the special case of premenstrual syndrome, or PMS. I can't tell you how many times I've heard girls blame PMS for their emotions, or how many times I've heard girls yell at boys who accuse them of being crazy thanks to PMS. For all the boys out there, I'll start at the very basics: about 5-11 days before a girl begins her period, a female may experience premenstrual syndrome, a collection of symptoms that are directly related to fluctuating hormone levels. About 85 percent of women experience at least 1 premenstrual syndrome symptom, while only about 5 percent experience incredibly intense symptoms which are called premenstrual dysphoric disorder, a more severe diagnosis. We don't know exactly hormones interact with the brain and body to produce symptoms. However, it's well documented that estradiol, a variant of estrogen, regulates many chemicals in the brain, including the pleasure chemicals serotonin and dopamine. Mental PMS symptoms may be caused partly or largely by estradiol fluctuations in the brain. Though we often talk about PMS in terms of emotional symptoms, most of the

symptoms are physical, and include cramps, back pain, bloating, headache, fatigue, and muscle and joint pain. These physical symptoms alone seem like enough to create the anxiety, depression, irritability, and mood swings that often accompany PMS, but neurotransmitters like serotonin, a pleasure chemical, probably also play a role. Bottom line is, PMS is a largely physical phenomenon, and it's not just an emotional meltdown that happens to girls once a month. It also differs hugely from girl to girl, and though I don't take offense to jokes about PMS, some girls might get rightly annoyed if you chalk up their behavior to their menstrual cycle.

Finally, I'd like to spend a bit of time talking about one last difference between men and women, and the one that heterosexual people such as myself probably care most about: sexual behavior. Talking about sexual behavior isn't just about birth control and consent, like you might have discussed in health class. I want to be more honest and say that sex and sexuality is a huge part of a person's life and relationships, and a big part of adolescence is navigating a post-pubescent body that craves sex and intimacy. The issue of sex differences in sexual behavior and attitudes has become more and more relevant to me as I've gotten older, largely because of the hook-up culture and sexual liberation that has taken place not only on college campuses, but increasingly in high schools. How different are men and women when it comes to sexual desire and behavior, biologically and even culturally? What about during adolescence? Do our current attitudes towards sex favor men and women equally, or is one gender being hurt by our cultural expectations?

Obviously, the biological function of puberty is to make us capable of reproduction. If you remember all the way back to episode 1, we discussed how puberty changes the male and female bodies: boys gain the ability to ejaculate sperm, and girls begin the menstrual cycle, releasing an egg for fertilization every 28 days or so. At this point, all of the sexual machinery gets in gear and starts to grind away in both sexes. By the time children enter puberty, at age 11-12, both boys and girls report thinking about sex, but percentages tend to be somewhat higher in boys. To be clear, both girls and boys do report sexual desire, sexual fantasies, and sexual behavior at all ages of adolescence, but boys slightly exceed girls in these measures. Interestingly, sexual arousal is mediated by testosterone in both boys *and* girls- females do use testosterone, just not in the same magnitude or physical growth functions as men.

For a long time, I've harbored a belief that males are built for polygamy and sexual non-attachment, while females are built for monogamous, committed relationships. Evolutionary theories support this mindset well: men went around fertilizing as many women as possible, while women tried to get their mates to assist in child-rearing as a monogamous pair. Men were supposed to mate often and without much discrimination, while pregnancy and child-rearing meant that women had fewer sexual partners and more reason to pick a decent partner who might

stick around and help with parenting. As a modern extension, I thought that hook-up culture was advantageous for men but damaging for women, both physically and emotionally. However, statistics from the American Psychological Association only partially back up my assumptions. 50 percent of college-age men and 26 percent of college-age women have positive feelings after a hook-up, while 26 percent of men and 49 percent of women reported negative feelings, according to a study of 832 college students. In terms of hook-up regret, a study in Canada found that 78 percent of women and 72 percent of men had some regret following such an experience. Other studies have found a slightly wider gap between males and females. The surprising thing for me was noticing how many men regret or have negative feelings towards a hookup. Both men and women often report feeling lonely and depressed after a regretted hookup, and both seek mental health treatment for psychological repercussions of hookup culture. Men are not exclusively interested in sex as a physical activity, and they too experience discomfort with casual sexual encounters and non-committed sex; women just tend to fall a bit higher on that spectrum.

The one major difference between the sexes in terms of hook-ups is the rate of receiving and giving sexual pleasure. In an online survey of over 12,000 college students, researchers found that during hook-ups involving oral sex, 55 percent reported that only men received, 19 percent reported that only women received, and 27 percent reported that both received from each other. That's nearly three times as many men receiving exclusively as women, which can only make you realize why more women might report negative feelings after a hook-up. And here's the thing: it's not because men fundamentally enjoy sex more than women. Men may gain a sex drive at an earlier age than women, but by college, this discrepancy no longer exists by the college years. More likely, all of these discrepancies have to do with cultural double standards around sexuality. To be clear, I'm not just sounding off about the patriarchy here; women and men are both responsible for this double standard. Why don't we teach girls that they are allowed and supposed to desire and enjoy sex like men do? Not because of male discrimination, but because we all- men and women alike- harbor attitudes suggesting that women should be more modest and less interested in sex than men.

So, how different are we? Well, we certainly vary in some ways- cognitively, emotionally, and sexually- but not to the extent that we might expect from a sexually dimorphic species. Actually, scientists marvel at how *similar* we are, given how different our roles are in reproduction. Looking over all the research about adolescents and brain differences between the sexes, I think the most relevant difference is in timing. The female brain matures earlier than the male brain, just as the female body matures earlier than the male body. According to an international study headquartered at Newcastle University in London, neural pruning- the cutting down of brain pathways during adolescence- occurs sooner in girls than in boys. In fact, the female brain is about two years more developed than the male brain at any given point in adolescence, on

average. This means that females have more prefrontal cortex functioning, on average, and may take less risks as a result. Of course, this varies by individual, but the bottom line is that girls *do* tend to be more mature than their male counterparts until adulthood. At the same time, girls are likely to be more emotional and respond more negatively to stress, so if you're female, don't think that you're being "less mature" than you should be when emotions arise. Maturity and hyper-emotionality are coexistent during adolescence, and that's natural. On the flip side, boys might feel that they're constantly being compared to their female counterparts, and told that they need to "mature faster" like the girls are doing. But, by the law of biology, this is physically impossible. We can't expect boys to have the same maturity as girls, nor can we expect girls to bring down their emotions to meet their so-called maturity level.

Lastly, though sex differences are fascinating, nobody exists in a biological box. The variation within each gender is far greater than the variation between genders- any individual girl may far exceed the male average on spatial skills, and any individual boy may far exceed female verbal skills. The value in averages is that they help us to understand the population as a whole, to increase tolerance and empathy, but shouldn't be taken as some sort of tell-all about a person's cognitive, emotional, or sexual abilities. More so than most other species, male and female *Homo sapiens* are extraordinarily similar, and we can use those few differences to better relate to one another as a whole.

Thank you so much for listening. If you enjoy Brainstorms, please rate us on iTunes so that others can find Brainstorms as well. Please also like Brainstorms on Facebook, and use the comments or contact section if you'd like to add to the conversation! Thank you and tune in next week for our last episode of Brainstorms Season 1!