The Truth about

The preference for playing hockey, or in the brain are small—unless grown-up

By Lise Eliot

Parents anticipate sex differences from the first prenatal ultrasound but then seem amazed when their son goes gaga over trucks or their daughter will wear nothing but pink. Boys and girls are obviously different, and in many cases the gaps between them seem stark. But stereotypes do not always hold up to scientific scrutiny. Are boys really more aggressive and girls really more empathetic—or do we just see what we expect in them? Where true sex differences exist, are those gaps inborn, as our current Mars-Venus obsession implies, or shaped by environment—that is, by us?

A natural place to look for answers is in the brain. If there is a neurological disparity between the genders, it could explain important behavioral differences. But surprisingly, researchers have found very few large-scale differences between boys and girls in brain structure or function. Yes, boys have larger brains (and heads) than girls—from birth through old age. And girls’ brains finish growing earlier than boys. But neither of these findings explains why boys are more active and girls more verbal or reveals a plausible basis for the consistent gaps in their reading, writing and science test scores that have parents and teachers up in arms.

Brain differences are indisputably biological, but they are not necessarily hardwired. The crucial, often overlooked fact is that experience itself changes brain structure and function. Neuroscientists call this shaping plasticity, and it is the basis of all learning and much of children’s mental development. Even something as simple as the act of seeing depends on normal visual experience in early life, without which a baby’s visual brain fails to wire up properly and his or her vision is permanently impaired.
Boys and Girls

house, is far from fixed. Sex differences assumptions magnify them

Does growing up as a boy or as a girl also wire the brain in a particular way? Obviously, girls and boys are not identical at birth: genetic and hormonal differences must launch the male and female brain down somewhat different developmental pathways. But early experience, we now know, permanently alters the chemistry and function of the genes inside cells, leading to significant effects on behavior. Neuroscientist Michael J. Meaney and his colleagues at McGill University, among others, have found that the quality of maternal care is associated with a host of neural and psychological consequences—from the production of new brain cells to altered stress responses and memory function. The different ways parents raise boys and girls may similarly leave its stamp on their developing brains. [For more on how early care affects later behavior, see “The New Genetics of Mental Illness,” by Edmund S. Higgins; Scientific American Mind, June/July 2008.]

Most sex differences start out small—as mere biases in temperament and play style—but are amplified as children’s pink- or blue-tinted brains meet our gender-infused culture, including all the tea parties, wrestling matches, playground capers and cafeteria dramas that dominate boys’ or girls’ existence. Through better understanding of these environmental influences, we can break down some of the gaps between boys and girls—in school achievement, risk taking, competitiveness, empathy and conscientiousness.
Boys tend to be more rambunctious than girls. Peer influences amplify innate triggers such as a relative abundance of testosterone in the womb.

The Kickoff
Boys are more physically active than girls, in infancy and throughout childhood. They kick, swing their arms and race around the house noticeably more than girls do, as many exhausted parents can testify. The difference may emerge before birth, although not every ultrasound study finds a sex difference in fetal movement. Nevertheless, the disparity is clear during the first year and expands through childhood, according to a 1986 analysis of more than 100 studies by psychologist Warren Eaton and his colleagues at the University of Manitoba in Canada, which reveals that the average boy is more active than about 69 percent of girls.

That gap is statistically moderate, larger than differences in verbal and math skills but small enough to permit many exceptions to the rule, notably the 31 percent of girls who are more active than the average boy. Sex hormones—in particular, a relative abundance of testosterone in the womb—appear to trigger boys’ fidgetiness. And yet the sex difference in physical activity continues to widen during childhood, despite the fact that sex hormone levels do not differ between boys and girls from six months of age to puberty. Parenting is likely one factor amplifying the disparity. Mothers discourage physical risk taking more in daughters than in sons, suggest studies in the laboratory and on playgrounds. (Fathers encourage more risk taking in children than mothers do—see “Family Guy,” on page 46—but no one has studied whether dads pressure sons more than daughters in this respect.) Peers also push conformi-
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Boy Meet Barbie

Yes, boys like trucks and girls like dolls. Given a choice of Power Rangers, Tonka, Bratz and a Barbie beauty set, preschool-age boys and girls strongly prefer the gender-obvious picks. In fact, children’s gendered toy choice is one of the largest sex differences in behavior, second only to sexual preference itself! But this preference is not nearly so clear in infancy, when boys, in many studies, have been found to like dolls as much as girls do. (All babies are strongly attracted to faces, for obvious survival reasons.) Rather, toy preference emerges toward the end of infancy, grows stronger through the preschool years and then declines somewhat because of a complex interaction of nature and nurture.

Toddlers’ toy preference is shaped, in part, by prenatal testosterone: girls with a genetic disorder that exposes them to high levels of testosterone and other androgens before birth are much more interested in toy trucks and cars than typical girls are. Even male and female monkeys prefer gender-stereotyped toys, telling us there is something about vehicles, balls and moving parts that resonates with boys’ hormonal priming, drawing them away from their initial face preference and toward toys they can interact with more physically.

Starting from this innate bias, children’s toy preferences grow more extreme through social shaping. Parents reinforce play that is considered gender-appropriate, especially in boys, and beginning at age three, peers perpetuate gender norms even more than adults do. In one example of peer influence, psychologists Karin Frey of the University of Washington and Diane Ruble of New York University reported in 1992 that elementary school-age boys and girls both opted for a less desirable toy (a kaleidoscope) over a slick Fisher-Price movie viewer after watching a commercial of a same-sex child choosing the kaleidoscope and an opposite-sex child choosing the movie viewer. And yet around age five, girls begin choosing “boy” toys and “girl” toys equally. Boys, however, rarely do this crossover—a divergence that reflects different societal

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Competition can be highly motivating, especially for boys, and girls need to develop greater comfort with open competition, which remains an inescapable reality of our free-market culture.

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Sticks and Stones

Boys are more physically aggressive than girls, according to many studies, including a 2004 analysis by psychologist John Archer of the University of Central Lancashire in England. That difference is linked to prenatal testosterone but not, surprisingly, to the resurgence in boys’ testosterone level in adolescence, because boys do not suddenly become more aggressive when they go through puberty, as Archer’s work also indicates. Nor is this sex difference absolute. Two- and three-year-old girls, for instance, frequently kick, bite and hit other people—not quite as much as toddler boys but about three times more than either sex does later in childhood. In addition, girls fight with indirect, or relational, aggression. Through gossip, ostracism, whispers and, most recently, harassing text messages, girls leave more scars on competitors’ psyches than on their bodies. [For more on gender and aggression, see the Facts and Fictions in Mental Health column on page 64.]

Thus, both sexes compete and both sexes fight; what differs is the degree to which such behavior is overt or hidden. Because physical aggression is a much greater taboo for girls than boys, they learn,
even early in elementary school, to keep it below the surface, in the eye rolling and best-friend wars that teachers rarely notice and are harder to police.

But by admitting that competitive feelings are natural for all children, we can find ways to channel them into healthier pursuits. In recent years educators have tended to take competition out of the classroom, reasoning that the opposite style of interaction—cooperation—is more important in a civil society. But competition can be highly motivating, especially for boys, and girls need to develop greater comfort with open competition, which remains an inescapable reality of our free-market culture. One solution is team competitions, where groups of students work together to try to beat others at solving math, vocabulary, history and science problems.

I Know How You Feel

Aggression and empathy are inversely related. It is hard to attack someone if you are acutely aware of what he or she is feeling. So whereas men and boys score higher on measures of physical and verbal aggression, girls and women score higher on most measures of empathy, or the awareness and sharing of other people’s emotions, conclude psychologist Nancy Eisenberg of Arizona State University and her colleagues in studies dating back to the 1980s.

And yet the sex difference in empathy is smaller than most people realize and also strongly dependent on how it is measured. When men and women are asked to self-report their empathetic tendencies, women are much likelier than men to endorse statements such as “I am good at knowing how others will feel” or “I enjoy caring for other people.” When tested using more objective measures, however, such as recognizing the emotions in a series of photographed faces, the difference between men and women is much smaller, about four tenths of a standard deviation, meaning the average woman is more accurate than just 66 percent of men.

In children, the difference is tinier still, less than half that found in adults, reported psychologist Erin McClure of Emory University in 2000 after analyzing more than 100 studies of sex differences in facial emotion processing in infants, children and adolescents. So although girls do start out a bit more sensitive to other people’s faces and emotions, their advantage grows larger with age, no doubt because of their stronger communication skills, more practice at role playing with dolls and more intimate friendships as compared with boys.

Little is known about the neural basis for the sex difference in empathy, although a grape-size region on each side of the brain called the amygdala is likely to be involved. The amygdala is highly activated by faces. According to a 2002 analysis of several studies, the amygdala is larger in men than in women, a fact that seemingly belies men’s lesser ability to recognize facial emotions. Other studies reveal an imbalance in the activation of the right and left amygdala in men and women, however. When they are recalling highly charged emotional scenes—the kind that trigger empathetic responses—women’s left amygdala is more strongly activated than their right amygdala, whereas the right amygdala is more strongly activated than the left in men, as indicated by both a study in 2004 led by neurobiologist Larry Cahill of the University of California, Irvine, and a report in 2002 by psychologist Turhan Canli, then at Stanford University, and his colleagues.

It is not yet known if this left-right difference in amygdala activation is related to empathy per se or if the same neural sex difference is present in children. Indeed, when it comes to emotionality, boys and girls differ much less in early life; if anything, baby boys are known to cry and fuss more than baby girls. As boys grow, they—much more than girls—are taught to hide their expressions of fear, sadness and tenderness. Scientists agree that social learning largely shapes the male-female gap in emotional responding. Boys are toughened up in a way girls rarely are, making them less expressive but also less attuned to others’ feelings. This training almost certainly leaves its imprint on the amygdala, one of the
more plastic structures in the brain. Teaching girls to be more resilient and boys to be more sensitive is possible and beneficial for both genders.

**Girl Talk**

Let us dispense with the urban legend that “women speak three times more words every day than men.” The real numbers: 16,215 for women and 15,669 for men, according to a 2007 study of nearly 400 college students fitted with digital recorders, led by psychologist Matthias Mehl of the University of Arizona. Females do outscore males on most measures of speaking, reading, writing and spelling from early childhood and throughout life, but the gaps are generally small and change with age.

Girls read more than boys, and the extra practice results in better scores on language proficiency tests. But schools with strong reading programs show that boys who read a lot are as verbally adept as their female classmates.

**Gender counts for at most 3 percent of the variance in toddlers’ verbal ability. By comparison, about 50 percent is determined by a child’s environment and language exposure.**

Language differences emerge early in development. As infants, girls begin talking about one month earlier than boys and are some 12 percent ahead of boys in reading skills when kindergarten begins. Girls’ advantage in reading and writing continues to grow through school, until by 12th grade, an alarming 47 percent more girls than boys graduate as proficient readers, with an even larger gap for writing, a conclusion drawn from several decades of data collected by the U.S. Department of Education.

These gaps appear to shrink in adulthood, however. The average woman scores higher than just 54 percent of men on a combined measure of all verbal skills, indicates a 1988 analysis by psychologist Janet Hyde and her colleagues at the University of Wisconsin–Madison. That the difference is so tiny may explain why the neural bases for language or literacy differences have yet to be uncovered. In 2008 neuroscientist Iris Sommer and her colleagues at University Medical Center Utrecht in the Netherlands dispelled one popular theory—that women use both sides of the brain to process language, whereas men use mainly the left. In their analysis of 20 functional MRI studies, the researchers detected no difference in the degree of language lateralization between men and women.

Similarly, there is scant proof that girls and women are better neurologically wired for reading. If anything correlates with reading skill, it is quite simply the amount of reading children do for pleasure outside school. Girls read more than boys, and this additional exposure makes a difference in their academic performance.

Beginning at birth, a child’s language exposure is the single most important determinant of his or her later verbal abilities. Large studies in several different countries demonstrate that gender accounts for at most 3 percent of the variance in toddlers’ verbal ability, compared with at least 50 percent determined by a child’s environment and language exposure. Thus, the more parents can immerse their sons in conversation, books, songs and stories, the better are boys’ chances of getting off to the right start in language and literacy skills.

**ABC and rhyming books are great for teaching phonemic awareness—the link between sounds and letters that is the first hurdle in learning to read. As compared with girls, boys often select different genres—especially nonfiction, comedy and action stories—so getting boys to read may be largely a matter of finding books and magazines that appeal to them. Schools with strong reading programs have managed to eliminate the difference between boys’ and girls’ scores, proving that this worrisome gap is more a matter of education and practice than inborn literacy potential.**

**Thinking in 3-D**

If girls have the advantage in verbal skills, boys have it in the spatial domain—the ability to visualize and manipulate objects and trajectories in time.
and three-dimensional space. Sex differences in spatial skills are among the largest of the cognitive gaps. The average man can perform mental rotation—that is, he can imagine how a complex object would look when turned around—better than up to 80 percent of women.

In 2008 two research groups reported a sex difference in mental rotation in babies as young as three months of age, and other evidence suggests that this skill is influenced by prenatal testosterone. Yet the actual size of the skill gap is much smaller in children than in adults: among four-year-olds, the average boy outperforms just 60 percent of girls. So it seems likely that the skill improves in boys thanks to the wide range of visuospatial interests—targeting, building, throwing and navigating through innumerable driving and shooting games—that they pursue far more than girls. In support of this idea, neurobiologist Karin Kucian and her colleagues at University Children’s Hospital in Zurich reported in a 2007 study that boys’ and girls’ brains display similar MRI patterns of neural activity while performing a mental rotation task that, as a 2005 study by the same researchers revealed, evokes different responses in the brains of adult men and women. So it appears that boys’ and girls’ brains diverge in spatial processing as they grow and practice different skills.

Spatial skills are important for success in several areas of science and higher math, including calculus, trigonometry, physics and engineering. Research by educational psychologist Beth Casey of Boston College shows that the spatial skill gap between boys and girls largely accounts for the consistent male advantage on the math SAT exam, an obvious hurdle for admission to engineering and other technical degree programs.

As important as they are, spatial skills are not something we deliberately teach in school. But many studies have shown they can improve with training, including playing video games! If boys naturally get more such practice in their extracurricular pursuits, girls may benefit from greater exposure to three-dimensional puzzles, fast-paced driving and targeting games, and sports such as baseball, softball and tennis.

Gender, Culture and the Brain

Boys and girls are different, but most psychological sex differences are not especially large. For example, gaps in verbal skills, math performance, empathy and even most types of aggression are generally much smaller than the disparity in adult height, in which the average five-foot, 10-inch man is taller than 99 percent of women. When it comes to mental abilities, males and females overlap much more than they stand apart.

Furthermore, few of these sex differences are as fixed, or hardwired, as popular accounts have lately portrayed. Genes and hormones light the spark for most boy-girl differences, but the flame is strongly fanned by the essentially separate cultures in which boys and girls grow up. Appreciating how sex differences emerge can reduce dangerous stereotyping and give parents and teachers ideas for cross-training boys’ and girls’ minds, to minimize their more troubling discrepancies and enable all children to more fully develop their diverse talents. M