

Simon Baron-Cohen argues that the female brain is predominantly hard-wired for empathy, the male brain for understanding and building systems.

Making sense of sex differences

IN 1987, Vancouver psychologist Doreen Kimura asked the question, "Are men's and women's brains really different?" She continued, "It would be amazing if men's and women's brains were not different, given the gross morphological and often striking behavioural differences between women and men."¹ Kimura is a good example of traditional researchers in this area who have emphasised two different dimensions in defining the male and female brain: language (female superiority) and spatial ability (male superiority). I do not deny the importance of language and spatial ability in defining sex differences but I do believe that two neglected dimensions are empathising and systemising.

Moreover, language superiority in women may exist because of their stronger empathising ability, and good spatial ability in men may be just one instance of their stronger systemising.

What does empathising mean?

Most of us have some awareness of our empathising skills but we may not know when we have reached our limits. In this sense, empathising is not like athletic ability, where you get direct feedback during your performance about whether you are any good at it or not. You try for that high jump and, if you miss, you hit the bar with some force, and see and feel the bar as it falls from its supports. During a conversation you may aim to understand and share the thoughts and feelings of another person, and you may walk away from it believing that you were truly empathic, that you sailed over the bar with plenty of room to spare; however, the person you were just interacting with might never tell you how limited your empathy was, that you hit the bar with such an impact that they could hear the clang for a long time afterwards, but that they were too hurt, or too diplomatic, to tell you.

Empathising is about spontaneously and naturally tuning into the other person's thoughts and feelings, whatever these might be. It is not just about reacting to a small number of emotions in others, such as their pain or sadness; it is about reading the emotional atmosphere between people. It is about effortlessly putting yourself into another's shoes. A good empathiser responds intuitively to a change in another person's mood with concern, appreciation, understanding, comforting or whatever the appropriate emotion might be.

Empathising leads you to pick up the phone and tell someone you are thinking about them and their current situation, even when your own life demands

are equally pressing. Empathising leads you to constantly search people's tone of voice and to scan people's faces, especially their eyes, to pick up how they might be feeling or what they might be thinking. Empathising drives you to do this because you start from the position that your view of the world may not be the only one, or the true one, and that their views and feelings matter.

Even at a very early age, children demonstrate gender differences in their abilities to empathise.

Female babies like faces

Two enterprising students of mine, Jennifer Connellan and Anna Batki, videotaped over 100 babies who were just one day old, in the Rosie Maternity Hospital in Cambridge. Little did these babies know what lay in store for them. No sooner had they emerged from the womb than they were recruited into this scientific study. The babies were shown Jennifer's tanned Californian face, smiling over their crib. Her face moved in the natural way that faces do. They were also shown a mobile. It was made from a ball the same size as Jennifer's head, with the same colouring (tanned) but with her features rearranged, so that the overall impression was no longer face-like. Around the lab we called it 'The Alien'. To make it look more mechanical, we hung some material from it that moved every time the larger mobile moved. In this way we could compare the baby's interest in a social object (a face) and a mechanical object (a mobile). Finally, in order for the experimenters to remain unbiased, mothers were asked not to tell the researchers the sex of her baby. This information was only checked after the videotapes had been coded for how long each baby looked at each type of object. When we analysed the videotapes, we found that girls looked for longer at the face and that boys looked for longer at the mobile. And this sex difference in social interest was on the first day of life.²

This difference at birth echoes a pattern we have seen right across the human lifespan. For example, on average, women engage in more consistent social smiling and maintained eye contact than does the average man. The fact that this difference is present at birth strongly suggests that biology plays a role.

Empathising abilities in boys and girls

When a group of children is given a toy movie player to play with, boys tend to get more than their fair share of looking down its eyepiece. They will just



shoulder the girls out of the way: they have less empathy and are more self centred.³ If you put girls together with the same toy, the girl who ends up with more than her fair share gets there not by using such obvious physical tactics, but rather by verbal skills. She will bargain and persuade, rather than push. This example demonstrates that, on average, young girls show more concern for fairness than boys do, and that even when a young girl's self interest drives her, she will use mind-reading to manipulate the other person into giving her what she wants.

A small number of boys end up in the clinics of child psychiatrists where they are diagnosed with 'conduct disorder'. Such children tend to get into a lot of fights. They tend to perceive others as treating them in a hostile or aggressive way, even when to the reasonable observer there was no definite sign of hostility intended. This is an example of inaccurate empathising: the child misjudges another person's intentions and emotions. Such misattribution of hostile intent is more common in boys.

A number of studies suggest that, by the age of three, young girls are already ahead of boys in their ability to infer what people might be thinking or intending – that is, in using a 'theory of mind'. For instance, when asked to judge when someone might have said something that was inappropriate, girls from the age of seven score more highly than boys.⁴

Pretend play

When children engage in pretence during play, this is an even more specific window into empathising. For example, in social pretence, one must imagine what the other person is imagining. This is a big leap. When a child watches mummy soothing a doll, the child has to keep track that this is all just in mummy's mind and that mummy is imagining the doll's mind. In reality, dolls do not need soothing. This is a double level of empathising: girls seem to be more prone to this than are boys.

The content of children's play is also relevant here. Girls' pretence tends to involve more cooperative role taking. They say things like, "I'll be the mummy; you be the child" and they show more reciprocity ("Now it's your turn"). Girls tend to ensure that the other person understands where the imaginative pursuit is leading. All very empathic.

In contrast, boys show more solitary pretence. Even if it is social, their pretence often involves a lone superhero (for example, Batman, Robin Hood, Action Man or Harry Potter) engaging in combat. Mortal combat. The aim of the pretence is to eliminate the other person, the deadly enemy, not to worry about his feelings. This is certainly evidence of an ability to pretend, but the focus is on the imagined self's strength and power, rather than being empathic. This male preoccupation with power and strength suggests that males are less concerned with a sharing of minds and more interested in social rank [see below]. You see the same

thing when children tell make-believe stories. In their narratives, boys focus more on lone characters in conflict. In contrast, girls' stories focus more on social and family relationships.⁵

Sex differences in communication

Listening to people chat is another rich source of empathy skills. There is a lot of evidence for sex differences in communication, across a large number of settings and age ranges. Boys in early childhood are more likely to do what psychologist Eleanor Maccoby calls 'grandstanding' – in other words, giving a running commentary on their own actions, whilst ignoring what the other person is doing. It has been suggested that boys' talk tends to be 'single-voiced discourse'. By this it is meant that the speaker presents their own perspective alone. When two boys do this, conflict is likely to escalate. In contrast, it is suggested that female speech style tends to be 'double-voiced discourse'. The idea is that, whilst little girls still pursue their own objectives, each also spends more time negotiating with the other person, trying to take the other person's wishes into account. These differences in conversational style are seen even more dramatically in middle childhood and in the teenage years.

Boys are also more egocentric in their speech, by which I mean that they are more likely to brag, dare each other, taunt, threaten, override the other person's attempt to speak and ignore the other person's suggestion. They are also less willing to give up the floor to the other speaker. Males more often use language to assert their social dominance, to display their social status, especially when there are other males around.

Women and relationships

Women are more sensitive to facial expressions. They are better at decoding non-verbal communication, picking up subtle nuances in tone or voice or facial expression, and using them to judge a person's character. On the most well-known test of sensitivity to non-verbal cues of emotion, women are more accurate in identifying the emotion of an actor. This sex difference holds up in countries as varied as New Guinea, Israel, Australia and North America. Women tend to value the development of altruistic, reciprocal relationships. Such relationships require good empathising skills. In contrast, men tend to value power, politics and competition. This pattern is found across widely different cultures and historical periods, and is even found among chimpanzees.

If you ask people about their sexual fantasies, these too reveal how the two sexes think differently about relationships. Women tend to think about the personal and emotional qualities of their fantasy partner, which suggests that they are unable to turn off their empathising abilities even when they are thinking about sex. In contrast, men tend to focus on the physical characteristics of their partner.



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Mums and dads

Parenting style is another good place to test if women are more empathic than men. Here again, sex differences are found. Fathers are less likely than mothers to hold their infant in a face-to-face position. One consequence of this is that there is less exchange of emotional information via the face between fathers and infants. Mothers are more likely to follow through the child's choice of topic in play, whilst fathers are more likely to impose their own topic. Moreover, mothers fine-tune their speech more often to match what the child can understand. For example, a mother's mean length of utterance tends to correlate with her child's comprehension level, whilst fathers tend to use unfamiliar or difficult words more often. Finally, when a father and child are talking, they take turns less often. These examples from parenting again suggest that women are better at empathising than men.

An experimental demonstration of this is seen in a study by Eleanor Maccoby and her colleagues. They used a communication task in which a parent and his or her six-year-old child were given four ambiguous pictures. The parent described one of the pictures and the child was asked to pick out which one was being described. Mother-child pairs were more successful than father-child pairs at identifying the intended picture, presumably because of women's greater communicative clarity.⁶

The significance of social status

Murder is the ultimate in lack of empathy. Regarding sex differences, Daly and Wilson wrote, "There is no known human society in which the level of lethal violence among women even approaches that among men".⁷ They analysed homicide records dating back over 700 years, from a range of different societies. They found that male-on-male homicide was 30 to 40 times more frequent than female-on-female homicide. Studies show that, in a range of different societies, two-thirds of male homicides do not occur during a crime but simply when there is a social conflict, in which the man feels he has been 'disrespected' (disrespected). Such homicides are carried out to save face and retain status.⁸

The male preoccupation with social status may be a useful marker of a higher systemising drive in males. After all, social hierarchies are systems. In groups, boys are quick to establish a 'dominance hierarchy'. Typically, a hierarchy is established by one person pushing others around, uncaringly, in order to become the leader. It is not dissimilar to the way our male non-human primate relatives behave. For example, in a troop of monkeys or apes, males rapidly recognise their place in the system.

Even among young children in nursery schools, there are more boys at the top of these dominance hierarchies. They are pushier and they back down less often. In addition, the hierarchies are better established among the boys. The boys spend more time monitoring and maintaining the hierarchy –

it seems to matter to them more. Even in pre-school, little boys feel it is important not to appear weak, so as not to lose rank. They care about their own feelings and image more than someone's else's, even if this means leaving the other person hurt. Young girls also establish social rank, but more often this is based on other qualities than simply acting tough.

What is systemising?

Systemising is the drive to understand a system and to build one. By a system I do not just mean a machine (like a tool or a musical instrument or the insides of your watch). Nor do I even just mean things that you can build (like a house, a town or a legal code). I mean by a system anything that is governed by rules specifying input-operation-output relationships. This definition takes in systems beyond machines, such as maths, physics, chemistry, astronomy, logic, music, military strategy, the climate, sailing, horticulture and computer programming. It also includes systems like libraries, economics, companies, taxonomies, board games or sports. The system might be tiny (like an individual cell) or larger (like a whole animal) or larger still (like a social group or a political system).

Systemising involves first the analysis of the features in a system that can vary, followed by close, detailed observation of the effects that occur when each feature is varied ('systematically'). Repeating such observations leads one to discover the input-operation-output rules governing the behaviour of the system.

Here's a simple example: "If I push the red button, the projector advances to the next slide". Here, the red button is the input, pushing is the operation and the next slide popping up is the output.

Systemising needs an exact eye for detail, since it makes a world of difference if you confuse one input or operation for another. The pay-off of good systemising is not only being able to understand the system but also being able to predict what it will do next. The key thing about systemising is that the system your brain is trying to understand is finite, deterministic and lawful. Once you have identified the rules and regularities of the system, then you can predict its workings absolutely.

You might feel that I am using such a broad notion of 'system' that it includes almost everything. This is a reasonable worry. In fact, systemising (and empathising) are *processes in the mind*, and as such they can indeed be applied to almost any aspect of the environment. In practice, empathising is most easily applied to agents (ie entities that are capable of self propulsion, even virtual ones), while systemising is most easily applied to lawful aspects of the environment. We can draft a classification of the six major kinds of system that exist, which the brain can analyse and/or build [see panel].

Systemising is different from classical or operant conditioning, in that the motivation is not external but intrinsic – to understand the system itself. The

buzz is not derived from some tangible reward (such as a food pellet when you press a lever or a salary when you do a job). Rather, the buzz is in discovering the causes of things, because discovering causes gives you control over the world.

How boys and girls fare with systems

In a classic test, one leaves a choice of toys out on the carpet and waits to see which one a child picks. By two years of age, little boys are far more likely to select toy vehicles and building bricks to play with, leaving the dolls to one side. Girls of this age tend to choose the dolls. Boys seem to love putting things together. Often, when they have sat and admired their wonderful construction, they will simply take it apart again. As the children grow older, one can see the same pattern: boys spend more time engaged in mechanical play and construction play than do girls. This interest in the mechanical and constructional is not simply a sign that boys are more object oriented, since girls play with some objects (like clay and marker pens) more often than boys. Rather it seems that boys are more interested in mechanical and constructional systems.

Interestingly, you see the same sort of pattern in the adult workplace, too. Some occupations are almost entirely male. Take, for example, the fields of metalworking, weapon making or crafting musical instruments. This sex difference does not reflect the greater physical strength in males since, in many of these occupations (for instance, making a violin or knife), strength is not the key factor. The focus of these occupations is on constructing systems.⁸

In one fascinating test, men and women were shown a series of human figures and mechanical objects, using a stereoscope. This equipment allows the human-figure picture and the mechanical-object picture to fall on the same part of the observer's visual field. The two stimuli compete for the observer's attention. Guess the results? Male observers reported seeing more mechanical objects than people, compared to the females. Female observers reported seeing more people than mechanical object, compared to the males.⁹

Physics and engineering are, of course, the adult equivalent of children's play with mechanical and constructional toys. Indeed, all the sciences utilise systemising as their basis, and all are dominated by men. According to a headline in the *Times Higher*, only three of the 170 living Nobel Prize-winners in science are women.¹⁰ In the 1970s, the sex ratio of those working in the fields of maths, physics and engineering was about 9:1 (male:female) and this remains the case today. Whilst not denying the existence of possible social factors that are creating inequalities between male and female scientists at the higher levels, I think we need to remain open to the possibility that, on average, men are more often drawn to pursue these interests.

Let's have a closer look at maths. Boys at school tend to receive lower grades in mathematics than

The six major kinds of systems

Technical systems may be complex, such as computers, vehicles, tools and other machines. They also include the complex systems of the kind that academics would study in branches of physics, electronic and mechanical engineering, computer science and material science. But a technical system can be as basic as a roof, a sail, a plane wing or a compass. For instance, a surfer may discover that by using a surfboard (input) three inches wider (operation), the board becomes stable (output).

Natural systems include the complex systems in nature of the kind that academics study in ecology, geography, medicine or meteorology, for instance. And again, these systems can include quite ordinary things like soil, rivers, rocks, an insect or a leaf. For instance, a gardener might discover that, if he grows a hydrangea (the input) in alkaline soil (operation), the flower colour changes from pink (output 1) to blue (output 2).

Abstract systems include complex examples such as maths, logic, grammar, music, computer programs, taxation, mortgages, stocks and shares or maps. A programmer might notice that an extra bracket (operation) in a computer program (input) changes what was otherwise an endless loop (output 1) to quit (output 2). Some abstract systems are really quite ordinary, such as the rules for reading text, or a train timetable.

Social systems are the rules describing groups of people. Complex systems include those studied by academics in politics, business, law, theology, the military, economics, history and social science. Simpler social systems include a committee, a political group, a group of friends, a pop-music chart or a list of players in the sports team. For instance, a football manager might notice that when he plays his team (input) with three particular players in offensive positions (operation), the average number of goals scored is increased (output).

Organisable systems include encyclopaedias, museums, second-hand record shops or sets of stamps in an album. A music enthusiast might decide her CD collection (input) should be reorganised chronologically (operation), producing a new sequence on her shelf (output).

Motoric systems may be complex, such as the finger movements required to play a Beethoven sonata on the piano, or simpler, such as the ability to throw a dart at a bull's-eye. A tennis player might realise that if he changes the topspin (operation) the ball (input) bounces right (output).

do girls. On the face of it, this looks like counter-evidence for the male brain being a better systemiser. However, although they score lower on *accuracy* in maths, boys tend to score higher on tests of mathematical *ability*. Despite their work being less neat, and more erratic, boys tend to see mathematical solutions more easily.

Girls do not score worse than boys in all aspects of maths ability, though. Across the school years, girls score better in tests of mathematical sentences, and in tests of mathematical reasoning, such as calculations. Some people have wondered if this is because these are maths tasks on which it is easier to use verbal strategies. When you look at the maths tasks where verbal strategies are arguably less useful (for example geometry, probability and statistics), girls score lower than boys.

Reading the route

Reading maps is another everyday test of systemising – you have to operate on 3-D input in order to predict how it will appear in 2-D. In one study children were asked to describe if they would be turning left or right at a particular intersection on a city map, to reach a particular destination. To make it a touch harder, they were not allowed to rotate the map. Boys performed at a higher level than girls. If you ask people to put together a 3-D mechanical apparatus in an assembly task, on average men score higher than women. And in relation to construction tests, boys are also better at constructing block buildings from 2-D blueprints.

Men can also learn a route in fewer trials, just from looking at a map, correctly recalling more details about direction and distance. If you ask boys to make a map of an area they have only visited once, their maps are more accurately laid out in terms of the features of the environment – for instance, showing which landmark

is south-east of another. The boys tend to emphasise directions, routes or roads, whereas the girls tend to emphasise specific landmarks (the corner shop, for example).

You might wonder if this reflects a less accurate visual memory in women, rather than a less accurate understanding of the system. In fact, women do better on one aspect of visuospatial memory, namely the ability to remember the relative location of objects. There is clearly nothing wrong with their memory of important components. Rather, their spontaneous recall of the systematic properties of maps (for example, geometric or network aspects) is not as good as men's.¹¹

What about organisable systems? In one unusual study, people were asked to classify over 100

examples of local specimens into related species. The people who took part in this experiment were the Aguaruna, a tribal people living in the forest in northern Peru. The following results were found: men's classification systems had more sub-categories and more consistency. More strikingly, the criteria that the Aguaruna men used to decide which animals belonged together more closely resembled the taxonomic criteria used by Western (mostly male) biologists.¹² Another culture that has been studied is that of the Itza-Maya, in Guatemala. Here, as in the Peruvian example, men used a more complex set of criteria to classify local animals. Women were more likely to use 'static' morphological features (such as the colour or the shape of the animal's body); men were more likely to use a cluster of related features (such as the animal's habitat, diet and even their relationship to humans).¹³

Before we move on [from systemising], it is worth perhaps just thinking about how early we see sex differences in this domain. Recall that, in Cambridge, we found that one-day-old boys looked longer at a mechanical mobile (a system with predictable laws of motion) than at a person's face (an object that is next to impossible to systemise. [We have also shown that], at one year old, boys showed a stronger preference to watch a video of cars (predictable mechanical systems) than to watch a film showing a talking head (with the sound switched off). One-year-old girls showed the opposite preference.¹⁴

Culture versus biology

Most people are likely to assume that such sex differences are due to a mix of cultural and biological factors. There is some support for cultural determinism. A clear example can be found in the different ways that parents speak to their sons and their daughters, something that could contribute to the differences we observe in the development of empathy. But some of the sex differences are present so early (at birth) that it is hard to see how culture could be the *sole* cause. In addition, some parents try to do everything to avoid such cultural influences on their child. They buy their sons dolls, and their daughters toy trucks, only to find that the child still chooses to play with sex-typical toys. For these and other reasons, it seems possible that the development of sex differences in behaviour are due to factors other than, and additional to, the cultural ones. Biological factors are the only other candidates.

Are there sex differences in other species which mirror what we see in humans? The key danger here is, of course, anthropocentrism – the age-old tendency to assume that other animals have attributes just like ours. This is an important risk to keep in mind, since it is hotly contested whether other animals (apart from human) are capable of empathising or systemising at all. But other animals do have simpler forms of sociability and spatial ability than humans, which may be relevant.



Let's start with the great apes, baboons and rhesus monkeys. Males in all these species show more 'play-fighting' than the females – what would be called 'rough and tumble play' in human children. Another apparent similarity across humans, monkeys and apes is the greater interest that females on average show in babies (of their own species).

However, if an infant monkey is holding tight to its mother's fur on her belly whilst she walks through the deeper waters, the mother will not check if her baby's face is out of the water. The result is that her offspring is at major risk of drowning. This strongly suggests that female monkeys as mothers cannot take into account the perspective and needs of another animal (in this case, her baby). Among the great apes, such as the chimpanzee, this never occurs. Primatologist Frans De Waal suggests that this is because the great apes have rudimentary empathy. Examples of empathy in apes include 'targeted help' (where one animal will provide just the right sort of help that the other needs) and 'consolation' (for example, caressing an animal that has suffered loss).

What about animal studies of systemising? Studies of simpler behaviours in the rat, such as spatial ability, may teach us something about the animal equivalent of systemising. Male rats generally find their way through mazes more quickly and with fewer errors. Mazes are traditional tests of spatial ability, but of course a maze is also a system.

Sex in the mind

An obvious biological factor that might be causing sex differences in the mind is the hormone (or endocrine) system. Norman Geschwind, a neurologist, formulated a brilliantly simple idea. He speculated that fetal testosterone affects the growth rate of the two hemispheres of the brain. The more testosterone you have, the faster your right hemisphere develops and, correspondingly, the slower your left hemisphere develops. Svetlana Lutchmaya, my talented PhD student, and Peter Raggatt, a biochemist at Addenbrooke's Hospital in Cambridge, decided to test the prenatal testosterone theory directly. We studied babies whose mothers had undergone amniocentesis during the first trimester of pregnancy. Addenbrooke's Hospital stores the amniotic fluid from each pregnancy in a deep freezer until each baby is born. It is therefore possible to analyse the amniotic fluid for levels of prenatal testosterone. The testosterone that one finds in that fluid is fetal in origin.

We took advantage of this situation by getting in touch with the mothers whose amniotic fluid was in the deep freezer, and asking them to bring their healthy, bouncing toddlers into our lab. We found that the toddlers (at 12 and 24 months of age) who we had identified as having lower fetal testosterone now had higher levels of eye contact and a larger vocabulary; or, putting it the other way around,

the higher your levels of prenatal testosterone, the less eye contact you now make and the smaller your vocabulary. This is exactly as Geschwind had predicted.

We decided to embark on a follow-up study of the children whose mothers had undergone amniocentesis. By the time they were four years old, I had a new PhD student, Rebecca Knickmeyer, a naturally gifted scientist. We gave these four-year-old children the Childhood Communication Checklist (CCC). This measures your social skill and how narrow your interests are. (The latter is an index of your systemising ability, since systemising typically involves a deep interest in one topic.) We found that those children who had had the higher prenatal testosterone now had lower social skills, and were more restricted in their interests, compared with those who had had lower prenatal testosterone.¹⁵

So lower levels of fetal testosterone (seen more commonly in females) lead to better levels of language, communication skills, eye contact and social skills – all signs of better empathising. And if restricted interests are an indicator of in-depth systemising, these results clearly show that good systemising abilities are linked to higher levels of fetal testosterone. But there are other clues that indicate that fetal testosterone is linked to systemising.

For example, if you castrate a male rat at birth, his testosterone stops flowing from his testes to his brain. Such rats end up without the typical male thickness difference between the left and right cortex. Male fetuses (human or rat) have a larger right hemisphere volume. If prenatal testosterone is responsible for accelerating the growth of the right side of the body, and the right hemisphere in particular, then castration should lead to less well developed spatial systemising, given that the right hemisphere is more strongly implicated in this ability. This is indeed the case.¹⁶ If a female rat is injected at birth with testosterone, she shows faster maze learning and makes fewer errors compared with a female rat who has not been given such an injection: masculinising the rat hormonally improves her spatial systemising. Amazingly, the testosterone-injected female rats perform as well as normal male rats (whose testes have been secreting testosterone all along). The normal male rats and the hormonally treated female rats use a directional strategy to find their way through the mazes. This strongly suggests good systemising ability. The normal females and the castrated males depend heavily on landmarks as cues.

Testosterone and the two hemispheres

Incidentally, the relationship between prenatal testosterone and systemising is not endlessly linear. There may be an optimal level of prenatal testosterone for the development of systemising – somewhere in the low-normal male range. Even if

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you look at current levels of testosterone, as it circulates in the blood or saliva of adult volunteers, men with low-normal levels of testosterone do best on systemising tests involving mathematics and spatial ability.

The right hemisphere is involved in spatial ability which, as we have seen, is assisted by the ability to systemise. The left hemisphere is involved in language and communication which, as we have seen, is assisted by the ability to empathise. If the right hemisphere in the male brain develops faster than it does in the female brain, this could explain why men's ability to systemise develops faster too. Equally, if the left hemisphere develops faster in the female brain than it does in the male brain, this could explain why women's language and empathising skills might develop faster too.

Geschwind also theorised that fetal androgens enhance the development of the right side of the body more generally (in other words, not just the right hemisphere of the brain). Thus in men, some (but not all) studies find that the right foot is larger than the left, and the right testis is larger than the left one. In women, the left foot tends to be larger than the right, the left ovary larger than the right one, and women on average report having a larger left breast. Of course, these are statistical averages.

Left-greaters versus right-greaters

Doreen Kimura had the imaginative idea of separating her subjects into two groups, according to whether they [reported having a] larger testis or breast on the left or right side. In this way, she was able to compare the 'left-greater' individuals to the 'right-greater' individuals (irrespective of whether they were male or female). When she gave them language tests (purportedly performed better by the female brain), the group with the left-larger testis or breast performed better than the group with the right-larger testis or breast. These results help explain why a woman might show a more male brain type, or why a man might show a more female brain type. The explanation is in terms of the person's early fetal androgen levels, and their consequent neural asymmetric development. The 'right-greater' individuals are assumed to have had higher levels of fetal androgens.

Even scientists feel uncomfortable about asking their volunteers to strip off to measure the size of their breasts or testes. So Doreen Kimura measured a less intrusive marker of fetal asymmetry, namely the fingerprint. The traditional system for classifying fingerprints involves counting the number of ridges on the fingertips of the left and right hands. Using counts from the thumb and little finger on each hand, Kimura confirmed the finding that most people have more ridges on the right hand. She calls this the 'right-greater' pattern. But she also confirmed that more females have the minority 'left-greater' pattern. This fits with the earlier broad finding that women are more likely to have en-

hanced left-sided growth.¹⁷

Since our fingerprints are laid down during the first four months of fetal life, and do not change for the rest of our life (barring major injury), they serve as a sort of fossil record of which half of our body developed earlier, whilst we were in the womb. They are thought to be a marker of levels of fetal testosterone, which drive asymmetric body development. Just as with the measures of testis or breast size, those individuals (irrespective of their sex) who showed the 'left-larger' pattern did better on the tests that women usually do better on.

Language ability is likely to be related to empathising (since both are involved in communication). Certain aspects of language are more closely linked to empathising – especially those aspects relating to 'pragmatics', interpreting a speaker's intention and meaning. Other aspects of language involve systemising – especially syntax (grammar) and lexicon (vocabulary). It will therefore be important to repeat Kimura's interesting observations with tests that measure empathising more directly, and with tests that distinguish between the empathising and systemising aspects of language. Certainly, there is evidence that, when it comes to matching faces in terms of emotional expression, boys show more right-hemisphere activity, whilst girls show more left-hemisphere activity.¹⁸

Men's brains are larger and heavier than women's brains. When the ratio of brain to body size is taken into account by comparing men and women of the same height, men's brains are still heavier. Post-mortem examination shows that men's brains contain about four billion more neurons in the cortex than women's. So men's heavier brains may be due to having more brain cells. Having more brain cells may lead to greater attention to detail, which in itself could lead to better systemising. However, the cost of such increased attention to detail could be a slower grasp of the overall picture.

And then there are genes

We have considered sex differences in the brain but the other big source of variation between the sexes is the genes. With the human genome mapped, and the determination of the function of genes now a major industry, we can be confident that genes controlling empathising and systemising will be identified. Such genes will not rule out the role of culture and environment. Genetically and/or hormonally based neural systems underlying empathising and systemising still require the right environmental input (sensitive parenting, for example, in the case of empathising) in order to develop normally. But identifying such genes or hormones will help us understand why, despite all the relevant environmental factors, some children are worse at empathising, or better at systemising, than others. ■

For a review of this book, see page 44.