The gender of the brain

Not Quite Equal Upstairs?

ANNA GRABOWSKA
Institute of Experimental Biology, Warsaw
Polish Academy of Sciences
a.grabowska@nencki.gov.pl

Professor Anna Grabowska is a neuropsychologist whose research focuses on the neurobiological foundation of cognitive functions in man. She is also interested in neural correlates of left-handedness and dyslexia

Why are the minds of women and men so engrossed in different issues, and why do we perceive reality in such differing ways?

Women do have smaller brains than men. And only 100 years ago, some scientists considered this to be sufficient evidence of women's mental inferiority. A neurologist from Leipzig compared brain sizes based upon data taken from... a hat-maker. His results? "A normal-sized man has to have a head circumference of at least 53 cm, while 51 cm suffices for a woman. And so, a brain that fits within a 51-cm head is enough for a woman to do her chores, but not for a man. A man's brain, after all, has different potential from the outset." This from a publication with the telling title: "*On Women's Mental Underdevelopment*"...

Nowadays, it is thought that the size of both men and women's brains is simply proportional to their body size, and that the two genders do not differ in terms of their overall intellectual capabilities.

Anna Bedyńska/Agencja Gazeta

Hormonal pathologies during early stages of brain development may result in an "internal conflict of genders"

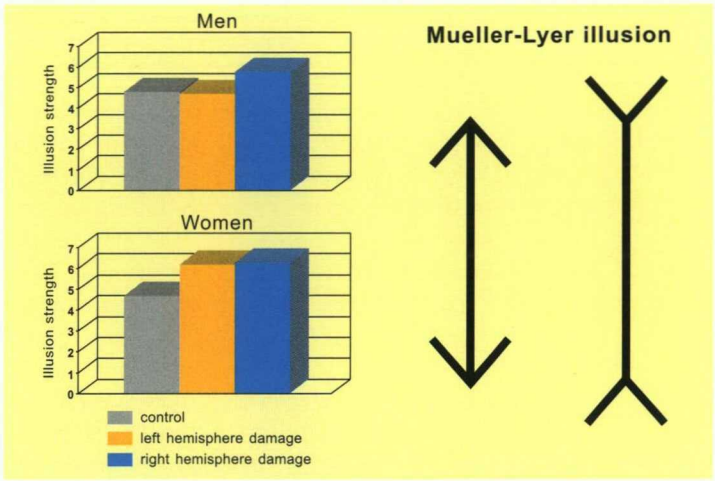
But how can the smaller female brain work just as well as the largest male "command center?" Certain data even suggest that the female brain in fact performs better, at least in certain regards. Brain activity imaging techniques show that men with outstanding mathematical abilities consume more energy to solve problems than similarly talented women do. Other neurobiologists have wondered whether the smaller female brains achieve greater efficiency through the denser packing of neurons. Team of Sandra Witelson from McMaster University, Hamilton, Canada have shown, for example, that in a part of the temporal lobe called the *planum temporale*, responsible for controlling language processes, the neural density is on average 11% higher in women.

Don't overload your mind!

As long as we are talking about efficiency, we should note that the process of aging in men is faster than in women. The greatest age-induced degenerative changes are observed in the frontal and temporal brain lobes, structures that are associated with mental effort. Importantly, excessive or pathological neural activity may lead to the secretion of harmful substances (such as glutamate). Perhaps the aforementioned excessive neural activity in men's brains contributes to their earlier death. It does not, however, mean that thinking is harmful! There is a considerable data to show that mental activity does keep our brains in good working order. Still, the previously cited results might serve as a warning to workaholics who overload their minds.

Nevertheless, density and overall size are not the only identifiable gender differences. The research team of R. Gur from University of Pennsylvania School of Medicine, Philadelphia, USA has identified that gray matter accounts for a relatively greater proportion of overall brain mass in women, whereas in men a greater proportion of white matter has been found. Moreover, men show an asymmetrical distribution of gray matter in the two hemispheres (more in the left then in the right). Because gray matter is comprised of cell bodies and dendrites (appendages that collect signals from ather neurons), while white matter is made up of myelinated axions (appendages that relay signals from a given neuron onward), these data confirm the notion that

Anna Grabowska



Women's brains are more symmetrical. Optical illusions such as the Muller-Lyer arrows (where the length of two equal lines is perceived as unequal) are more intensely sensed by men with damage to their right hemispheres, than by those with no brain damage to the left hemisphere. In women, however, damage to either hemisphere results in an increase of the illusion's strengh

neurons are more tightly packed in the female brain. The greater structural asymmetry of men's brains is also confirmed by data suggesting that the male brain does function in asymmetrical fashion.

It has long been known that the differences in the gender's mental abilities (men are better at spatial tasks, women at certain linguistic ones) are very reminiscent of the differences seen in how the two hemispheres specialize. It has thus been speculated that the differences between the genders stem from the differences in spatial organization of functions in the brain?

The balanced woman

If the brain hemispheres are indeed organized in different fashion in women and men, than damage to one of the hemispheres should cause different effects in each gender. Research performed at our institute in cooperation with the Neurosurgery Clinic of the Warsaw Medical Academy is frequently cited as evidence that points to different consequences of brain damage in men and women. Patients with left- or right-side brain damage were tested on optical illusions such as the Muller-Lyer arrows. Here the length of two equal lines is perceived to be unequal, when arrowheads pointing in opposite directions are placed at their ends. As it turns out, in women both left and right brain damage does increase the susceptibility to this illusion whereas in men only the right-side damage leads to similar effect. This shows that the visual and spatial functions underpinning this illusion are localized in the right hemisphere in men, but bilaterally in women. It is quite

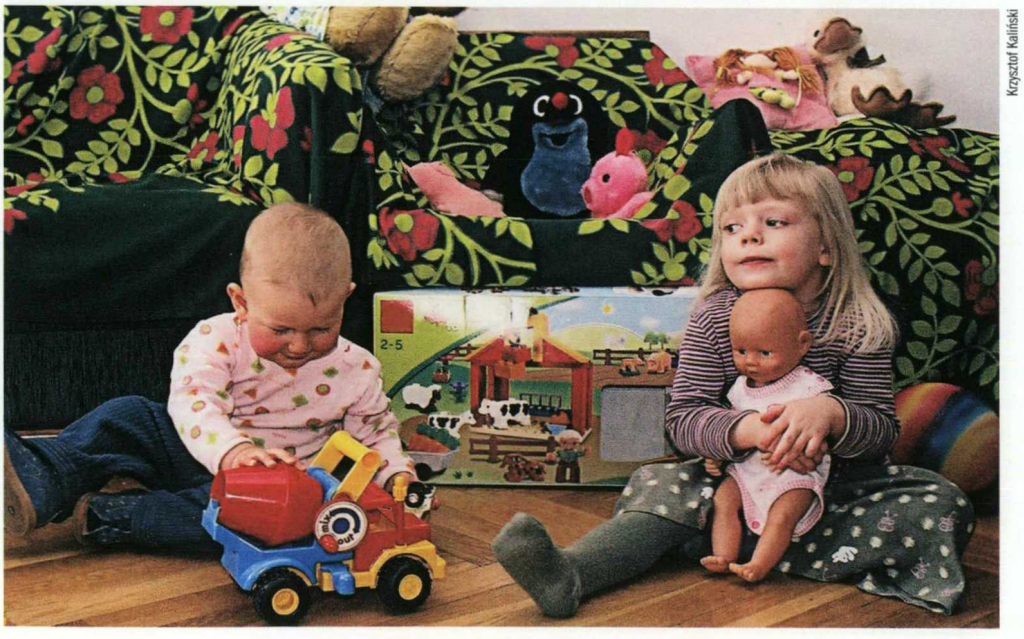
likely that this asymmetry is why men cope better with tasks demanding visual and spatial skills.

Consequently, in women who show greater verbal abilities, one could expect these functions to be more lateralized to the left hemisphere? So far, the research did not confirm this suggestion. Sally Shaywitz and her colleagues from Yale University School of Medicine, New Haven, USA published in *Nature* the results of their study performed using functional magnetic resonance. The authors measured the differences in blood flow to various regions of the brain while linguistic tasks were being performed. In one such experiment, participants were asked to identify which of the meaningless letters strings shown to them rhymed with each other. The pattern of brain stimulation observed during such rhyme identification was significantly different in men than in women. In men, performing this task resulted in an increased blood supply to the frontal cortex of the left hemisphere in the region associated with speech. Such an increase was seen in a similar region in women as well, albeit in both hemispheres. This result has been interpreted as tangible proof that women have more symmetrical brains than men do.

But this is still not the end of the gender differences. Our research has also turned up differences in how the hemispheres are organized. Studying patients with brain damage, we have learned that prosodic skills (i.e. understanding and generating language melodies that depend on experienced emotions) are controlled to a greater extent by subcortical structures in men, but by the prefrontal cortex area in women. Perhaps this shows why women are better at extracting the emotional subtleties....

Internal communications

If we assume that the brains of the fairer sex are characterized by less functional asymmetry, this leads to the conjecture that their cerebral hemispheres cooperate more closely, entailing a need for more extensive links between them. The two halves of the brain are connected to each other by several bundles of fibers known as commissures, of which the largest is called the *corpus callosum*. Research has not shown the total size of the *corpus callosum* to be notably larger in women, but it has discovered that certain parts of it, especially the *istmus* and the *splenium*, are indeed more sizeable in women. Intriguingly, these anatomical differences in the commissures are coupled with certain functional differences. Electrophysiological studies carried out at our research group Laboratory have shown that linguistic information is transmitted from one hemisphere to the other faster in women than in men, and that in men the speed of transmission does depend on its direction, whereas in women it does not. In men, the transmission time is shorter when information is sent from the right hemisphere to



Krzysztof Kalifiski

Inherited differences between the sexes are clearly manifested even in early childhood. Boys do usually prefer different toys and activities than girls do, even in the absence of suggestions from adults

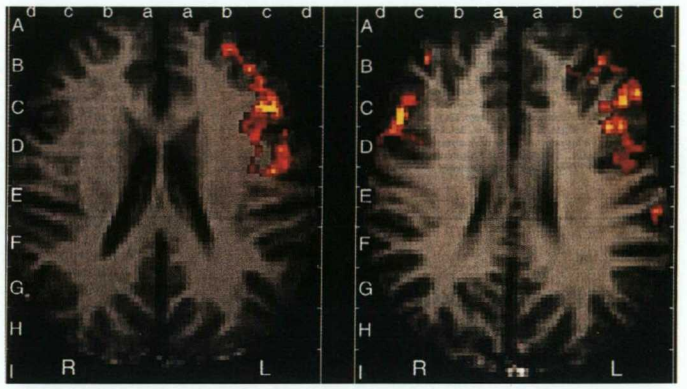
the left. Such directional asymmetry does of course make biological sense: it is the left hemisphere, after all, that specializes in linguistic processes (especially in men).

When studying gender variation in the construction of the brain, researchers devote great attention to the hypothalamus – a structure associated with sexual behavior, and with menstruation in women. This region also plays a key role in hormonal regulation. In-depth study has shown that the size of individual parts of this structure differ between the males and females of various species, and this holds true for humans as well. In women the so-called sexually dimorphic nucleus of the preoptic area is smaller than in men. Rats with damage to this nucleus experience sexual behavior disorders: for example, males begin to behave like females. Notably, in homosexual men this region shows a similar size as in women. Another part of the hypothalamus, in turn, dubbed the "bed nucleus of the stria terminales," is smaller in transsexual males than in control males and is of the same size as in women. On the basis of this data, however, it is still difficult to claim that gender identity disorders stem from disturbances in the differentiation of certain parts of the brain.

In the grip of hormones

Researchers agree that sex hormones undoubtedly play a role in shaping the brain. The most spectacular data comes from studying girls who were subjected to excessive quantities of male sex hormones (androgens) prior to their birth. This occurs, for example, in girls with congenital adrenal hyperplasia (CAH), a disorder of the adrenal gland. In such cases, the internal sexual organs develop normally, but the external organs become masculinized, and are usually corrected surgically. Androgen overproduction can be halted with proper pharmacological treatment. But can such procedures restore a girl's female "psychological" gender? As it turns out, not entirely so. Even with such treatment, girls demonstrate typically male behaviors; they get into fights, play war, and are indifferent to playing dolls. When they reach adulthood, they show less interest in having children, or in wearing feminine clothing and makeup. Many of them also demonstrate homosexual tendencies.

In men as well, early hormonal pathologies can not only lead to disturbances in the development of the sexual organs, they can also impart a more feminine nature to the brain, and consequently to adult behavior. This occurs, for example, in the case of men with inherited androgen insensitivity syndrome. Even though the testes of such men do produce testosterone, this hormone does not affect the developing fetus, or its impact is lessened due to impaired action of the androgen receptors. If their insensitivity is only partial, such men may develop normal male sex organs and a masculine sexual orientation, yet manifest typically female mental capabilities.



Nature

In men (left image) performing a rhyme-identification task stimulates the frontal cortex of the left hemisphere in the region associated with speech. Such increased activity was seen in a similar region in women, albeit in both hemispheres (right image).

And so, does the data accumulated to date justify the claim that our brains are shaped in a male or female fashion? The structural differences are very slight and involve quite subtle connections. Nevertheless, perhaps it is just such subtle differences in connections or the density of neurons in specific structures that determine how we think, what we feel, and how we react to events. The point is that science is a long way from explaining what link there might be between the observed differences in the brain and the male and female modes of behavior. We can be optimistic in light of the fact that we can now use neuro-imaging techniques that make it possible to observe how the brain functions in a living individual. Perhaps we will finally be able to catch our brains in the act – revealing their true gender. ■

Further reading:

Breedlove S. M., (1994). Sexual differentiation of the human nervous system. *Ann. Rev. Psychol.* 45, 389-418

Kimura D., (1996). Sex, sexual orientation and sex hormones influence human cognitive function. *Curr. Opin. Neurobiol.* 6, 259-263.

Grabowska A., Nowicka A., Szymańska O. (1999). Sex related effect of unilateral brain lesions on the perceptron of the Mueller-Lyer illusion. *Corex*, 35,231-241