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Male and female brains

Has evolution led to differences in brain structure and function between the sexes? Hannah Howes and Lance Workman consider some recent research and how it might relate to evolutionary theory.

There is an old joke about a family being told by a brain surgeon that their loved one will die unless they receive an immediate brain transplant. The surgeon explains that they could put in a male brain at a cost of £500,000 or a female brain for a mere £200,000. The male members of the family begin to grin, as this proves that male brains are superior to female ones, but the smiles are quickly wiped off their faces when the surgeon explains that the male brains are more expensive because they have not been used so much.

Are men and women different?

Brain transplants are not on the immediate horizon but this joke illustrates that, at some level, there is a widespread view that differences exist between male and female brains. Such a view may be, in part, due to the out-dated view of male cognitive superiority, with some early psychologists describing a woman's brain as being closer to that of a child's than a man's (Kimura 1999). During the early years of the last century, however, the feminist movement challenged this view and gradually it became clear that, in terms of overall cognitive abilities, the sexes have equal capacity. By the 1980s, notions of political correctness made even the suggestion of biologically-based sex differences in brain and behaviour morally suspect. In recent years, however, two developments mean that it is time to reconsider the evidence for broad differences in brain and cognitive function between men and women.

First, improvements in scanning techniques mean that it is now possible to make accurate, quantifiable comparisons between participants in the structure and function of specific brain areas.

Second, with the emergence of evolutionary psychology, there is now a well-established theoretical framework that might be used to explore the notion of sex differences in brain and behaviour (Barkow 2006). So, how well does the notion of male brains and female brains stand up to scrutiny today?

Sex and the brain

In 1985, Dutch scientists uncovered an area deep within the brain that differed between men and women (Kimura 1999). This was a part of the **hypothalamus** (an evolutionary ancient part of the brain involved in drives including hunger and sex), which became known as the **sexually dimorphic nucleus of the preoptic area** (SDN-POA). The SDN-POA in a man's brain is, on average, twice the

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Girls and boys are born with subtle differences in their brains and behaviour

size of that in a woman's brain. This area of the brain is known to be involved in sexual arousal and, unsurprisingly, neuropsychologists have debated what this finding means. Perhaps the difference reflects dissimilar strategies that the sexes have evolved for reproductive purposes, with males — who are not 'left holding the baby' — being less coy and more rapidly aroused sexually than females.

One possible problem with the notion of an evolved part of the brain that makes males more 'rampant', however, is that it is now known that the sex difference in the preoptic area does not appear until a child is 4 years old. This leaves plenty of time for gender socialisation to have an effect on brain development. It is fair to say that the jury is still out on the issue of the relationship between the preoptic area of the brain and sex differences in behaviour.

Do women have more cortex devoted to reason?

If an anatomical feature of the brain that differs between the sexes was found to be present from birth, then this would be stronger evidence that biological/evolutionary rather than social/cultural factors led to this difference. Until recently, no such features were detected. Over the last few years, however, scanning techniques have revealed a whole series of sex differences in the brain that appear to be related to cognitive and emotional processing. Some of these are known to be present at birth. For our purpose, an important cluster of sex differences was uncovered by Professor Jill Goldstein of Harvard Medical School. Goldstein and her co-workers have made discoveries that would make Victorian male psychologists turn in their graves.

In 2005, using an **MRI scanner**, Goldstein found that, relative to overall brain size, parts of the **frontal cortex** were significantly bulkier in females than in males. Given that the frontal cortex is associated with higher cognitive abilities, such as reasoning and attention, this might be seen as a blow to male pride. Moreover, parts of the limbic system, which process emotional responses, are also larger in the female brain. Before males start to become too disheartened, however, Goldstein did find that parts of the **parietal cortex**, which is involved in spatial awareness, were larger in male brains.

Goldstein's findings are of great interest, since a number of studies have demonstrated that women outperform men consistently on tests of **verbal fluency**, while men demonstrate superior **spatial reasoning** (Kimura 1999). Might these recently uncovered differences in specific areas of the cortex underlie sex differences in performance? However, once again, it might be claimed that these sex differences are related to social conditioning.

Again, a more convincing evolutionary argument would involve differences that are apparent from birth. Clearly, we cannot test such cognitive abilities in newborn babies but we can at least assess whether there are differences in what babies are motivated to look at from birth and see whether this fits in with the adult pattern of male and female cognitive abilities.

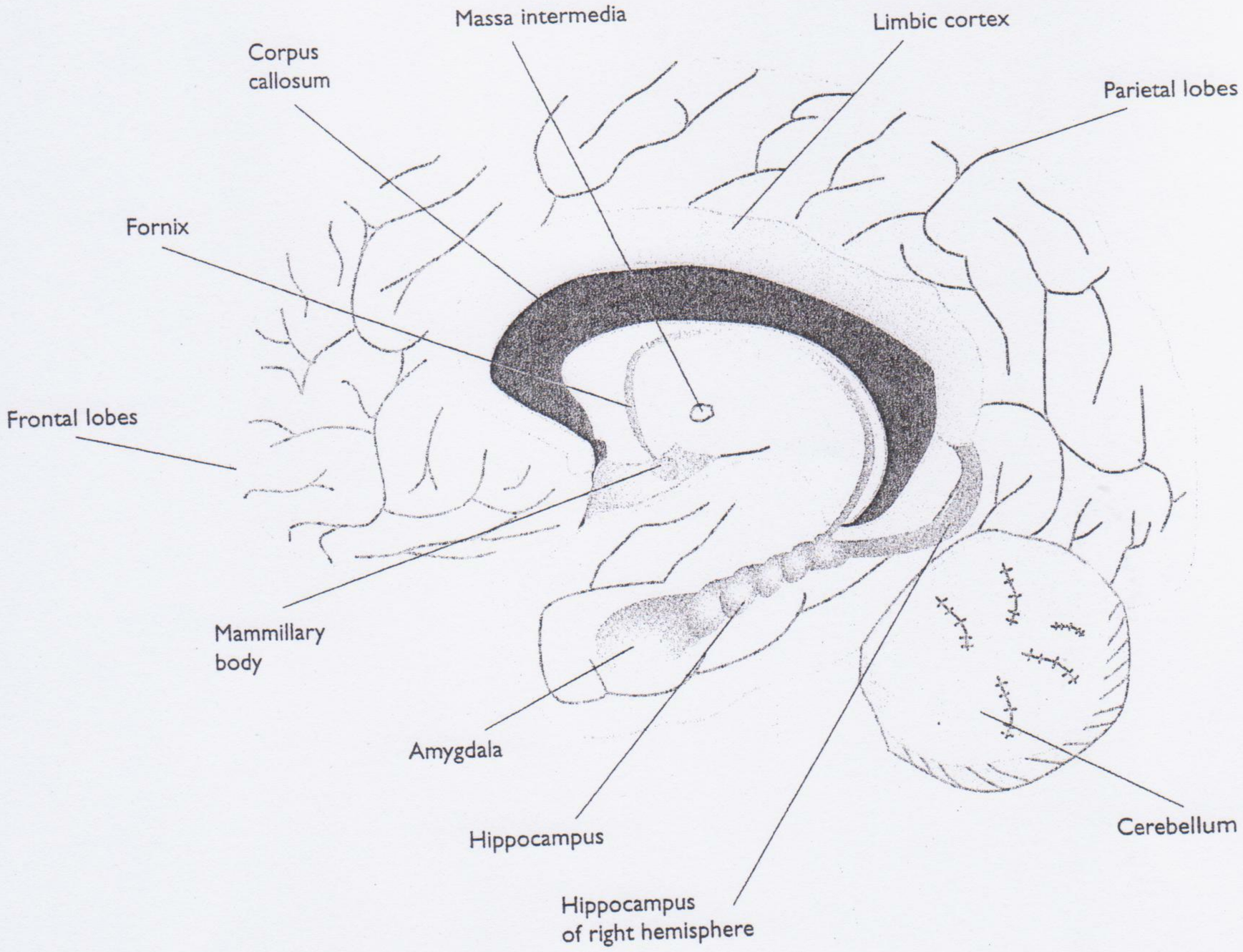

Figure 1 The major components of the limbic system

Box 1 Key concepts

Empathising and systemising

Frontal cortex

Hypothalamus

Lesion studies

Lateralised brain lesions

MRI scanner

Parietal cortex

Sexually dimorphic nucleus of the preoptic area (SDN-POA)

Spatial reasoning

Theory of mind

Verbal fluency

Newborn boys and girls look at different things

Behavioural studies of newborn infants by Cambridge developmentalist Simon Baron-Cohen have uncovered evidence that there are differences in what boys and girls prefer to view. Baron-Cohen and his team presented newborn infants with two video films, one of a friendly face and the other of a mobile. The observers, who were only told the babies' sex after they had finished t observations, found that boys spent longer looking at the mechanical mobile, whereas girls spent longer looking at the face (Baron-Cohen 2003).

Perhaps Baron-Cohen's findings of female preferences for observing other people and male preferences for mechanical objects are in some way directly related to the findings of Goldstein. The parietal lobes (male advantage) are known to be involved in spatial rotation and movement in space. In contrast, the frontal lobes, in association with the limbic system (female advantage), are related to social and emotional responses. This fits in well with the observations of Baron-Cohen's team but begs the question of why girls and boys are born with subtle differences in brain and behaviour. This is where evolutionary psychology (already alluded to) may help to complete the explanation.

t 2 People are just like chickens

Workman argues that if human males have evolved superior visuo-spatial skills because they range over a wider area, then if we can find another species where the sexes also differ in this respect, we would be able to predict superior visuo-spatial skills in the males of that species also. In the case of domestic fowl, free-ranging roosters maintain large territories whereas hens do not. In field observations and laboratory studies, during the first week of post-hatch life, male chickens were found to use the same sort of (human male-like) mechanisms to find their way around and were observed to wander further afield than their female counterparts. This may be an example of convergent evolution in humans and chickens.

Source: Workman and Andrew (1989)

Empathisers and systemisers

Baron-Cohen (an evolutionary psychologist) has recently suggested that women in general are better at **empathising** and men are better at **systemising**. Empathising is the ability to read people's thoughts and emotions and respond appropriately. It covers not only what is sometimes called '**theory of mind**' but also what is meant by the words 'empathy' and 'sympathy'. Empathising allows you to predict a person's behaviour and to care about how they feel. Systemising is a process; the person watches what happens each time and derives general rules from such data. Systemising allows you to predict the behaviour of a system and to control it.

As well as the evidence from the early baby mobile studies, it has been found that little girls show more eye contact than boys, even at a young age. From birth, females look longer at faces, and particularly at people's eyes, and males are more likely to look at inanimate objects (Connellan 2001). By 3 years of age, little girls are already ahead of boys in their ability to infer what people are thinking (Happe 1995).

Boys are more interested than girls in toy vehicles, weapons, building blocks and mechanical toys, all of which can be systemised. Maths, physics and engineering are largely male-dominated subjects and some careers are almost entirely male, such as boat building, weapon making and the construction industries, which again fits with the systemising brain type (Baron-Cohen 2003).

These observations have led Baron-Cohen to argue that autism might be an extreme version of the male brain. This condition affects far more males than females. The condition is strongly heritable and neurodevelopmental (Baron-Cohen 2003), which supports the notion of early sexual differentiation of the brain.

Evolution of sex differences

Based on the arguments presented above, some evolutionary psychologists have argued that modern-day sex differences in brain and behaviour arose because our early male and female ancestors faced different pressures (Barkow 2006). Men would have spent a relatively large amount of time hunting and would have required good visuospatial skills to organise hunts, throw spears and find their way home. This, in turn, may have led to a slightly different development of the parietal lobes (and hence systemising skills).

Women, for their part, would have gathered plant food near the tribal base while caring for their young and would have developed good empathising skills. This, in turn, may have led to the relatively greater development of specific parts of the frontal lobes and of the limbic system.

Too neat?

This may all sound too neat and simple. Perhaps it is, but it should be borne in mind that modern-day forager societies do show this division of labour and artefacts and fossil finds suggest that this is an ancient sex role division (Barkow 2006). It is important to realise, however, that both males and females are able to conduct tasks that require empathising and systemising; the point is that one sex is better on average at one task *relative* to the other and vice versa.

It is also important to realise that the variability within the sexes is greater than the variability between the sexes. So, on average, individual females differ from each other to a greater extent than the sexes differ from each other. This has led some researchers to question the validity of

Box 3 Recovery from brain damage: are the sexes the same?

More evidence for the existence of sex differences in the brain comes from lesion studies (where the brain is damaged in a specific area). Lesion studies show that males have greater language impairment from left hemisphere lesions than females and this has been interpreted as meaning women have a more distributed (lateralised) system for processing language (involving both hemispheres).

With **lateralised brain lesions,** women appear to have a distinct right hemisphere superiority for recognising facial expressions, which contrasts with the male right hemisphere visual-spatial advantage (Lezak, Howieson and Loring 2004). However, these findings of sex differences following lesions have not always been replicated.

Mauricio Anton/SPL

Early man spent a large amount of time hunting and gathering, so would have developed good visuospatial skills

sex differences in brain and behaviour (Kimura 1999). The sex differences are slight — but they are robust. This means that the differences, although small in both brain and behaviour, are 'real' — and that needs explaining.

Given both the recent findings revealed by scanning techniques and the early observations of baby girls and boys, it may mean that we need to be careful when studying the relationship between brain and behaviour. In future, one of the first questions we might need to consider is, 'What is the sex of the brain we are dealing with?'

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