

Why did you conduct the study?

I wanted to test the mosaic hypothesis, published in 2011 (“Male or female? Brains are intersex”), according to which there are no “male brains” and “female brains” but rather brains are composed of unique mosaics of features, some more common in males and other more common in females. This hypothesis was built on animal data showing that the effects of sex on the brain may be different and even opposite under different environmental conditions (i.e., what is typical in one sex under some conditions may be typical in the other sex under other conditions).

Your study seems to contradict a lot of research done in the past.

This is not correct, because no study has tested what we have.

We, as other studies, find differences between the brains of males and females.

What we have done in addition, and no previous study has, is look whether brains are internally consistent, that is, have either only “male-end” features (i.e., features in the form more common in males compared to females) or only “female-end” features (i.e., features in the form more common in females compared to males).

What our study contradicts is the implicit assumption that differences between females and males add up to create two types of brains, “male brains” and “female brains”

You have found there are sex differences in brain structure but that brains do not fall into two classes. Can you explain more about this? What kind of differences have you found ?

The observation that there are differences between the brains of males and females does not necessarily mean that brains of males and brains of females belong to two distinct classes, although this is true for the genitalia of males and females.

What makes the genitalia special is the almost lack of overlap between the form in males and females and the internal consistency. In the genitals, if you have one female feature (lets say a clitoris), you are highly likely to also have all other genital organs in the female form, and no organ with the male form. This characteristic of the genital organs together with the low degree of overlap between the male and female forms are responsible for the observation that most genitalia are of two types, male genitalia or female genitalia.

We wanted to know whether there is also internal consistency in the brain. To answer this we looked only at brain features which showed large differences between males and females. We didn’t care what these differences were (i.e., in which region) - we simply used the largest ones. Then we looked for internal consistency in each brain in these features.

For example, in the first sample the left and right hippocampus and the left and right caudate were larger on average in females compared to males (as well as 6 additional regions, but for the example, let's focus on these 4). Internal consistency means that you will have a large left hippocampus, a large right hippocampus, a large left caudate and a large right caudate (i.e., all towards the "female-end" of the continuum), or that all will be small (i.e., all towards the "female-end" of the continuum). If brains were internally consistent, then there would only be brains in which the 4 regions are large, brains in which the four regions are small, and brains in which the four regions are intermediate in size. But it turned out that these types of brains are rare, and most brains are composed of combinations of large, intermediate and small regions (in this example).

The correct terminology would be: most brains are composed of combinations of features, some more common in females compared to males (large in the example), some more common in males compared to females (small in the example), and some common in both females and males (intermediate in the example).

Please explain what you mean by male-end brain or female-end.

Because of the overlap between females and males we could not differentiate between a "female" form and a "male" form in the brain (as we can for genital organs). Therefore we are talking about the "male-end" and the "female-end" of each distribution (i.e., the region of the distribution where males are more common than females and the region of the distribution where females are more common than males, respectively). The percent of consistently "female-end" and consistently "male-end" brains depends on the exact definition of the end-zones. What we found is that regardless of how we defined these zones, we found many more brains with both "male-end" and "female-end" features than brains that have only "male-end" or only "female-end" features. (see Table S2 in the paper).

If brain dimorphism is a myth, how do we explain differences in behavior?

As we show in our study, behavior is also not dimorphic, that is, there are many ways to be human, not just two, a "male way" and a "female way". So in fact, our results from analyzing human behavior fit nicely our results from the analysis of the human brain: they are both characterized by mosaic rather than two distinct forms.

Many believe that differences between male and female brains explain why women, for example, are more empathetic or social, and men more aggressive or better skilled for math or geometry. Based on your results, what can we say?

As with all other gender differences in behavioral and psychological characteristics, there is huge overlap between men and women on these abilities (see Hyde, J.S.

2014 Gender similarities and differences. *Annu Rev Psychol* 65, 373-398; Zell, E., Krizan, Z. & Teeter, S.R. 2015 Evaluating gender similarities and differences using metasynthesis. *Am Psychol* 70, 10-20). So it is misleading to say: "women are empathetic or social, and men more aggressive or better skilled for math or geometry" because this implies that all men are better than all women in math or geometry, etc. The correct way to state this is: on average, women are more empathetic or social, and men more aggressive or better skilled for math or geometry, and there is considerable overlap between the abilities of women and men.

(btw, regarding math skills, whether boys or girls do, on average, better, depends on the country, as evidenced in the results of international test such as the TIMSS)

What we show in our analysis is that even for characteristics that show large sex/gender differences, there are very few people who have only feminine or only masculine characteristics, and the majority of people have both feminine (more common in females compared to males) and masculine (more common in males compared to females) characteristics. So humans, like brains, do not come in two types. In other words, one cannot speak of a 'male nature' and a 'female nature'.

Last, we have not looked at the relations between brain structure and function, but studied them separately in different datasets.

Where does the idea "Men are from Mars and Women are from Venus", in your opinion, come from?

In short, the myth of fundamental differences between males and females (Men are from Mars and Women from Venus) is a cornerstone of patriarchy (as well as any other form of oppression, i.e., according to color, cast, etc.). The myth of the male and female brain is just a modern version of it.

See Shields (1975) *American Psychologist*, 30, 739-754 for a review of the history of the myth of fundamental differences between the brains of males and the brains of females.

According to your observations, should we change the way we raise our children?

We should teach are kids that there are many ways to be human; that in contrast to the message they get from media and friends, there is no one way to be a girl or one way to be a boy; that there are nothing that is inappropriate for one sex but is appropriate for the other - things are either appropriate for humans or not-appropriate for humans; that they should go with their heart and brain.

In parallel, we should teach them that not everyone thinks this way, and help them see how these beliefs affect their environment and attempt to channel them in

specific ways (e.g., boys don't cry, girls don't get angry, girls plays with dolls, boys with balls, etc.). This is important first to protect them from violence that may be directed at them if they don't behave in a gender-typical way (so they can choose wisely where not to take the risk), and second, immunize them against these stereotypes and schemas.

Why, from the evolutionary point of view, there are differences between male and female characters?

Our study (as well as other studies of the adult brain) has no bearing on this question. We do not know whether the differences we observed between the brains of females and the brains of males were a result of nature or nurture.