

Yes, there is a female and a male brain: Morphology versus functionality

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In a recent PNAS paper (1), Joel et al. examine several large datasets of MRI images and surveys of human brains. The authors conclude that brains of women and men are not dimorphic and not categorically different, as are the genital systems of the two genders, but resemble more an overlapping mosaic of specific functional regions and therefore cannot be distinguished as male and female brains. This conclusion cannot be drawn based on the methodology used. MRIs are “still images.” Looking at these is more akin to examining a road map and drawing conclusions about traffic patterns. Other imaging methods might have yielded different results (2). Reality is not fully revealed from quantities or distributions of quantities but from the functionality of the system. There are functional differences in various activity centers in the brain while performing physical or cognitive tasks or undergoing emotional experiences, but there are no morphological distinctions between brains that experience pain, happiness or sorrow, love or hate, empathy or compassion. There was in fact no need for such an elaborate study that eventually corroborates a rather obvious fact: that one cannot morphologically distinguish between a male and a female brain like one can concerning male and female genitalia. Whenever the terms “female brain” and “male brain” are used, the intention should be functional and not morphological, qualitative and not quantitative. Functionally, brains of women and men are indeed different. Not better, not worse, neither more nor less sophisticated, just different. The very brain

cells differ chromosomally. The male brain is exposed to a completely different hormonal environment during intrauterine life than the female brain. The available scientific data as to the crucial effect of testosterone on the developing male brain is overwhelming (3, 4).

Our gonads function differently because of differences in the hypothalamus, pituitary, and gonad axis. These brain regions look morphologically exactly the same; the hormones secreted are exactly the same, just the patterns of secretion are different—pulsatile in the female and almost constant in the male—which leads to fundamentally different gonadal function. The future effects of highly elevated testosterone in the male fetus are numerous, including behavioral characteristics, toy preferences, verbality (5), and many other features. Of course, this is not categorical and overlaps are common. Consider the heart, which is morphologically indistinguishable between the sexes; however, more women than men who suffer from a heart attack will have open coronary arteries and atypical symptoms. Consider drugs: prophylactic aspirin taken by women will more often prevent strokes, and if taken by men will more often prevent a heart attack. Consider the gastrointestinal system: passage time of food and drugs will more often be longer in women than in men, with consequences for drug absorption and food digestion. Most functional differences of our bodily systems are controlled by our functionally different brains, and yes, there is a female and a male brain.

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- 1 Joel D, et al. (2015) Sex beyond the genitalia: The human brain mosaic. *Proc Natl Acad Sci USA* 112(50):15468–15473.
 - 2 Ingalhalikar M, et al. (2014) Sex differences in the structural connectome of the human brain. *Proc Natl Acad Sci USA* 111(2):823–828.
 - 3 Abramov I, Gordon J, Feldman O, Chavarga A (2012) Sex & vision I: Spatio-temporal resolution. *Biol Sex Differ* 3(1):20.
 - 4 Chura LR, et al. (2010) Organizational effects of fetal testosterone on human corpus callosum size and asymmetry. *Psychoneuroendocrinology* 35(1):122–132.
 - 5 Shaywitz BA, et al. (1995) Sex differences in the functional organization of the brain for language. *Nature* 373(6515):607–609, 373, 6515.

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Author contributions: M.G. analyzed data and wrote the paper.

The author declares no conflict of interest.

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